Dušan Surla
Dragan Ivanović
Zora Konjović
Miloš Racković

Rules for Evaluation of Scientific Results Published in Scientific Journals

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Summary

This looks into some issues appearing in scientific journals evaluation based on their impact factor (IF). An analysis of the publicly available data on journals' IFs results in finding that there exist a significant number of journals publication years missing their IF data. Therefore, this article proposes the IF based rules enabling the determination of the journal's category for the publication years with no IF available. Application of the proposed rules is illustrated through the example of the scientific fields of mathematics, computer science and mechanics. Finally, the examples of the evaluation completed by applying the proposed rules are given. Application of the proposed rules is automated within the CRIS system of the University of Novi Sad (CRIS UNS) using the data available in the database of this system.

Keywords

journals evaluation, journal impact factor, evaluation, CRIS UNS

1. Introduction

The main results of the scientific research are the publications containing scientific research results: journal articles, monograph publications, conference proceedings articles, etc. As in all other industries, the evaluation of the achieved results is important for the field of science and research. States, regions or institutions make decisions based on evaluation of the results achieved by individual researchers, scientific institutions or scientific projects.

In order to evaluate scientific and research results, it is necessary to collect metadata on these results at the beginning. CRIS systems are those who store all relevant data on scientific and research field such as data on scientific projects, scientific institutions, results, researchers, etc. Therefore, these systems can be utilized for storing metadata on scientific results that should be evaluated.

Once metadata on scientific results have been collected, it is necessary to decide how they will be used for evaluating results. One approach is to evaluate the results by applying rule books. Very often these rule books heavily rely on rules based on bibliometric indicators like citations, impact factors, etc. In this case, prior to the evaluation, it is indispensable to collect these bibliometric indicators along with metadata. Collecting bibliometric indicators could be an ambiguous task due to incompleteness of such data.

This article prpoposes a set of impact factor based rules for evaluation of the scientific results published in journals. The rules that are defined are aimed to resolve the problem of the missing impact factors data.

The rest of the article is organized in the following way. Research motivation is described in the first section. Section two presents related work focusing on the JIF bibliometric indicator, since this indicator is the basis of the evaluation model proposed in this article, as well as for the researched carried out in hitherto development of the CRIS UNS System's segment related to scientific results evaluation. Section three, which is the central part of the article, presents the proposed evaluation model. The last section concludes the article and suggests further research directions.

2. Motivation

The CRIS UNS system is used by the Faculty of Sciences Novi Sad. The Faculty consists of 5 departments (Department of Mathematics and Informatics, Department of Physics, Department of Chemistry and Environmental Protection, and Department of Geography, Tourism and Hotel Management). Each of these departments has its own rulebook for evaluating scientific results in its scientific field. The rulebooks cover evaluation of publications from journals, conferences' proceedings, and monographic publications. The database contains metadata on about 14.000 publications in total, out of which over 5500 journal articles, over 6500 conference proceedings articles, and about 500 monographic publications.

Motivation behind this article is to extend CRIS UNS system by the public electronic service aimed at evaluation of the articles published in journals for all scientific fields. Publicly available data on scientific journals have been collected for this purpose. So far the database stores the data for approximately 40.000 journals. Diverse rule books for specific scientific fields and specific aims can be adopted. Currently Serbian Ministry of Education and Science recognizes several scientific fields such as Physics, Chemistry, Mathematics, Computer Science and Mechanics, Geosciences and Astronomy, Social Sciences, etc. The rule books apply to evaluating individual researchers regarding the capacity to participate in research projects, appointments to professional research/teaching positions, accreditation of scientific institutions they are with, etc. Application of the evaluation rules will be automated through the public Internet service capable of evaluating the journal, published article, and editorial board membership based on journal's title, publication year and selected rule book.

3. Background and Related Work

The rules for evaluating scientific articles published in journals which are presented in this article are based on the journal's impact factor; therefore. this impact factor is described in section 2.1. emphasizing its advantages and disadvantages. The rules are applied in automated fashion providing for public evaluation service which is the part of the CRIS UNS system described in section 2.2.

3.1. Journal Impact Factor

The results published in a journal can be evaluated applying diverse bibliographic indicators. One of bibliometric indicators widely used for that purpose is the journal impact factor (JIF). It is calculated for each publication year in following way: the JIF for a particular year is the average number of particular year citations received per article published in that journal during some preceding period. If period of previous two years is used, then it is two-year JIF, and if period of previous five years is used, then it is five-year IF. Hereinafter, the term JIF refers to two-year JIF (which is a common practice).

The intent of the JIF is to measure the importance of a journal. Glänzel and Moed (2002) discuss the advantages and disadvantages of using that indicator. Articles (Garfield, 2000, 2006) explain the history and the proper uses of the JIF. Bensman (2008) and Bensman, Smolinsky and Pudovkin (2010) investigate the journals' impact factors distribution. Bordons, Fernández and Gómez (2002) discuss problems of using the JIF as measure in non-English speaking countries. Van Leeuwen and Moed (2002) also discuss some shortcomings of the JIF and propose a new measure called Journal to Field Impact Score (JFIS). Buela-Casal (2002) proposes taking into account the reputation of the publication from which the citation irugubates. Moreover, Bollen, Rodriguez and van de Sompel (2006) propose the measure of citations based on popularity (number of citations) and prestige (expert appreciation). Sombatsompop, Markpin and Premkamolnetr (2004) propose the modification to the JIF from the point of citation period (half-life of the journal). Frandsen and Rousseau (2005) generalize the definition of the JIF to allow different publications and citation periods. Van Leeuwen and Moed (2005) study the relationship between the JIF and other indicators. Egghe (2009) compares the evaluation based on h-Index with evaluation based on the JIF. There are also other metrics for journals' scientific prestige such as Eigenfactor (Bergstrom, 2007) and SCImago Journal Rank (González-Pereira, Guerrero-Bote, & Moya-Anegón, 2010). It is obvious that the JIF has weaknesses that researchers have tried to eliminate by proposing some modifications of the JIF. Despite its weaknesses and existence of other metrics for journal ranking, journal impact factor is a widely spread bibliometric indicator for evaluation of journals. Also, the JIF can be starting point for measuring other aspects relevant for scientific-research activity. Chinchilla-Rodríguez, Vargas-Quesada, Hassan-Montero, González-Molina and Moya-Anegón (2010) propose an approach based on the JIF that visualizes international scientific collaboration.

3.2. CRIS UNS

CRIS UNS is a CERIF compatible research management system under development at the University of Novi Sad since the year 2008. The system is built on the CERIF-compatible data model presented in the article (Ivanović, Surla, & Konjović, 2011) which is based on the MARC21 format. The first phase of CRIS UNS development covered implementation of a data entry system for metadata about articles published in journals, articles published in conferences proceedings, monographs, and articles published in monographs. The system implementation is

described in the articles (Ivanović, Milosavljević, Milosavljević, & Surla, 2010; Milosavljević, Ivanović, Surla, & Milosavljević, 2011), while the module for automatic extraction of metadata from scientific articles in PDF format for CRIS UNS is described in the article (Kovačević, Ivanović, Milosavljević, Konjović, & Surla, 2011). The current phase of the system development is related to evaluation of those results. Scientific research results from the system are available to anonymous users via the Internet. Along with being compliant with CERIF, the system meets requirements prescribed by Ministry of Education and Science of the Republic of Serbia for the scientific-research results evaluation (Ivanović, Surla, & Racković, 2011). Moreover, the system is implemented as web application that enables authors to input metadata about their own research results without the knowledge of CERIF and MARC21. The system's data model and architecture enable its easy integration with library information systems.

4. Findings

In order to evaluate scientific/research results published in journals CRIS UNS requires:

- Results metadata;
- Evaluation rule book;
- JIFs data;
- Data on journal's category assigned by the official body - Commission (optional).

Once the above data is provided, CRIS UNS is able to generate evaluation reports on results described by a metadata.

Since the impact factors of journals are stored in the CRIS UNS data model, CRIS UNS can suggest categorization of a journal that has an impact factor. Additionally it is necessary to determine journal category for the journals which do not have impact factor already assigned. According to the Rulebook of the Serbian Ministry of Education and Science, in that case a Commission of Competence appointed for each scientific field is authorized to assign a category to a journal (for example: for physics, for medicine, for social sciences, languages and literature, etc.).

In the follow up of this (third) section, a case study of introducing rules for evaluation (categorization) of journals will be described. This use case is for the scientific field of mathematics, computer science, and mechanics.

3.3. Categorizing Journals with IF

The Rulebook of the Serbian Ministry of Education and Science recognizes three categories of journals depending on the value of JIF (Table 1).

Table 1 Journal categories

Journal category	Definition
Leading international journal	Ranked among the top 30% in the JCR list of journals.
Outstanding international journal	Ranked between the top 30% and 50% in the JCR list of journals.
International journal	Exists on the JCR list of journals, but is not ranked among the top 50%.

Source: Authors

Record of journals by these categories are kept by the National Library of Serbia. Records are publically available on the web site (http://kobson.nb.rs/servisi/pretrazivanje_casopisa.84.html). Committees of Competence of the Ministry use this data for journals categorization. However, there are cases when years the data on IF are missing for some publications. Then it is necessary to define additionally IF based determination of journal's category for publication years with no IF available. There are several reasons for absence of IFs for particular publication years. One is that the journal's editorial board did not submit requested documentation to the Thomson Reuters, while the second could be that a journal does not meet conditions for IF assignment.

The following findings emerge from the analysis of the publicly available data on impact factors for journals:

- The year 1981 is the first year of IF appearance.
- There are journals missing Ifs for particular publication years.
- Data on Ifs are not available for neither of either journal for the following publication years: 1989-1991, 1993-1997. In addition, data on IFs for the journals from the social sciences field do not exist for the year 1992.

In order to implement IF based journals categorization consistently it is necessary to consider journals' categorization for the publication years when IF is missing. These are publication years prior to 1981, and the time span 1989 - 1997. This article proposes a consistent journal's categorization by defining rules for the following cases:

1. Categorization for the publication years when the journal's IF exists.

2. Categorization for the years prior to the year 1981.
3. Categorization for the publication years with no journal's IF available, but such that these publication years are close to the years for which IFs are available, i.e. belongs to some of the categories given in Table 1.
4. Categorization for the publication years from 1989 to 1997.
5. Categorization for all the publication years not covered by the above cases.

Additionally, even when an IF for a journal is available, the particular journal can be differently ranked within different scientific disciplines as published by Thomson Reuters. Actually, the journal's ranking depends on IFs of other journals belonging to the particular scientific discipline ranking these journals. The consequence is that a journal having a unique IF for the particular year can achieve multiple different rankings for different scientific disciplines for this very same publication year as shown by Table 2. Table 2 presents two-year IFs for the Scientometrics journal, publication years 2001 – 2009. The third and fourth row of this Table contain the journal's ranking for two scientific disciplines ranking this journal.

Table 2 Impact factors and rankings for the Scientometrics journal

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
Two-year JIF	0.676	0.855	1.251	1.120	1.738	1.363	1.472	2.328	2.167
Ranking Scientific field: Computer Science, Interdisciplinary Applications	25/76	19/80	16/83	24/83	18/83	24/87	24/92	13/94	18/95
Ranking Scientific field: Information Science & Library Science	16/55	16/55	9/55	14/54	5/55	12/53	12/56	8/61	10/65

Source: Authors own work based on Journal Citation Reports

The journal Scientometrics for the year 2001 belongs to the scientific disciplines Computer Science, Interdisciplinary Applications and Information Science & Library Science. Within the first scientific discipline, the journal is ranked 25th out of 76 journals, i.e. below the top 30% but within the top 50% of all journals belonging to this scientific discipline. Therefore this journal is categorized as an Outstanding international journal within this scientific discipline. Within the second scientific discipline, the journal is ranked 16th out of 55 journals, i.e. within the top 30% journals belonging to this scientific discipline and therefore within this discipline categorized as a Leading international journal. The decision on the journal's category is the mandate of the Evaluation Commission. It is therefore necessary to decide which scientific disciplines are recognized as those belonging to the particular scientific field as well as a rule for determining the category for a journal belonging to multiple scientific disciplines. For our case study (scientific fields Mathematics, Computer Science, and Mechanics), we have accepted the following Thomson Reuters's disciplines:

1. Computer Science, Artificial Intelligence;
2. Computer Science, Cybernetics;
3. Computer Science, Hardware & Architecture;
4. Computer Science, Information Systems;
5. Computer Science, Interdisciplinary Applications;
6. Computer Science, Software Engineering;
7. Computer Science, Theory & methods;
8. Information Science & Library Science;
9. Mathematics;
10. Mathematics, Applied;
11. Mathematics, Interdisciplinary Applications;
12. Mechanics;
13. Statistics & 'Probability;
14. Physics – Mathematical;
15. Thermodynamics.

The following rules apply for determining a journal's category holding for a particular scientific field:

Rule 1. If a journal is categorized for a publication year within at least one scientific discipline belonging to the considered scientific field, then the highest category achieved by the journal in disciplines belonging to a considered scientific field shall be assigned to the journal for this publication year. If a journal is not categorized within any of the disciplines belonging to the considered scientific field, then the lowest category achieved by the journal in all disciplines categorizing this journal shall be assigned to this journal for this publication year.

Since 1981 is the earliest year of IFs appearance, journals that received IFs for the year 1981 are those that had a significant rating before 1981. If a journal has improved its rating within the period 1981 – 1983, this also indicates the journal's rating in the years prior to the year 1981. The following rule was accepted based on these assumptions:

Rule 2. If a journal has received IF for the year 1981, than the highest category achieved by a journal within the time span 1981 – 1983 shall be assigned to a journal for all publication years prior to the year 1981.

It was also foundnd that some journals exist that are missing IFs for the particular previous publication years which do not fall within the time spans covered by Rule 1 and Rule 2 but that one can conclude from information on the journals' ratings for time spans immediately preceding and following the period when IF is missing, that the journal's quality was preserved. For example, Table 3 shows the two-year impact factors for the journal Advances in Chemical Physics, time span 2003-2010 and the corresponding categories obtained by applying the previous two rules. Here, LIJ stands for Leading international journal, OIJ stands for Outstanding international journal, and IJ stands for International journal.

Table 3 Data on the journal Advances in Chemical Physics

Year	2003	2004	2005	2006	2007	2008	2009	2010
Impact factor	2.105	-	-	-	-	-	2.471	4.294
Ranking Scientific field: Physics, Atomic, Molecular & Chemical	9/33	-	-	-	-	-	11/33	4/33
Category	LIJ						OIJ	OIJ

Source: Authors own work based on Journal Citation Reports

As one can see from the Table 3, IFs for the publication years 2004, 2005, 2006, 2007, and 2008 are missing. The following rule applies to this situation:

Rule 3. If a journal has no IF(s) needed for determining its category for a publication year, then the most beneficial category from a three-year period (one year prior to publication year, publication year, and one year following the publication year or two years prior to the publication year, and the publication year) shall be assigned to the journal for this publication year.

By applying Rule 3 to the journal from Table 3, the journal receives category Leading international journal for the years 2004, 2005, and category Outstanding international journal for the year 2008, but the category for the years 2006 and 2007 still remains indeterminate.

As already said, data on IFs does not exist for any journal in publication years 1989-1991 and 1993-1997, and for journals of social sciences also for the publication year 1992. Table 4 shows the two-year example (impact factors and rankings obtained by applying first three rules) for the journal Essays in Biochemistry for the publication period 1988-1998.

Table 4 Data on the journal Essays in Biochemistry

Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Impact factor	3.556	-	-	-	-	-	-	-	-	-	0.905
Ranking Scientific field: Biochemistry & Molecular Biology	27/151	-	-	-	-	-	-	-	-	-	214/295
Category	LIJ	LIJ	LIJ							IJ	IJ

Source: Authors own work based on Journal Citation Reports

This example shows that, due to an extremely wide IF gap, application of the Rule 3 does not assign category in all publication years. Therefore the following rule applies:

Rule 4. Rule 3 is reapplied for the years 1989 to 1997, including journal categories for subsequent years obtained by the first application of Rule 3. If some publication year(s) from the period 1988-1997 remain afterwards for which a journal still did not receive a category, then a known category from the period 1989-1997 which is the closest one in time to the unresolved publication year shall be assigned for unresolved publication year. If two different categories exist at the same time distance for a publication year, then the higher one shall be assigned for this publication year.

By applying the Rule 4 to the journal from the Table 4, publication years 1989, 1990, 1991, 1992, 1993 and 1994 receive the category Leading international journal, while the publication years 1995, 1996 and 1997 receive the category International journal.

After applying rules 1 to 4, only those journals remain that are missing IFs for the time spans 1989-1991 and 1993-1997, and for the years 1985, 1986,1987, 1988, 1992, 1998, 1999.

The following rule applies to the journals that have not received some category after applying all former rules:

Rule 5. If, after applying rules 1, 2, 3 and 4, publication years with missing category still remain, then the national journal category is assigned to these publication years.

Evaluation of journal articles. Once the journal categorization is done, the task remains to evaluate articles that are published in these journals. Diverse rules can also be applied for that purpose. Since it is a common practice that some time passes between article submission and its publication, it is reasonable to apply rules that consider journal's category holding for the years preceding the year when the article was published. Also, an article can contribute to increasing journal's category for the years subsequent to the publication year of this particular article. For these reasons, the following rule is suggested for article's evaluation:

Rule 6. If the article is published in a journal which has IF for each year from a three-year period (one year prior to publication year, publication year, and one year following the publication year or two years prior to the publication year, and the publication year), the article SHALL receive the highest journal's category from this period; otherwise the article will receive journal's category for publication year.

Application of the proposed rules serves for categorization of the articles published in scientific journals. By the Rulebook of Serbian Ministry of Education and Science, effective score which is assigned to each article's author/coauthor is calculated following the rules defined for each scientific field by the Competence Commission in charge for this particular scientific field. CRIS UNS service also enables these scores calculations.

4.1. Categorizing Journals without IF

The formerly defined rules apply to all journals that have received some impact factor for at least one publishing period. Other journals' categories recognized by Serbian Ministry of Education and Science sorted by descending ranks are:

- National journal of international importance;
- Leading national journal;
- National journal;
- Scientific journal.

The category National journal of international importance is assigned to a journal based on the decree issued by the Ministry. The lists of the categorized journals for each scientific field are published annually by the Ministerial Commissions of Competence. For the scientific field Mathematics, Computer science, and Mechanics these lists are available for all years starting with the year 2009 and for these years categories are assigned by simply applying these lists. For the years missing such lists it is necessary to define additional rule for assigning the category. The following rule is proposed by this article:

Rule 7. Journals that have received the category National journal of international importance at least for one publication year belonging to the period 2009-2011 shall receive the category Leading national journal for all preceding publication years. Other journals from the list (those categorized as Leading national journal, National journal or Scientific journal) shall receive the highest category from the period 2009-2011.

Application of the proposed rules can be automated as done in the system CRS UNS. Naturally, an authorized body can change this automatically determined categorization based on the expertise opinion or by applying some other bibliometric indicators, provided that publicly available argumentation is provided for each category change.

If a journal receives IF (enters the SCI list), it will be re-categorized following applicable rules. If this re-categorization results in multiple unequal categories of the journal for some publication years, the highest of these multiple categories will be assigned to the journal.

5. Illustrative Examples

This section presents two illustrative evaluation examples for journal articles carried out by application of the rules presented in previous section, and the rules for calculating the total score assigned to a published result according to the Evaluation Rulebook of Serbian Ministry of Education and Science.

The first example presents evaluation of the results scored in the journal Scientometrics, publication year 2007.

Journal rank based on impact factor can be determined within each scientific field to which a journal belongs. Table 2 (section 4.1) presents the two-year impact factors of Scientometrics for the period 2001-2009. According to the rules described in section 4, this journal's category for the year 2007 is Leading international journal (Table 1).

Table 5 presents evaluation report for the three research results scored in Scientometrics journal in publication year 2007. Here, codes (M21, M25 and M27) denote the type of the achieved result (original research article, book review, and editor-in-chief duty for one publishing year respectively) while the numerical values in Table 5 are scores assigned to a corresponding result for the journal of the corresponding category.

Table 5 Evaluation results – Example 1

Evaluated results:	Code	Score
Original research article published in leading international journal	M21	8
Book review published in outstanding international journal	M25	1.5
Editor-in-chief of an outstanding international journal	M27	3

Source: Authors

The second example illustrates evaluation of the results scored in the journal Novi Sad Journal of Mathematics, publication year 2007.

This journal has no impact factor, but it is categorized as Leading national journal for the publication year 2009 by the Competence Commission for the scientific field Mathematics, Computer science, and Mechanics.

Table 6 presents evaluation report for the two research results scored in Novi Sad Journal of Mathematics journal for 2007.

Table 6 Evaluation results – Example 2

Evaluated results:	Code	Score
Article published in leading national journal	M51	2
Editor –in-chief of leading national journal	M55	2

Source: Authors

6. Conclusion

IF based evaluation of scientific journals is considered in this article. The findings are that comprehensive and consistent IF based evaluation requires definitions of the rules for determining journal category in the following cases:

1. publication years when the journal's IF exists,
2. publication years prior to the year 1981,
3. publication years with no journal's IF available, but such that these publication years are close to the years for which IFs are available,
4. publication years from 1989 to 1997,
5. all publication years not covered by above cases.

Rules for evaluating scientific results scored in journals are proposed for the scientific field Mathematics, Computer Science, and Mechanics.

CRIS UNS rule books applying to all departments of the Faculty of Science (Department of Mathematics and Informatics, Department of Physics, Department of Chemistry and Environmental Protection, and Department of Geography, Tourism and Hotel Management) are implemented within the software system. These rulebooks are used for generating various reports needed for the faculty accreditation and for generating the report called Researcher Record for individual researchers that are affiliated with the Faculty.

The software system also provides a public electronic service aimed at evaluation of the research results scored in scientific journals by applying different rulebooks.

Analogously to the rules proposed for the scientific field mathematics, Computer Science, and Mechanics the rules for other scientific fields could be defined and for the majority of scientific fields the rules proposed in this article are acceptable. Diverse rulebooks can be accepted for diverse scientific fields and for diverse purposes.

Further research is planned towards modelling evaluation of other forms of published research results (monographic publications, technical solutions, etc.) and development of the software supporting application of these evaluation models within the system CRS UNS.

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Dušan Surla
University of Novi Sad
Faculty of Sciences
Trg Dositeja Obradovića 4
21000 Novi Sad
Serbia
Email: surla@uns.ac.rs

Dragan Ivanović
University of Novi Sad
Faculty of Technical Sciences
Trg Dositeja Obradovića 6
21000 Novi Sad
Serbia
Email: chenejac@uns.ac.rs

Zora Konjović
University of Novi Sad
Faculty of Technical Sciences
Trg Dositeja Obradovića 6
21000 Novi Sad
Serbia
Email: ftn_zora@uns.ac.rs

Miloš Racković
University of Novi Sad
Faculty of Sciences
Trg Dositeja Obradovića 4
21000 Novi Sad
Serbia
Email: rackovic@dmi.uns.ac.rs