Research Article

Impact of Journals and Academic Reputations of Authors: A Structured Bibliometric Survey of the IEEE Publication Galaxy

—FLAVIO CANAVERO, FELLOW, IEEE, FIORENZO FRANCESCHINI, DOMENICO MAISANO, AND LUCA MASTROGIACOMO

***Abstract*—Research problem:** *This study explores the use of bibliometric indicators to objectively evaluate IEEE scientific journals from two different perspectives: (1) journal impact and diffusion and (2) the academic reputation of journal authors.* **Research questions:** *(1) Which journals are better at selecting articles with high scientific impact (measured by average citations per article), and publishing authors with strong reputations (measured by h-indices)? (2) Does the impact of journal articles correlate positively with the reputations of their authors? and (3) Can bibliometric indicators provide a simple way for journal editors to monitor journal performance in a manner complementary to traditional ISI impact factor (IF)?* **Literature review:** *This paper reviews literature on citation analysis, a bibliometric method of measuring impact based on the number of times a work is cited, and explains such bibliometric indicators as* CPP*, Hirsch index, and IF which measure the impact of a journal, and introduces a new indicator called h-spectrum to objectively measure the reputation of a journal's author group.* **Methodology:** *This quantitative study performed citation analysis on 250,000 authors in 110 IEEE journals using citation statistics from the Google Scholar, Web of Science, and Scopus databases to construct the h-spectrum indicator. The authors used automated filtering techniques to exclude questionable author data.* **Results and conclusions:** *The first phase of analysis indicated significant differences among IEEE publications in journal impact, and found that the h-index and* CPP *were suitable for evaluating journals except in their most recent five years where annual rankings are proposed instead. The second phase of analysis found that h-spectra distributions of author reputation differ among journals in a single year, and are generally stable for a single journal over five years. Maps were constructed to locate journals graphically based on the complementary indicators of impact and reputation, and to show changes in impact and reputation over time. The maps indicated that journals with high impact tend to have authors with high reputations but the opposite is not necessarily true. Suggestions were made to explain different combinations of high and low impact and reputation for journals. The use of maps complements IF and provides a simple tool to monitor journal reputation at the time of most recent publication. The study is limited by assumptions about the value of citations, the reliability of search engine statistics, and the homogeneity of IEEE journal citation practices, as well as the failure to account for coauthors, article age, and authors who publish multiple times per year in the same journal. Future research could examine non-IEEE journals and normalize subfields within IEEE journals to avoid favoring fields that use more citations.*

Index Terms*—Academic research output, bibliometrics, citations, Hirsch index, Hirsch spectrum, IEEE journal, impact factor (IF), journal authors.*

INTRODUCTION

The continuing increase in scientific journals presents a challenge for researchers and practitioners in monitoring and evaluating the scientific impact of each journal, and the reputation of its authors.

Some criteria for evaluating a scientific journal, such as its circulation, or the prestige of its editorial board or its authors, are subjective and not reliable. In contrast, bibliometric indicators, based on citation statistics, are a more objective tool for ranking scientific journals [1]–[4]. Two types of bibliometric indicators are "journal diffusion/impact" based on the citations received by journal articles, and "academic reputation of journal authors" based on the authors' overall research output. The link between the diffusion of journal articles and their impact on the scientific community is described in [5], and indicators of journal diffusion/impact are widely used and debated in the literature [6]–[9]. In contrast, indicators of the academic reputation of journal authors are more recent [10]. Both sets of indicators are based on citation statistics and should not be used to compare journals from disciplines that use different citation practices [3].

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The authors are with the Politecnico di Torino—DET and DIGEP, Corso Duca degli Abruzzi 24, Torino 10129, Italy (email: flavio.canavero@polito.it; fiorenzo.franceschini@polito.it; domenico.maisano@polito.it; luca.mastrogiacomo@polito.it).

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This study uses bibliometric indicators to analyze the "galaxy" of IEEE journals to answer the following research questions:

(4) Which journals are better at selecting articles with high scientific impact (measured by average citations per article), and publishing authors with strong reputations (measured by h-indices)?
(5) Does the impact of journal articles correlate positively with the reputations of their authors?
(6) Can bibliometric indicators provide a simple way for journal editors to monitor journal performance in a manner complementary to traditional ISI impact factor (IF)?

This study not only describes a novel quantitative and objective methodology for evaluating the reputation of journal authors, but also establishes a large data set for more complex evaluations of IEEE journals.

Literature Review

This section reviews the literature relevant to bibliometric indicators, by explaining how the literature was selected, describing the theoretical orientation of the review, then illustrating the indicators used in each of the two phases of the study.

How Literature Was Selected When selecting references from the literature, priority was given to the most recent contributions of eminent bibliometricians in the major international peer-reviewed journals. Additional references appear throughout this paper to support analyses or observations.

Theoretical Orientation This study is based on one of the most widely used methods of bibliometrics called citation analysis. Citation analysis is an objective method of determining a journal's impact (by measuring the number of times a work is cited), or the breadth of fields cited in a journal [16]. Citation analysis requires a researcher to choose a population of articles, then determine how many times each article is cited by other works. The works citing the articles may be separated into categories, such as articles, conferences, books, periodicals, or electronic dissertations, and the researcher may assign a weighted value to each category. Each article is then ranked by its overall score. A closer examination of the mathematical basis underlying bibliometric indicators is presented in [13] and [14]. Citation studies are primarily used to assess the development of a field, or the impact of an article or author, but may also be used to determine a quality ranking for journals through impact analysis.

Despite the limitations of citation analysis discussed in [16], the approach has become widely accepted in the scientific community because other methods, such as peer review, are not practical for large-scale evaluations of hundreds or thousands of articles, and may lack objectivity. Citation analysis is also often used by universities in competitive examinations for research positions and promotions, and by government organizations for the allocation of funds to research groups and institutions.

Indicators for the First Phase of Analysis
This section describes three popular groups of bibliometric indicators used to assess the citation impact of scientific articles: P, C, and CPP; h-index; and ISI IF. These indicators are available from bibliometric search engines, such as Web of Science (WoS), Scopus, and Google Scholar (GS), and do not require calculations [9], [18], [19].

P, C, and CPP: CPP indicates the average impact of a journal's articles by calculating the average number of citations per article. CPP is used to compare journals regardless of differences in the number of articles or issues they publish per year. CPP is calculated by dividing C by P, where C is the total number of citations received by the articles in a specified amount of time, and P is the total number of articles.

h-Index: The h-index, or Hirsch Index, is a recent indicator for evaluating the scientific impact of an author based on citations. The greater the value of h, the greater the impact of the author in the scientific community. For a given author, h is defined as the number such that h articles received at least h citations, while the author's other articles received no more than h citations [7], [20].

A peculiarity of the h-index is that it cannot decrease with time because it synthesizes the number of articles and the corresponding number of citations. The h-index of an author who retires will remain constant, or will increase if published articles accumulate new citations, and when comparing scholars with different seniority, the h-index will favor those with longer careers [34].

The h-index is a simple, synthetic, and robust indicator [21]–[29], and there are many proposals for new variants and improvements [10], [30]–[35].

Braun et al. [31] propose using the h-index for evaluating and comparing scientific journals by examining the articles published by the journals in a specific publication period. For a group of articles published by a given journal in a specific time period, *h-for-journal* (h_J) is defined as the number such that h_J articles received at least h_J citations while the other articles received no more than h_J citations.

ISI IF: IF is an indicator of "mean citedness" similar to CPP, and was created in the 1960s to measure the value of scientific journals. For a given journal and year, IF is the average number of citations to articles published by the journal during the preceding two years, by all articles published in the given year [36]. IF is often misused [6] by generalizing the superiority of a journal's IF to the individual articles, people, programs, or even disciplines featured in that journal. Although the IF of journal A may be greater than that of journal B, an article or author in journal A is not necessarily superior to an article or author in journal B.

IF values are calculated only for the "ISI journals" indexed by the WoS, and are reported annually in the Journal Citation Reports (JCR) by Thomson Scientific [9]. Most IEEE journals are ISI journals.

Indicators for the Second Phase of Analysis Other methods to assess journal reputation consider circulation, rejection rate, prestige of the editorial board, or expert-opinion surveys [15]. In contrast, this paper uses an indicator characterized by objectivity and transparency: h-spectrum.

h-Spectrum: h-spectrum is a bibliometric indicator for the reputation of authors in a scientific journal, with reputation meaning the capacity to produce scientific articles of impact. Given a specific journal and publication period, h-spectrum is defined as the distribution of h-index values for the authors and coauthors of that journal [10]. Several indicators can be associated with the h-spectrum: the average $(\bar{h})$ and the median $(\tilde{h})$ as indicators of central tendency; and the corresponding standard deviation (s) and interquartile range (IQR) as indicators of dispersion. The term "spectrum" was chosen because the distribution provides an image of a journal's author population for a precise time period.

METHODOLOGY

This section explains our choice of research methodology, our methods of data collection and data analysis, related limitations, and our efforts to ensure validity and generalizability.

Choice of Research Methodology We chose citation analysis for a number of reasons: this large-scale study examines more than 100 journals with approximately 250,000 authors; citation analysis complements other approaches based on circulation, acceptance/rejection rate, expert-opinion surveys, or content analysis (see [15] and [38]–[40]), and citation analysis is simple and can be translated into an objective, algorithmic procedure.

We collected citation statistics (apart from IF) from the GS search engine for three reasons: in contrast to its competition, GS is freeware; GS coverage is probably higher than the WoS and Scopus databases because GS includes additional materials, such as monographs, book chapters, dissertations, conference articles, and journal articles published in non-ISI and open access journals [43], [57], [58]; and GS can be automatically queried through software such as Publish or Perish, or other ad-hoc applications, which are more difficult to adapt to other databases [18].

GS is generally less accurate than other bibliometric databases, such as WoS or Scopus; however, data were automatically checked and cleaned to eliminate the most common database mistakes [41], [42], as described later in this section.

Data Collection Input data for querying GS were obtained from the IEEE Xplore and WoS databases, as illustrated in Fig. 1 and explained as follows.

(1) The IEEE Xplore search engine was used to select 110 IEEE journals (excluding magazines) [44] as set out in Table I. IEEE journals are historically classified in several categories: (J) journals, (L) letters, (R) review journals, (O) online journals, (T) transactions, and (X) other journals. This classification raises another research question: Is there any systematic difference in bibliometric indicators among journal categories?
(2) Indicators for the first phase of analysis were obtained from GS for the annual values of P, C, CPP, h_J, and from WoS for the annual values of IF. Indicators obtained from GS were collected for the 21 consecutive years from 1990 to 2010, while indicators for IF were limited to the four consecutive years from 2006 to 2009.

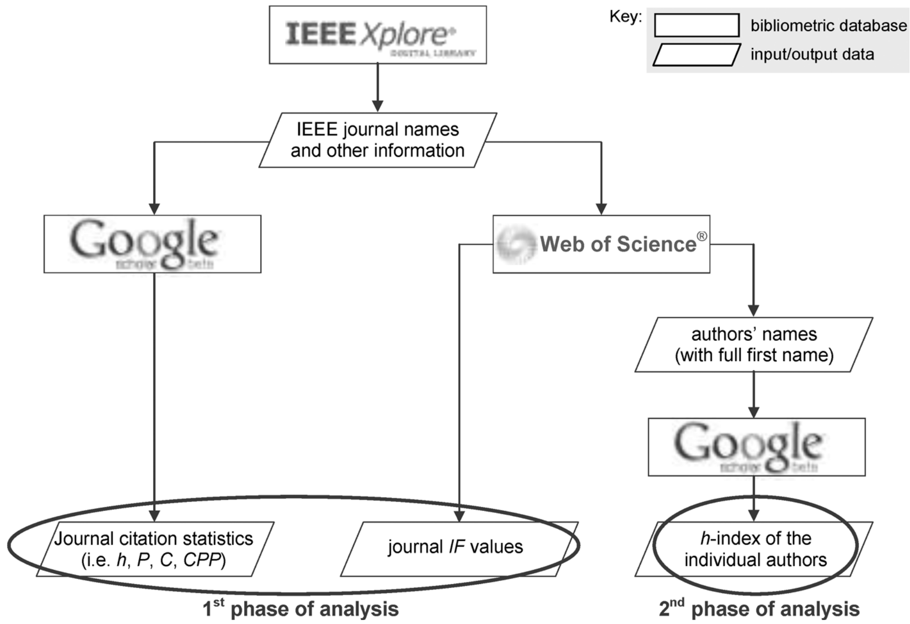


Fig. 1. Flowchart representing the sequence of actions to collect citation statistics for the analysis. Three databases (i.e., IEEE Xplore, WoS, and GS) were used in a combined way.

(3) For the second phase, we collected citation statistics about the journal (co)authors to calculate their individual h-indices for the five consecutive years from 2006 to 2010. This time period is significantly smaller than the first group of indicators due to the higher complexity in data collection.

A crucial problem in the second phase of analysis arose from "homonym authors," those with common names, or those identified only by surname and first name initials. Contributions of different homonym authors could be erroneously added up to inflate one author's h-index.

For most IEEE journals, IEEE Xplore reports only first name initials, and the only way to find full first names is to manually examine each article's PDF to extract the name from the document heading; this procedure is unsustainable for hundreds of thousands of authors. To automate this procedure, we used the WoS database because, with rare exceptions, it provides authors' full first name(s). The complete list of authors' names was used to query GS to obtain their individual citation statistics.

Data Analysis The values of the C, CPP, h-index, and IF indicators are reported by bibliometric databases. The objective of the analysis is to construct the h-spectrum indicator.

For simplicity, h-spectra are constructed according to the following assumptions and conventions:

- All (co)authors in a journal have the same importance, so their h-indices are not weighted in inverse proportion to the number of (co)authors of the corresponding paper(s);
- The h-index of an author who publishes more than one paper in a journal during the period of interest is counted only once;
- When calculating a journal's h-spectrum, two parameters must be stated: (1) the period of interest in which the journal authors are identified (e.g., the whole year 2009); and (2) the precise moment in which author h-indices are calculated (in our case, August 2010). The h-index of each author is calculated based on the scientific articles and citations accumulated at the time of data collection. As previously mentioned, the h-index of an author tends to increase over time because of the gradual accumulation of articles and citations. The analysis could be developed to consider the articles and citations accumulated up to the journal publication date, excluding subsequent ones, but the average growth rate of the h-index over time is relatively small (particularly in engineering disciplines), so the variations in h-spectra would be limited [33].

TABLE I
LIST OF THE 110 IEEE JOURNALS SELECTED FOR THE ANALYSIS, REPORTING THE JOURNAL CATEGORY, TITLE, START YEAR, AND NUMBER OF ANNUAL ISSUES. JOURNALS OF THE SAME CATEGORY ARE SORTED ALPHABETICALLY WITH RESPECT TO THE TITLE. ALSO, WE SPECIFY IF A JOURNAL IS INDEXED BY WOS AND GS AND, IN THE LAST TWO COLUMNS, WE INDICATE THE PART OF ANALYSIS (FIRST OR SECOND PHASE) THAT WAS POSSIBLE TO CARRY OUT

Journal category	Journal title	Abbr.	Start year	Issues	Indexed by WoS	Indexed by GS	1st ph.	2nd ph.
Journals/magazines	IEEE Computer Graphics and Applications	J1	1981	6	Yes	Yes	Yes	Yes
Journals/magazines	IEEE Intelligent Systems (and their Applications)	J2	1998	6	Yes	Yes	Yes	Yes
Journals/magazines	IEEE Journal of Oceanic Engineering	J3	1976	4	Yes	Yes	Yes	Yes
Journals/magazines	IEEE Journal of Quantum Electronics	J4	1965	12	Yes	Yes	Yes	Yes
Journals/magazines	IEEE Journal of Solid-State Circuits	J5	1966	12	Yes	Yes	Yes	Yes
Journals/magazines	IEEE Micro	J6	1981	6	Yes	Yes	Yes	Yes
Journals/magazines	IEEE Multimedia	J7	1994	4	Yes	Yes	Yes	Yes
Journals/magazines	IEEE Pervasive Computing	J8	2002	4	Yes	Yes	Yes	Yes
Journals/magazines	IEEE Sensors Journal	J9	2001	12	Yes	Yes	Yes	Yes
Journals/magazines	IEEE Systems Journal	J10	2007	4	Yes	Yes	Yes	Yes
Journals/magazines	Journal of Display Technology	J11	2005	4	Yes	Yes	Yes	Yes
Journals/magazines	Journal of Lightwave Technology	J12	1983	24	Yes	Yes	Yes	Yes
Journals/magazines	Journal of Microelectromechanical Systems	J13	1992	6	Yes	Yes	Yes	Yes
Letters	IEEE Antennas and Wireless Propagation Letters	L1	2002	1	Yes	Yes	Yes	Yes
Letters	IEEE Communications Letters	L2	1997	12	Yes	Yes	Yes	Yes
Letters	IEEE Computer Architecture Letters	L3	2002	24	No	Partially	Yes	No
Letters	IEEE Electron Device Letters	L4	1980	12	Yes	Yes	Yes	Yes
Letters	IEEE Geoscience and Remote Sensing Letters	L5	2004	4	Yes	Partially	Yes	Yes
Letters	IEEE Microwave and Wireless Components Letters	L6	2001	12	Yes	Yes	Yes	Yes
Letters	IEEE Photonics Technology Letters	L7	1989	24	Yes	Yes	Yes	Yes
Letters	IEEE Signal Processing Letters	L8	1994	12	Yes	Partially	Yes	Yes
Letters	IEEE Transactions on Circuits and Systems II: Express Briefs	L9	2004	12	Yes	Partially	Yes	Yes
On-line Journal	IEEE Communications Surveys & Tutorials	O1	1998	4	No	Partially	Yes	No
On-line Journal	IEEE Internet Computing	O2	1997	6	Yes	Yes	Yes	Yes
Review	IEEE Engineering Management Review	R1	1973	4	No	Partially	Yes	No
Review	IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing	R2	2008	4	Yes	No	No[2]	Yes
Review	IEEE Journal of Selected Topics in Quantum Electronics	R3	1995	6	Yes	Yes	Yes	Yes
Review	IEEE Journal of Selected Topics in Signal Processing	R4	2007	6	Yes	Yes	Yes	Yes
Review	IEEE Journal on Selected Areas in Communications	R5	1983	12	Yes	Yes	Yes	Yes
Review	IEEE Reviews in Biomedical Engineering	R6	2008	1	No	Yes	Yes	No
Review	Proceedings of the IEEE	R7	1963	12	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Advanced Packaging	T1	1999	4	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Aerospace	T2	1965	4	Yes	Yes	Yes	Yes

The resulting output data, particularly those concerning the second analysis phase, were then automatically cleaned on the basis of several criteria described in more detail in [45]:

TABLE I (Continued)

	and Electronic Systems							
Transactions	IEEE Transactions on Antennas and Propagation	T3	1963	12	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Applied Superconductivity	T4	1991	6	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Audio, Speech, and Language Processing	T5	2006	8	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Automatic Control	T6	1963	12	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Automation Science and Engineering	T7	2004	4	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Biomedical Circuits and Systems	T8	2007	6	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Biomedical Engineering	T9	1964	12	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Broadcasting	T10	1963	4	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Circuits and Systems for Video Technology	T11	1991	12	Yes	Partially	Yes	Yes
Transactions	IEEE Transactions on Circuits and Systems I: Regular Papers	T12	2004	12	Yes	Partially	Yes	Yes
Transactions	IEEE Transactions on Communications	T13	1972	12	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Components and Packaging Technologies	T14	1999	2	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems	T15	1982	12	Yes	No	No[2]	Yes
Transactions	IEEE Transactions on Computers	T16	1968	12	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Consumer Electronics	T17	1975	4	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Control Systems Technology	T18	1993	6	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Dependable and Secure Computing	T19	2004	4	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Device and Materials Reliability	T20	2001	4	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Dielectrics and Electrical Insulation	T21	1994	6	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Education	T22	1963	4	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Electromagnetic Compatibility	T23	1964	4	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Electron Devices	T24	1954	12	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Electronics Packaging Manufacturing	T25	1999	2	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Energy Conversion	T26	1988	4	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Engineering Management	T27	1988	2	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Evolutionary Computation	T28	1997	6	Yes[1]	Yes	Yes	No
Transactions	IEEE Transactions on Fuzzy Systems	T29	1993	6	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Geoscience and Remote Sensing	T30	1980	12	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Haptics	T31	2008	4	No	Partially	Yes	No
Transactions	IEEE Transactions on Image Processing	T32	1992	12	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Industrial Electronics	T33	1982	12	Yes	Yes	Yes	Yes

- Remove common US and Chinese family names. We used dictionaries of common US and Chinese names and removed corresponding cases such as “Smith” or “Chang.” These cases are especially likely to be ambiguous;
- Remove last names with fewer than five characters. Very short names such as “Mata” or “Tsai” were removed. This filter removes additional names of Asian origins, for which disambiguation is a serious problem, and

TABLE I (Continued)

Journal category	Journal title	Abbr.	Start year	Issues	Indexed by WoS	Indexed by GS	1st ph.	2nd ph.
Transactions	IEEE Transactions on Industrial Informatics	T34	2005	4	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Industry Applications	T35	1972	6	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Information Forensics and Security	T36	2006	4	Yes	Partially	Yes	Yes
Transactions	IEEE Transactions on Information Technology in Biomedicine	T37	1997	6	Yes[1]	Yes	Yes	No
Transactions	IEEE Transactions on Information Theory	T38	1963	12	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Instrumentation and Measurement	T39	1963	12	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Intelligent Transportation Systems	T40	2000	6	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Knowledge and Data Engineering	T41	1989	12	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Learning Technologies	T42	2008	4	No	Partially	Yes	No
Transactions	IEEE Transactions on Magnetics	T43	1965	12	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Medical Imaging	T44	1982	12	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Microwave Theory and Techniques	T45	1963	12	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Mobile Computing	T46	2002	6	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Multimedia	T47	1999	8	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on NanoBioscience	T48	2002	4	Yes	Partially	Yes	Yes
Transactions	IEEE Transactions on Nanotechnology	T49	2002	6	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Network and Service Management	T50	2004	2	No	Partially	Yes	No
Transactions	IEEE Transactions on Neural Networks	T51	1990	12	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Neural Systems and Rehabilitation Engineering	T52	2001	6	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Nuclear Science	T53	1963	18	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Parallel and Distributed Systems	T54	1990	12	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Pattern Analysis and Machine Intelligence	T55	1988	12	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Plasma Science	T56	1973	6	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on	T57	1986	4	Yes	Yes	Yes	Yes

removes some artifacts where a sequence of initials was interpreted as a name;

- Remove authors with h-index >50 and/or P >600. Most of these impressive results were due to the erroneous combination of homonymous authors. While Hirsch has shown that researchers with an h-index≥ 45 are very likely to become members of the US National Academy of Sciences, and Nobel Prize winners [7], our "low pass filter" affects only a small part of the authors examined (about 2%–6%).

TABLE I (Continued)

	Power Delivery							
Transactions	IEEE Transactions on Power Electronics	T58	1987	12	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Power Systems	T59	1986	4	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Professional Communication	T60	1988	4	Partially	Partially	Yes	Yes
Transactions	IEEE Transactions on Reliability	T61	1986	4	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Robotics (and Automation – before 2004)	T62	2004	6	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Semiconductor Manufacturing	T63	1988	4	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Signal Processing	T64	1991	12	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Software Engineering	T65	1976	12	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Systems, Man and Cybernetics, Part A: Systems and Humans	T66	1996	6	Yes	No	No[2]	Yes
Transactions	IEEE Transactions on Systems, Man, and Cybernetics, Part B: Cybernetics	T67	1996	6	Yes	No	No[2]	Yes
Transactions	IEEE Transactions on Systems, Man, and Cybernetics, Part C: Applications and Reviews	T68	1998	6	Yes	No	No[2]	Yes
Transactions	IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control	T69	1986	12	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Vehicular Technology	T70	1967	6	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Very Large Scale Integration (VLSI) Systems	T71	1993	12	Yes[1]	No	No[2]	No
Transactions	IEEE Transactions on Visualization and Computer Graphics	T72	1995	6	Yes	Yes	Yes	Yes
Transactions	IEEE Transactions on Wireless Communications	T73	2002	6	Yes	Yes	Yes	Yes
Transactions	IEEE/ACM Transactions on Computational Biology and Bioinformatics	T74	2004	6	Yes	Yes	Yes	Yes
Transactions	IEEE/ACM Transactions on Networking	T75	1993	6	Yes	Yes	Yes	Yes
Transactions	IEEE/ASME Transactions on Mechatronics	T76	1996	6	Yes	Yes	Yes	Yes
Others	Canadian Journal of Electrical and Computer Engineering-Revue Canadienne de Genie Electrique et Informatique	X1	2003	4	Yes	No	No[2]	Yes
Others	IEEE Annals of the History of Computing	X2	1979	2	Yes	Yes	Yes	Yes
Others	IEEE Latin America Transactions	X3	2003	4	Yes[1]	Yes	Yes	No

Notes:

(1) for these journals it was not possible to collect authors' full first name(s) from WoS (initials only), thus the second phase of analysis is missing;

(2) apart from *IF*, for these journals it was not possible to collect the other indicators relating to the first phase (i.e. the annual h_J, P, C, CPP), because they are not indexed by GS.

On average, we excluded around 45% of the total number of authors to reduce the risk of distorting the second phase of the analysis. Considering the large amount of data available (around 250,000 authors) the statistical sample remains reasonably significant. A possible way to overcome the problem of author disambiguation would be to associate a unique identifier to each author [46].

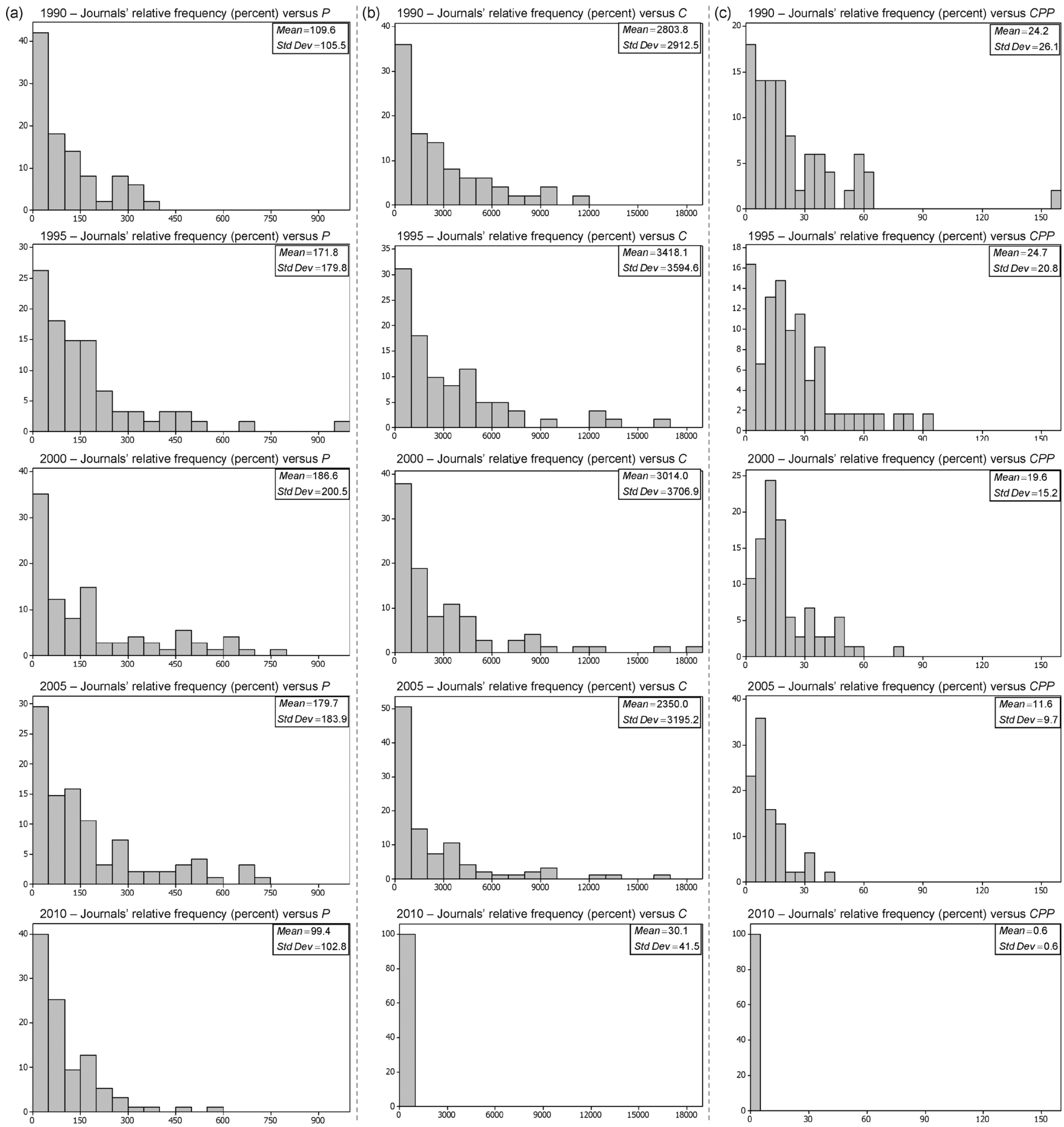


Fig. 2. Histograms relating to values of P (column a), C (column b) and CPP (column c), associated with the IEEE journals, for five (i.e., 1990, 1995, 2000, 2005, and 2010) of the 21 years examined. For each histogram, the mean value and the standard deviation relating to the indicator of interest are reported in the top-right square.

Limitations Some potential database mistakes cannot be avoided through automated cleaning and filtering of data, and would require manual filtering, an unreasonable approach for such a large sample; for example, in the first phase of analysis, some IEEE journals had the same name as international symposia, conferences, or workshops, allowing some proceedings papers to be confused with journal articles.

Although we analyzed all 110 journals listed in Table I, it was not possible at the moment of the analysis to obtain complete data for some journals for several reasons:

- Some journals were not indexed by WoS and/or GS.
- For some journals indexed by GS, it was not possible to obtain the complete list of coauthors with full first name(s), even from WoS.

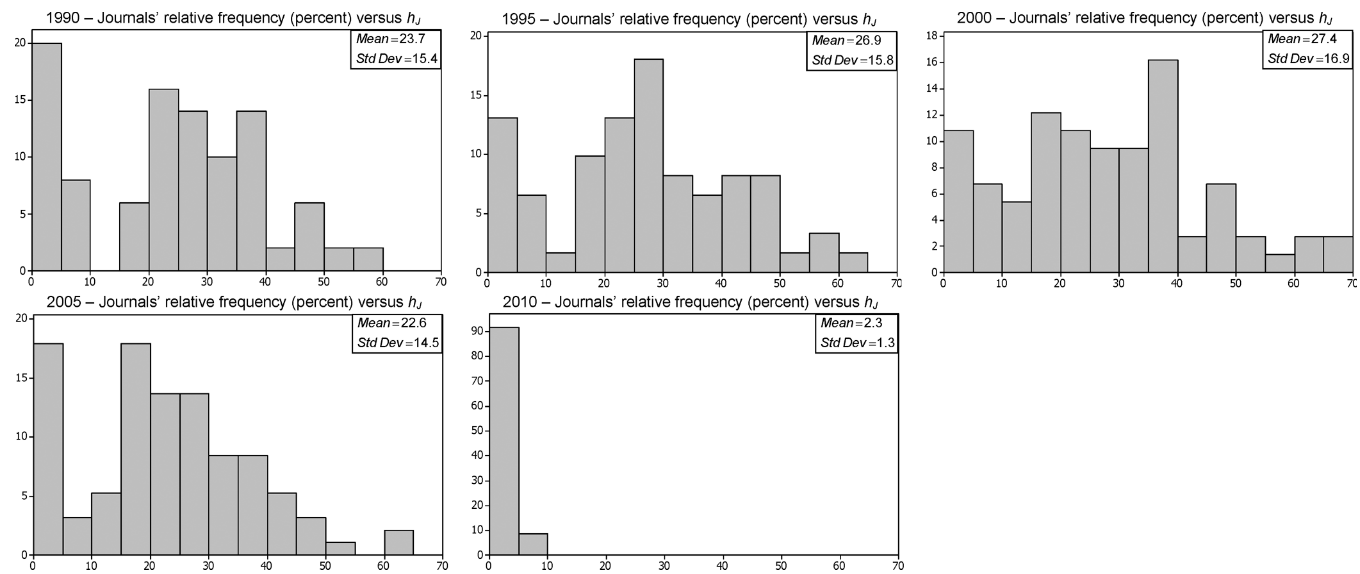


Fig. 3. Histograms relating to h_J values associated with the IEEE journals for five (i.e., 1990, 1995, 2000, 2005, and 2010) of the 21 years examined. For each histogram, the mean value and the standard deviation are reported in the top-right square.

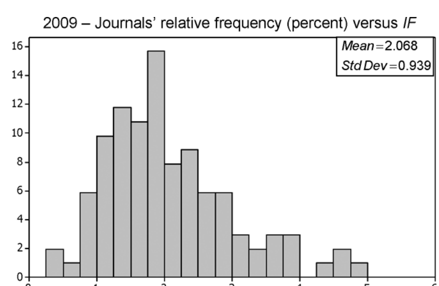


Fig. 4. Histogram relating to IF values associated with the IEEE journals, considering the year 2009 only. The mean value and the standard deviation are reported in the top-right square.

- Some journals were only partially indexed by GS and, for some years, data were missing or incomplete.
- Some journals were very recent and analysis was limited to their relatively few years of activity.

Details about the journals that were missing from the reference databases are reported in the last four columns of Table I. The last two columns indicate which of the first or second phases of analysis that we could perform. For some journals, they are missing or incomplete.

Apart from IF, which is provided annually by Thompson Scientific in scheduled periods, the other indicators are calculated using citations accumulated up to the moment of analysis (August 2010).

Ensuring Validity and Generalizability Apart from some inevitable distortions, the general validity and generalizability of the data are ensured by our use of conservative, automated filtering techniques, which excluded dubious data from the analysis. The filtering techniques were tested through the manual control of random portions of data. Similar filtering criteria were used in other empirical studies, such as in [13] and [45].

RESULTS

This section describes the results of the first and second phases of analysis, and how they can be synthesized and interpreted, even by nonbibliometricians.

Results of the First Phase of Analysis Complete results of the first phase of analysis for our chosen IEEE journals appear in Table A.1, shown as supplementary material at http://ieeexplore.ieee.org). The results indicate a substantial variability of the indicators, P, C, h_J, CPP and IF, from journal to journal. Figs. 2 and 3 show the histograms for the first four indicators for five of the years examined (1990, 1995, 2000, 2005, and 2010). Fig. 4 shows the histogram related to the IF for the year 2009. These histograms are a useful reference for comparing the position of a single journal against the whole set of IEEE journals: a journal with $CPP = 12$ for 1995 would fall on the 20th percentile of the corresponding CPP distribution. [See Fig. 2(c).]

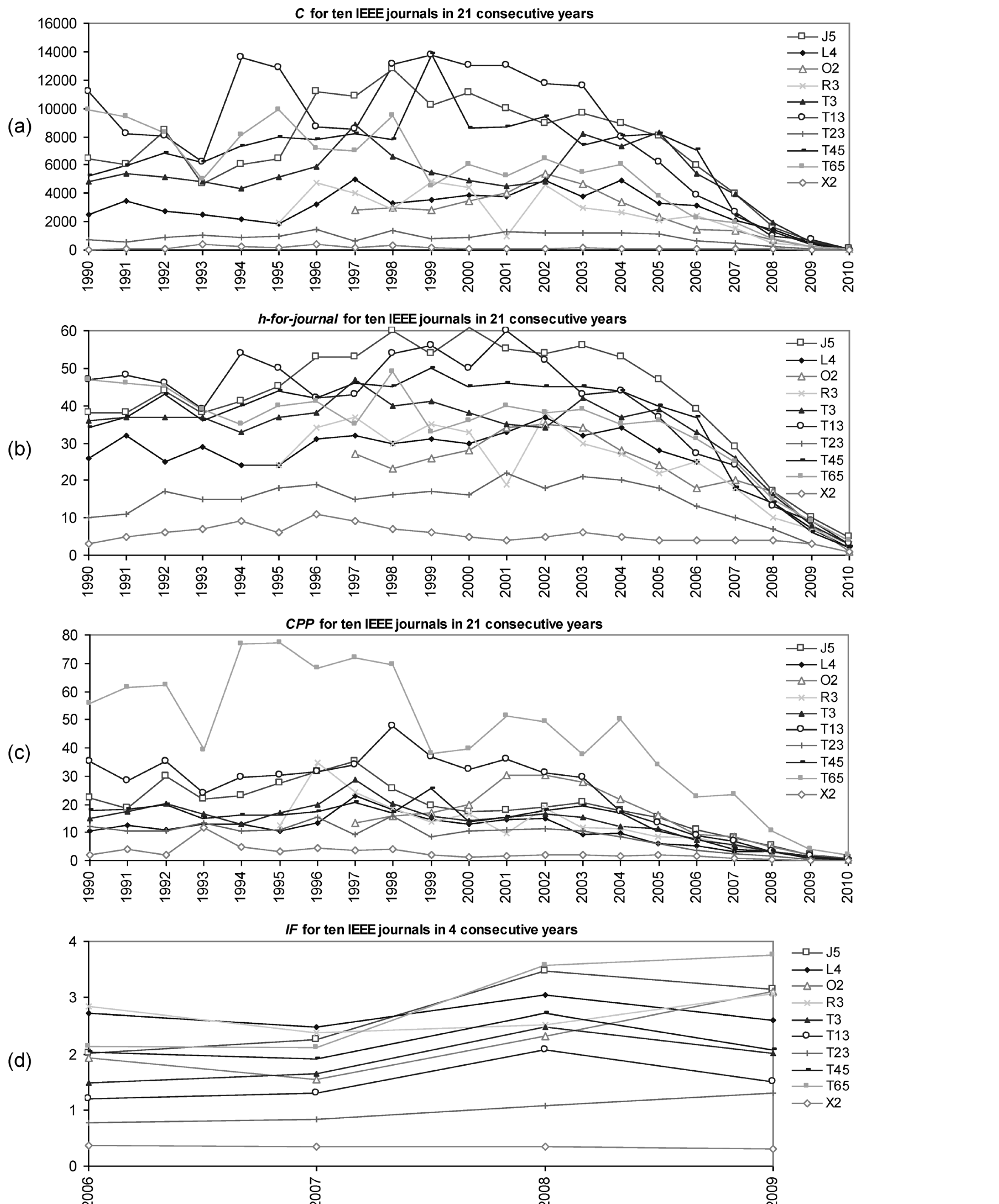
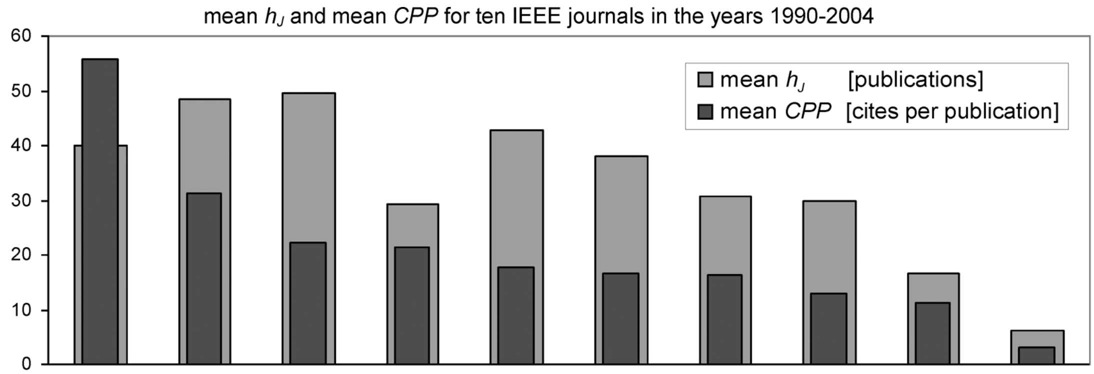


Fig. 5. Diagrams (a)–(c), respectively, show C, h_J, and CPP annual values for ten of the IEEE journals analyzed (see Table I), in 21 consecutive years (1990 to 2010). Diagram (d) shows IF annual values for the same journals, in four consecutive years (2006 to 2009). Apart from IF, which is annually reported in the Thomson Scientific's JCR, the other indicators are calculated, taking into account the citations accumulated up to the moment of the analysis (August 2010).

Temporal profiles are a simple and effective way of representing the indicators for individual journals. Fig. 5 represents the annual values of C, h_J, CPP and IF for a subset of ten IEEE journals (J5, L4, O2, R3, T3, T13, T23, T45, T65, and X2) from Table I. The subset of journals was selected randomly to include at least one journal for each journal category (i.e., J, L, O, R, T, and X). These ten



Journal	T65	T13	J5	O2	T45	T3	R3	L4	T23	X2
mean h_J	39.9	48.5	49.5	29.4	42.8	37.9	30.7	30.0	16.7	6.3
s_h	4.9	5.9	8.1	4.4	4.3	3.5	6.0	3.2	3.3	2.1
mean CPP	55.9	31.4	22.2	21.5	17.7	16.7	16.5	13.0	11.2	3.1
s_{CPP}	14.2	6.6	5.6	6.7	2.8	4.1	7.6	3.0	2.1	2.7

Fig. 6. h_J and CPP mean values and corresponding standard deviations—s_h and s_{CPP}, respectively—for ten IEEE journals, in the years 1990–2004. Journals are sorted in decreasing order according to their CPP mean value. From this diagram, it emerges that journals with a relatively high h_J (indicator of overall impact) are not necessarily as much "efficient" in terms of CPP (indicator of impact of the "average article"). (For example, T65, despite the lower h_J with respect to J5, is much better in terms of CPP.

journals do not differ significantly from the others in any particular aspect.

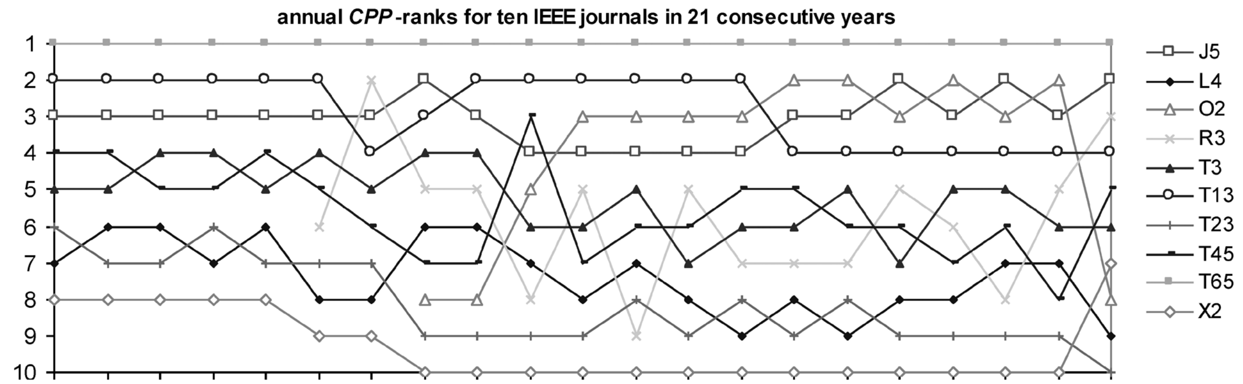
For example, T45 published 544 articles in the year 1999. (See Table A.1, shown as supplementary material at http://ieeexplore.ieee.org.) In this year, its h-index is 50, meaning that the 50 most cited articles published in T45 have received at least 50 citations each. On average, journals with the highest profiles of h_J and C are T13, J5, and T45.

h_J and C have quite similar patterns. Regarding the scientific production of one scholar, Hirsch empirically showed that C is approximately proportional to h^2 [7]. Considering data reported in Table A.1, this behavior applies to h_J as well, with an empirical correlation between C and h_J and a very high coefficient of determination ($\mathrm{R}^2 \approx 0.96$). h-profiles are relatively less nervous than the corresponding C-profiles, since h_J is more insensitive to the accidental excess of lowly and highly cited articles, and is considered to be a more robust indicator [27]. h_J and C can be used to compare the overall impact of different journals, but if calculated on a yearly basis, they tend to favor journals with many articles or issues per year, and a high number of articles per year does not make one journal better than another. It may be more "bibliometrically efficient" to compare journals according to CPP. For example, J5, despite being one of the highest-ranking journals for most years, in terms of C or h_J (indicators of overall impact), is not quite as high in terms of CPP (indicator of impact of the "average article"). Conversely, the CPP profile of T65 is steadily above the others, although this journal is not the highest in terms of C and h_J values.

The behavior of C, h_J, and CPP in Fig. 5 suggests that the process of accumulating citations requires time to become stable—according to some authors, about five to six years for journals in the engineering field [5], [45]. This "physiological" behavior applies to most of the journals: in the last years from 2005 to 2010, h_J, C, and CPP values tend to become significantly smaller. Thus, these indicators are not suitable to evaluate recently published journals, or to compare them with other older publications.

For most of the IEEE journals (not only those in Fig. 5), IF values gradually increase. The reasons for this inflation are discussed by Althouse et al. [47] and others, and include improved availability of scientific publications, an increasing tendency for journal self-citation, and an increasing tendency of publishers to invite submissions of popular interest, or to include regular review articles.

Apart from the last five to six years, most of the h_J values and CPP values seem relatively stable. Fig. 6 shows the journal h_J (indicator of overall journal impact), CPP mean values, and the corresponding standard deviations (respectively, s_h and s_{CPP}), in the years 1990–2003.



annual rank position	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Avg rank	Overall rank
J5	3	3	3	3	3	3	3	2	3	4	4	4	4	4	3	3	2	3	2	3	2	3.0	3
L4	7	6	6	7	6	8	8	6	6	7	8	7	8	9	8	9	8	8	7	7	9	7.4	8
O2	-	-	-	-	-	-	-	8	8	5	3	3	3	3	2	2	3	2	3	2	8	3.9	4
R3	-	-	-	-	-	6	2	5	5	8	5	9	5	7	7	7	5	6	8	5	3	5.8	7
T3	5	5	4	4	5	4	5	4	4	6	6	5	7	6	6	5	7	5	5	6	6	5.2	5
T13	2	2	2	2	2	2	4	3	2	2	2	2	2	2	4	4	4	4	4	4	4	2.8	2
T23	6	7	7	6	7	7	7	9	9	9	9	8	9	8	9	8	9	9	9	9	10	8.1	9
T45	4	4	5	5	4	5	6	7	7	3	7	6	6	5	5	6	6	7	6	8	5	5.6	6
T65	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.0	1
X2	8	8	8	8	8	9	9	10	10	10	10	10	10	10	10	10	10	10	10	10	7	9.3	10

Fig. 7. Annual ranks relating to CPP values for ten of the IEEE journals analyzed (see Table I), in 21 consecutive years. Different from pure CPP profiles, these profiles are not subject to the "physiological" decrease in the last five to six years, because of the citation accumulation process. However, rankings relating to the last year are more likely to be unstable. A simple confirmation is given by the greater fluctuations in 2010, compared to previous years. The last column of the table reports the overall rank of the journals, constructed according to their average annual ranks ("Avg rank" in the second-to-last column of the table) in the last 21 years analyzed. Indicator values are calculated by taking into account the citations accumulated up to the moment of the analysis (August 2010).

Proposal for Annual Ranking:
Relative annual rankings may address the problem of citation accumulation that affects recent publications. Each year, journals would be sorted in descending order according to one indicator of interest, such as CPP, and assigned an annual Borda's ranking; for more information, see [48] and [49]. Using annual Borda's rankings, the performance of a journal in recent years could be compared with that in past years.

Rankings related to the last five to six years are less robust because they are more likely to change than those from earlier years. Fig. 7 shows CPP annual rankings for the years 1990–2010. This method is very simple but does not adequately consider the year-by-year "gap" among CPP values: for a specific year, the gap between two journals with rank positions 4 and 6 is not necessarily coincident with the gap between positions 1 and 3, a typical problem for indicators based on rankings [50]. Thompson [51] warns that rank positions should not be added or averaged because they are not equal-interval measurements. Leydesdorff [52] considers rankings an improvement over average-based indicators because they do not necessitate any assumption on the type of distribution followed by citations over articles. Analogous annual rankings can be constructed for C, h_J and IF, and extended to the whole set of IEEE journals using data reported in Table A.1.

A rough indication of the overall performance of a journal over the 21-year reference period is its average annual rank ("Avg rank") listed in the second-to-last column in Fig. 7. The last column shows the overall rank of the journals. Analogous overall ranks can be constructed for the entire set of IEEE journals, using data reported in Table A.1. Table II reports the resulting overall ranks in the last five years of analysis from 2006 to 2010, indicating the recent performance of the IEEE journals without being influenced by the accumulation of citations.

Results of the Second Phase of Analysis Fig. 8 shows the global h-spectrum for all 126,958 authors analyzed in the period from 2006 to 2010 using the h-indices of the authors of (at least) one article published in any IEEE journal during that time. The distribution is right-skewed and has a characteristic, approximately decreasing, profile

TABLE II
OVERALL RANKS RELATING TO THE AVERAGE ANNUAL CPP RANKS FOR THE ENTIRE SET OF IEEE JOURNALS, IN THE LAST FIVE YEARS ANALYZED (2006 TO 2010). THIS RANKING IS NOT APPLICABLE TO R2, T15, T66, T67, T68, T71, AND X1. SINCE THESE JOURNALS WERE NOT INDEXED BY GS AT THE MOMENT OF DATA COLLECTION (i.e., August 2010)–SEE TABLE A.1

Overall rank	Journal	Overall rank	Journal	Overall rank	Journal	Overall rank	Journal	Overall rank	Journal	Overall rank	Journal
1	T55	19	J6	37	T30	55	R3	73	T39	91	T25
2	O1	19	T36	38	T37	56	T27	74	L4	92	T23
3	T75	21	T47	39	O2	57	T26	75	T35	93	T20
4	T65	21	T51	40	T40	58	T3	76	L2	94	T56
5	T28	23	T6	41	T34	59	L5	77	T24	95	T12
5	T46	24	T73	42	T13	60	L8	78	L1	96	T4
7	T38	25	T62	43	T59	61	L6	79	J3	97	T43
8	R5	26	J5	44	L3	62	T45	80	J13	98	R6
9	T44	27	J8	45	T9	63	T49	81	T57	99	T60
10	T74	28	T31	46	J1	64	J12	82	T69	100	T17
11	T32	29	T64	47	T11	65	J11	83	T48	101	X2
12	T41	30	R1	48	T42	66	T2	84	X3	102	T63
13	R4	31	T16	49	T7	67	T22	85	J9	103	L9
14	T29	32	T52	50	T10	68	J4	86	T14		
15	T54	33	R7	51	T70	69	T50	87	T1		
16	T5	34	T33	52	T76	70	T8	88	J10		
17	T19	35	J2	53	T58	71	L7	89	T53		
18	T72	36	T18	54	J7	72	T61	90	T21		

[10]. The authors' h-index average and median value are $\bar{h} = 7.9$ and $\tilde{h} = 5$, while the standard deviation and the interquartile range are $s = 7.7$ and IQR $= 9$.

The global h-spectrum may be used to compare one author against a set of authors, or the population of authors for one journal against all IEEE authors. For example, an author with $h = 3$ compared to the whole set of IEEE authors would fall on the 35th percentile of the corresponding h-spectrum, while an author with $h = 1$ would fall on the 17th percentile.

Analysis in the Year 2009: This first part of the second phase of analysis compares the h-spectra of the IEEE journals in a reference year (2009) to investigate how the h-spectrum changes from journal to journal. Fig. 9 shows the h-spectra for the same subset of ten IEEE journals considered in the first phase of analysis. Results for the whole set of journals appear in Table A.2.

Fig. 10 shows the number of authors (N) in each journal and their values for $\bar{h}, \tilde{h}, s$, and IQR. Journals are sorted in descending order of $\bar{h}$. Despite their similar shape, distributions differ appreciably for $\bar{h}$ and s. Note that for the same journal, $\bar{h}$ and s have similar values with a nearly linear correlation $(R^2 = 0.80)$, further empirical confirmation of what was found in [12].

Consistent with Lazaridis [51], $\bar{h}$ is used as a synthetic indicator to perform quick evaluations and comparisons of local h-spectra even though it might be more conceptually correct to use $\tilde{h}$, because h is defined on an ordinal scale with only equivalence and ordinal properties, and h-spectra are highly skewed. For further details, see [29]. Since there is no empirical correlation between $\bar{h}$ and N or s and $N (R^2 < 0.08)$, it seems appropriate to use $\bar{h}$ as such a synthetic indicator.

Analysis Over Five Consecutive Years: This second part of the second phase of analysis compares the h-spectra for the same journal(s) across five consecutive years, from 2006 to 2010, to investigate how a journal's h-spectrum tends to change over time.

Fig. 11 reports the spectra for three of the IEEE journals analyzed (J5, O2, and T23). Results relating to all of the IEEE journals analyzed appear in Table A.2.

For J5 and O2, h-spectra look relatively stable over the five years. In contrast, T23 shows fluctuations in $\bar{h}$ values. Variations in a journal's profile may be due to factors, such as changes in the editorial board, variations in the article selection policy, newly competing journals, or the presence of special issues.

For the entire dataset in Table A.2, $\bar{h}$ values are generally stable, perhaps because authors of a particular journal tend to be "attracted" to it over the years, or because editorial board policy tends to remain consistent. This relative temporal stability is also visible in Fig. 12, which shows the annual $\bar{h}$ values for ten IEEE journals.

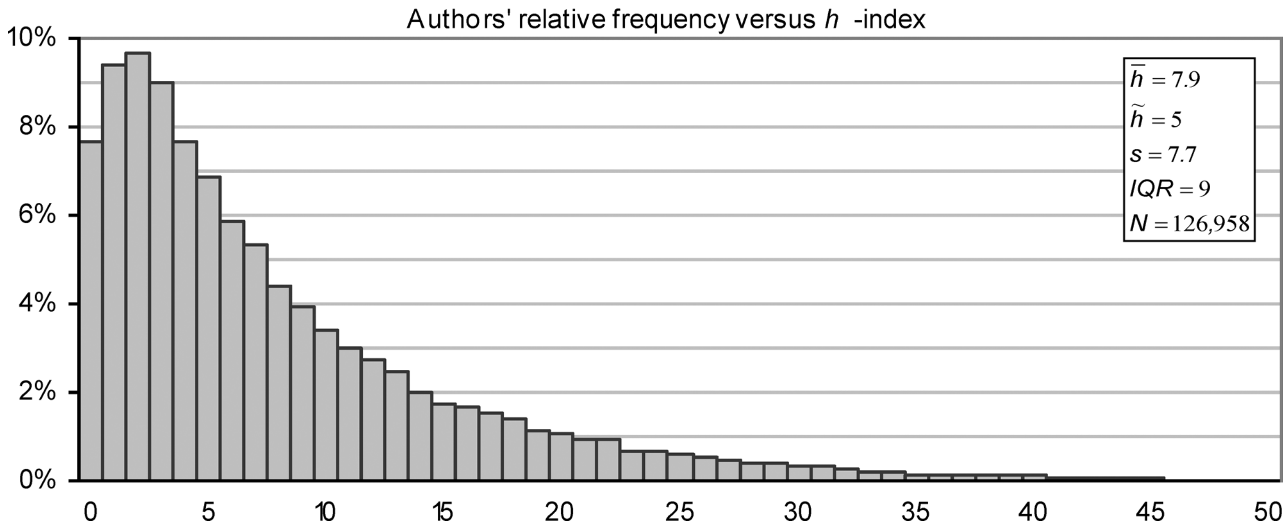


Fig. 8. Global h-spectra (authors' relative frequency versus h-index) for the totality of the authors analyzed, in the period from 2006 to 2010. The average value of the authors' h-index $(\bar{h})$, the corresponding median $(\tilde{h})$, standard deviation (s), interquartile range (IQR), and the total number of authors analyzed (N) are reported.

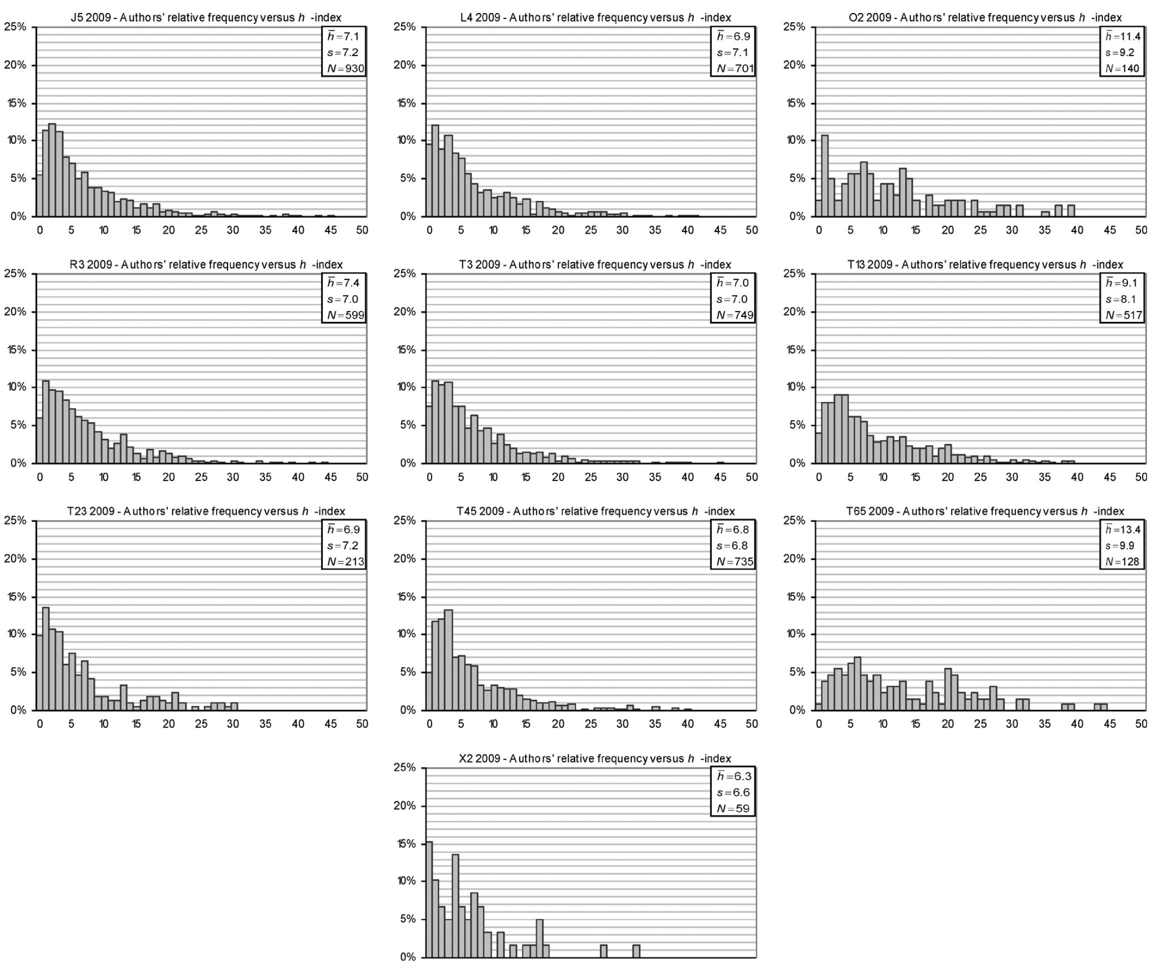
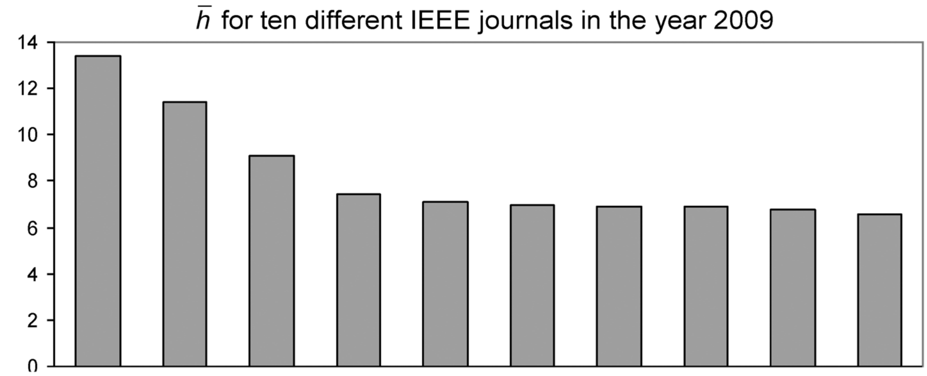


Fig. 9. h-spectra (authors' relative frequency versus h-index) for ten IEEE journals (see Table I), for the year 2009. For each journal, the average value of the authors' h-index $(\bar{h})$, the corresponding standard deviation (s), and the number of authors considered (N) are reported.



Journal	T65	O2	T13	R3	J5	T3	L4	T23	T45	X2
$\bar{h}$	13.4	11.4	9.1	7.4	7.1	7.0	6.9	6.9	6.8	6.6
$\tilde{h}$	11.0	9.0	6.0	5.0	5.0	5.0	5.0	4.0	5.0	4.0
s	9.9	9.2	8.1	7.0	7.2	7.0	7.1	7.2	6.8	4.0
IQR	15.3	10.0	10.0	8.0	8.0	7.0	8.0	7.0	8.0	6.5
N	128	140	517	599	930	749	701	213	735	59

Fig. 10. Synthetic results of the analysis of ten IEEE journals, for the year 2009. The table reports the $\bar{h}, \tilde{h}$, s, IQR, and N values associated with each journal. In the barchart, journals are sorted in descending order with respect to $\bar{h}$.

As the reference time period increases, the characteristic shape of a journal's h-spectrum consolidates, as illustrated in Fig. 13 where the h-spectra for three IEEE journals (J5, O2, and T23) are shown for three time periods: one year, three years, and five years.

Further Considerations on the h-Spectrum: h-spectrum may be used to provide a "snapshot" of the author population of a specific journal as a reference for other authors; or a rough indication of a journal's bibliometric positioning in the scientific community. h-spectra can reliably evaluate a journal at the moment of publication, despite using articles and citations accumulated before the publication date. Empirical evidence indicates that the citations received by a new article are generally consistent with the citations received by previous articles by the same author, that is to say the *author's reputation* [54].

Aggregation of the Two Analysis Perspectives: Based on the research methods used in our analysis, further questions arose for discussion: Are the results of the two phases of analysis correlated? How can they be aggregated effectively? h-spectrum, which is related to the reputation of a journal's authors, differs from CPP and other traditional bibliometric indicators, such as C, h_J, and IF, which are related to the average citations accumulated by a journal's articles. As the academic reputation of a journal's author group is not equivalent to either the reputation or the influence of the journal, these different indicator typologies are two complementary ways to evaluate scientific journals.

While the aggregation of the authors' reputation and journal impact remains a challenge, a "$\bar{h}$—CPP-rank map" can depict the bibliometric position of a journal based on those indicators: (1) the $\bar{h}$ value for the annual authors' h-spectrum and (2) the CPP values for the annual journals' rank position. The popular IF could be substituted for CPP-rank as an indicator of journal impact, but since IF is a special type of CPP that is calculated over a two-year rolling window, IF cannot punctually represent the journal impact for a particular year because it depends on the impact in the previous year. The correlation between annual IF and CPP-rank of the analyzed journals was quite weak (R^2 <0.5) for the four consecutive years from 2006 to 2009.

Fig. 14 shows the "$\bar{h}$—CPP-rank map" for 2009, excluding those journals lacking at least one of the two indicators in that year. (See Tables A.1 and A.2, available online as supplementary material at http://ieeexplore.ieee.org.) $\bar{h}$ and CPP-rank values are weakly correlated (R^2 <0.5) with an almost horizontal tendency line. This correlation seems slightly weaker in the upper right corner of the map with relatively high $\bar{h}$ values and low CPP-ranks, meaning that journals with high impact tend to have authors with high academic reputations, but the opposite is not necessarily true. The map

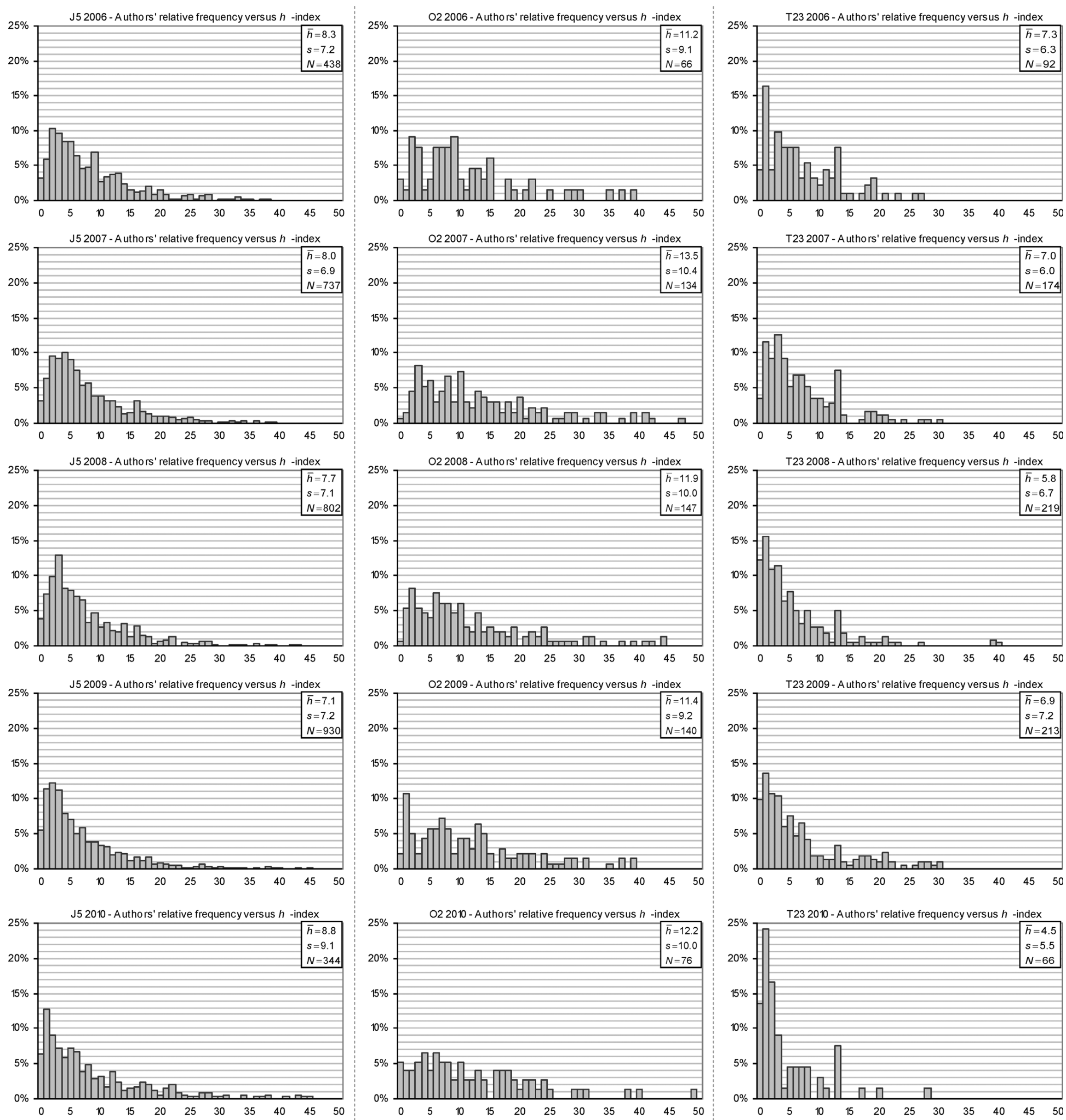


Fig. 11. h-spectra associated with three IEEE journals (J5, O2, and T23) for five consecutive years (from 2006 to 2010). For each spectrum, $\bar{h}$, s, and N are reported.

makes it possible to qualitatively identify different situations: (1) journals with low authors' reputation ($\bar{h}$ values) and few received citations (CPP-rank values); (2) journals with low authors' reputation and many received citations, such as journals open beyond the academic world to professionals and industrial managers, or journals concerning expanding sectors with many brilliant young researchers (e.g., T33 and T59 in Fig. 14); (3) journals with medium–high authors' reputation but few received citations, such as relatively recent journals struggling to become popular in the scientific community, or niche journals with limited diffusion (e.g., L6 in Fig. 14); and (4) journals with high authors' reputation and many received citations.

Similar maps can be constructed for longer timeframes to evaluate the average bibliometric performance of a journal over time, such as the map in Fig. 15, which shows the last five years of analysis from 2006 to 2010. Mean $\bar{h}$ values are calculated by a weighted average of the $\bar{h}$ annual values, using the corresponding number of authors (N, see Table A.2) as weight. Overall, CPP-rank

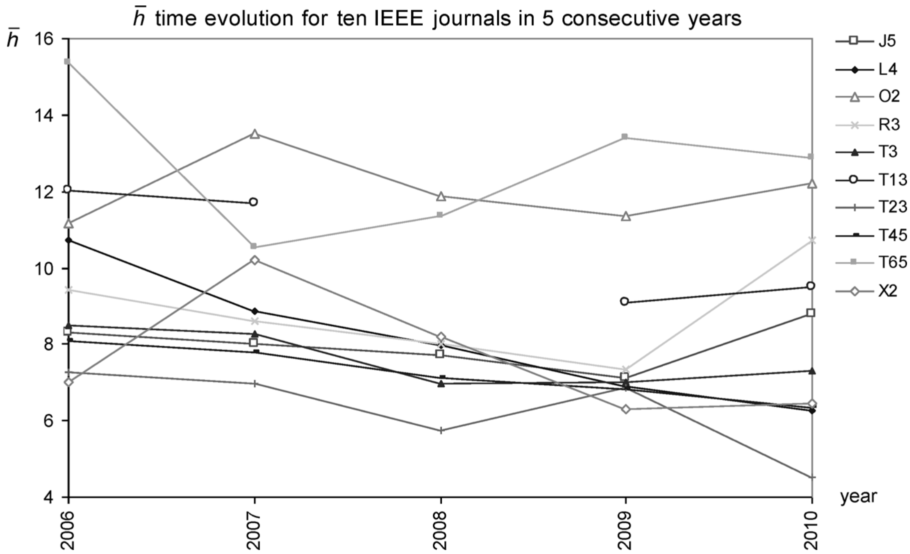


Fig. 12. Graphs showing the $\bar{h}$ time evolution for ten IEEE journals, for five consecutive years (from 2006 to 2010). The profile of T13 is broken because it was not possible to collect (from WoS) the authors' full first name(s) relating to 2008, thus h-spectrum construction is missing for this year.

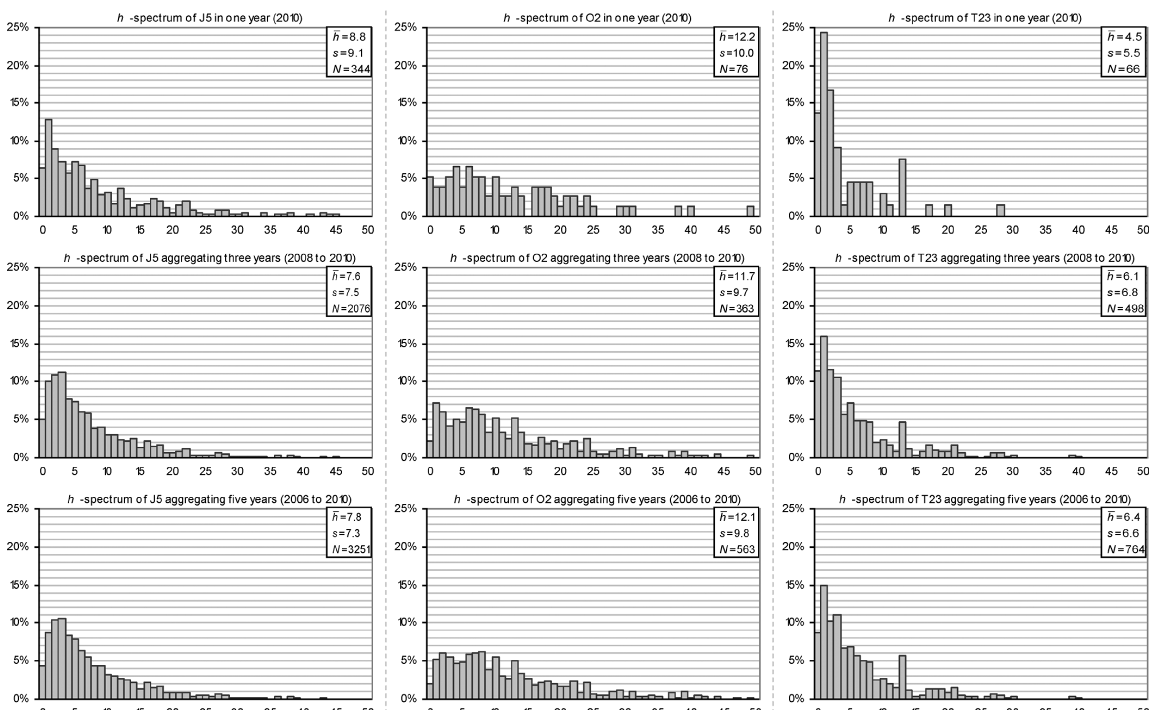


Fig. 13. h-spectra for three IEEE journals (J5, O2, and T23) calculated considering three different reference time periods (one, three, and five years). For each journal, $\bar{h}$, s, and N values are reported. It can be seen that the larger the time period, the more consolidated the journal's h-spectrum.

values are those reported in Table II and are determined by the procedure described before.

A $\bar{h}$—CPP-rank map can also be used to show the changes in bibliometric positioning of journals over time, such as the map in Fig. 16, which shows changes in three IEEE journals from 2006 to 2010. Based on the complete results in Tables A.1 and A.2, the general tendency of the journals to increase in CPP values is rarely associated with a tendency to increase in $\bar{h}$ values. Similar maps

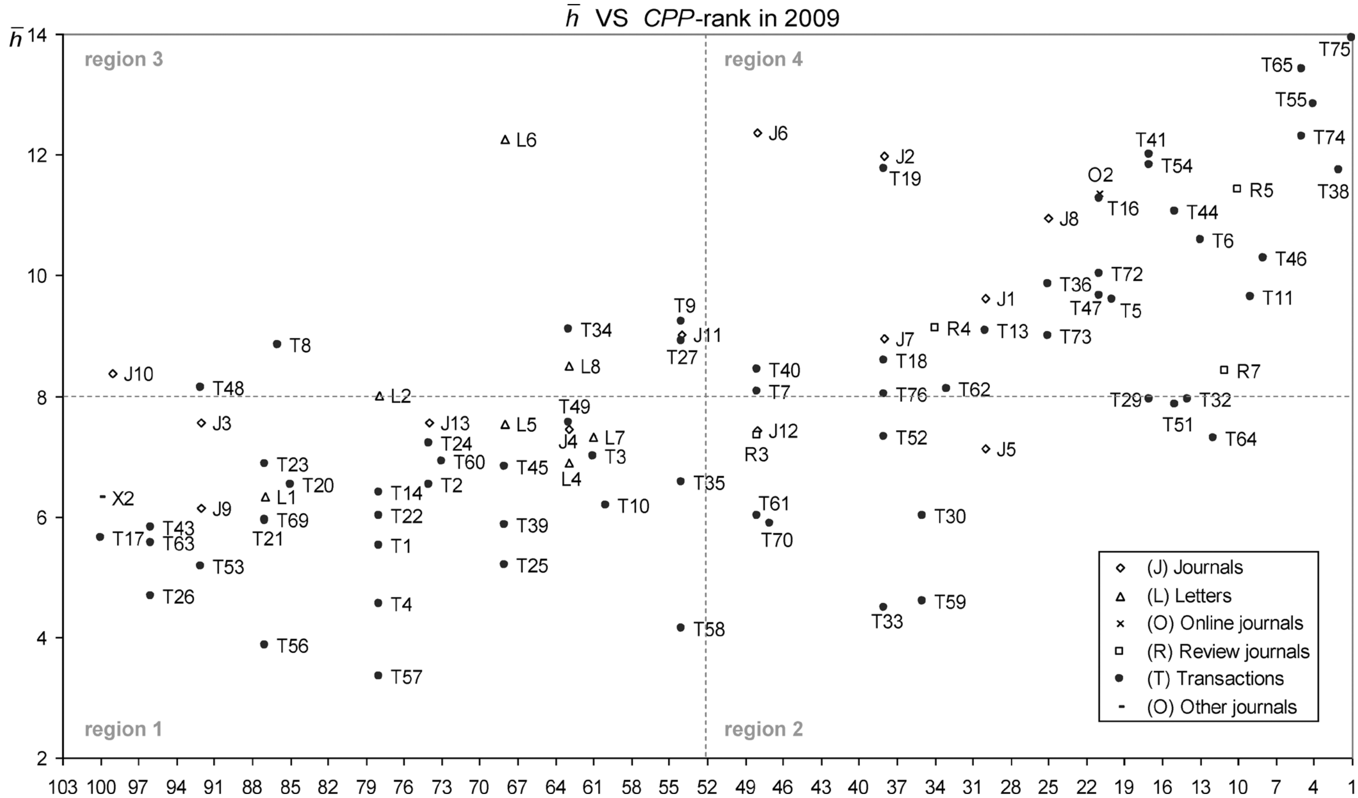


Fig. 14. Scatter map representing $\bar{h}$ values (vertical axis) against CPP-ranks values (horizontal axis) of the IEEE journals (see Tables A.1 and A.2) in 2009. Correlation between the two different indicators is very weak ($R^2 < 0.5$). The map makes it possible to (qualitatively) identify different regions: (1) journals with low authors' reputation (in terms of $\bar{h}$ values) and few received citations (in terms of CPP-rank values); (2) journals containing articles with a high number of citations, by authors with low h-indices; (3) journals with medium–high authors' reputation but few received citations; and (4) journals containing articles with a high number of citations, submitted by authors with high h-indices. Demarcation lines between regions are purely qualitative and roughly correspond to the mean value of the journal $\bar{h}$ and CPP-rank values.

can be constructed replacing the journal CPP-rank with other indicators of journal impact, such as IF.

General Differences Among Journal Categories: It is difficult to identify general differences among the categories of journals (i.e., $J, L, O, R, T,$ and X) shown in the $\bar{h}$—CPP-rank maps. In Fig. 15, different aspects emerge:

(1) journals (J) and transactions (T) seem uniformly distributed in journal impact and authors' reputation;
(2) review journals (R) seem to be positioned around the right side of the map due to the predictably higher CPP values than other standard research articles;
(3) letters (L) tend to be positioned in the top left, showing lower impact, but medium–high reputations for authors.

Differences are not systematic. For the boxplot in Fig. 17, the differences between the populations are not noticeable as most of the notches overlap.

Conclusions, Limitations, and Suggestions for Future Research

This section closes this paper with implications of the study, limitations, and ideas for future research.

Implications of the study for potential stakeholders include the following:

- For publishing professionals, this study provides a new methodological tool for monitoring a large number of scientific journals in a relatively homogeneous research field. $\bar{h}$—CPP-rank maps enrich the information given by a journal's IF for two reasons:

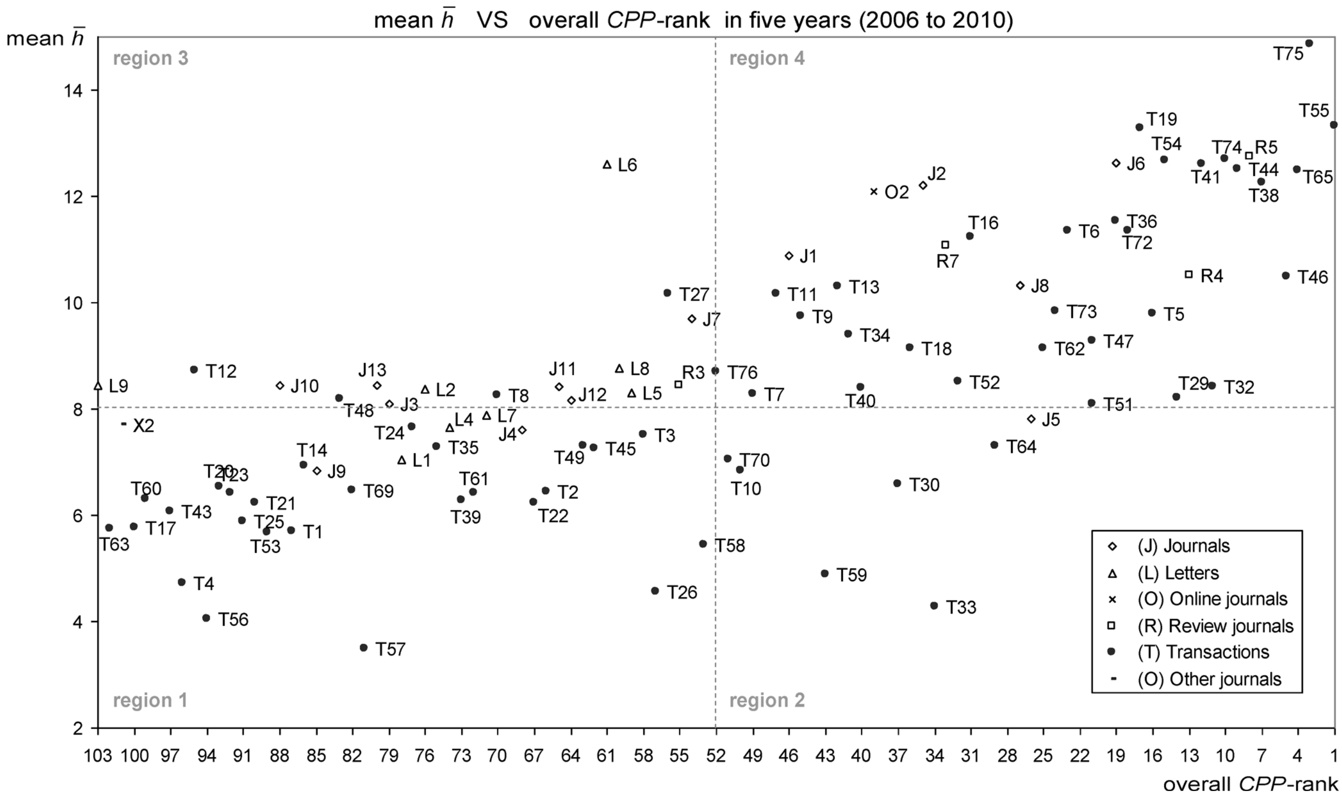


Fig. 15. Scatter map representing mean $\bar{h}$ values (vertical axis) against overall CPP-rank values (horizontal axis), using the data related to the IEEE journals (see Tables A.1 and A.2) in five consecutive years (2006 to 2010). Specifically, mean $\bar{h}$ values are calculated by a weighted average of the $\bar{h}$ annual values, using the corresponding number of authors (N, see Table A.2) as weight. Overall, CPP-rank values are those reported in this table. The procedure to determine them is illustrated in "Results." Demarcation lines between regions are purely qualitative and roughly correspond to the mean value of the journal $\bar{h}$ and CPP-rank values.

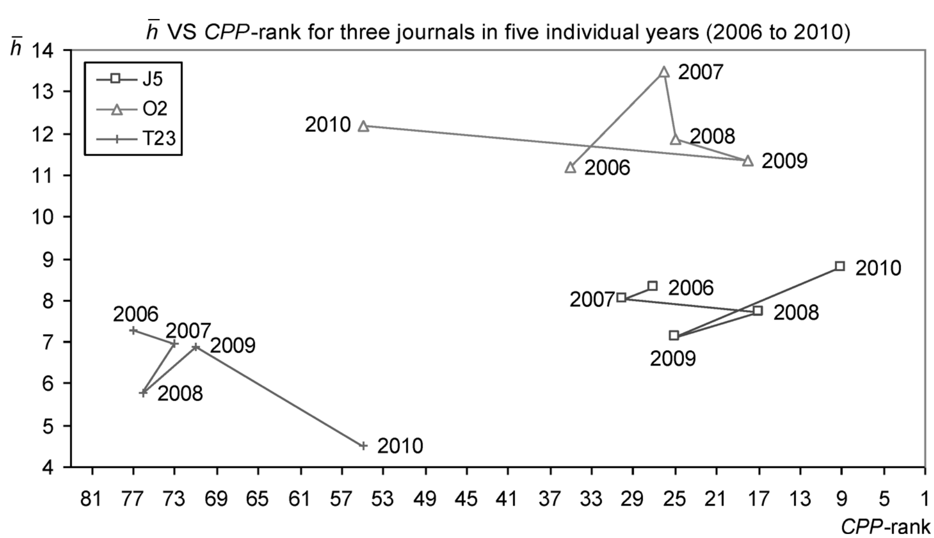


Fig. 16. Map showing the temporal evolution of three IEEE journals (i.e., J5, O2, and T23) according to their bibliometric positioning in terms of $\bar{h}$ and CPP-rank values. Five consecutive years are considered (2006 to 2010).

(1) CPP-ranks give a more precise picture of the average impact of a journal in a specific year, unlike IF, which mixes articles published in two consecutive years; and
(2) $\bar{h}$, which synthesizes the academic reputation of the authors, can be used as a coarse but prompt indicator of journal reputation; a journal editorial board could use $\bar{h}$ to monitor the practical effect of their paper selection policy based on their author population: if $\bar{h}$ decreases significantly from one year to the next, it probably means that the portion of authors who are young researchers or professionals/managers (generally, with small h values) is growing more than the portion of senior academics (generally, with high h values). Changes in $\bar{h}$ may signal editorial strategy.

CPP-ranks and $\bar{h}$ can be calculated at the moment of journal publication, unlike IF, which is calculated one to two years after publication. Thanks to its relative simplicity, the analysis can be periodically replicated and updated even by nonexperts.

- Most of the implications discussed before apply to technical communicators, members of evaluation committees for universities and research institutes, and librarians. In addition, the quantitative evaluation of the authors' reputation can be used as an external validation of the classical qualitative methods for assessing the reputation of journals [15].
- For authors who must decide where to submit their articles, this study provides a new reference to identify journals of greater or lesser impact in their field, and journals where their articles may be published next to authors of higher or lower reputation.

Limitations This section describes the limitations of the study arising from the use of citation analysis, and simplifications made during analysis.

First, the use of citation analysis and bibliometric indicators is subject to several typical criticisms:

- They rely on the controversial assumption that citations represent a good indicator of the impact of an article, without distinguishing between "external" citations and self-citations, or citations received by articles from more or less authoritative sources, such as international peer-reviewed journals, low-profile national journals, conference proceedings, or doctorate dissertations.
- The data harvested from bibliometric search engines may not be reliable, and may not provide the complete data required for analysis. However, filtering out dubious data reduces the risk of database errors significantly [27].
- The calculation of one author's h-index does not account for the number of coauthors of the articles [33].
- The calculation of one author's h-index does not account for the age of the articles; one might give more weight to the most recent articles [34].

In addition, other limitations arise from specific simplifications adopted in the analysis:

- Since the calculation of the citation statistics (apart from the IF) takes into account all of the citations accumulated up to the moment of the analysis in August 2010, results may change slightly if the analysis was replicated at another time. The most predictable changes are those arising from the most recent and less consolidated articles or journal issues;
- h-spectrum does not account for authors who publish more than one article in the same journal and in the same year;
- This study does not allow comparisons with competing journals within the same scientific discipline, but outside the "IEEE galaxy" that was studied;
- Since the proposed indicators should not be used to compare journals from different disciplines (owing to their different citation practices [10]), a fundamental assumption of this study is that IEEE journals are a homogenous portion of scientific literature. This assumption cannot be completely satisfied because IEEE journals address different scientific communities with specific fields of interest, and the average scientific production and impact of journals likely varies depending on the size and research subjects of each community [55];
- Finally, the positioning of journals in the $\bar{h}$—CPP-rank maps in Figs. 14 and 15 is only qualitative, because the two dimensions of analysis (journal impact and authors' reputation) are not merged together in order to avoid alterations of the indicators of interest.

Suggestions for Future Research Several research issues and possible developments of the present study arise from the assumptions and limitations described previously:

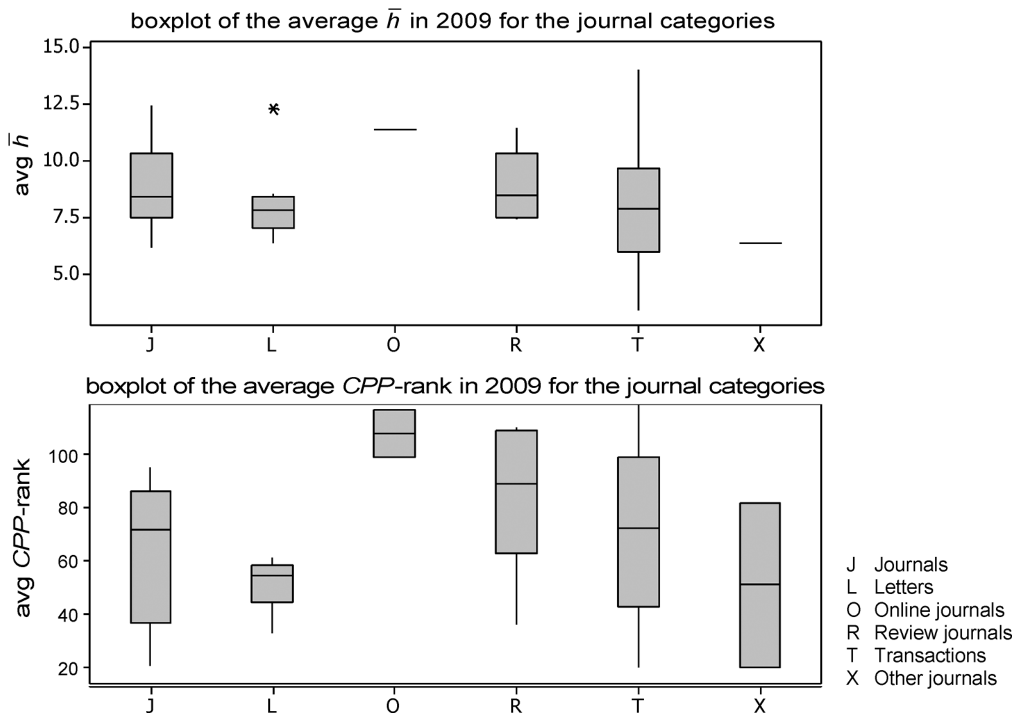


Fig. 17. Boxplots relating to the average $\bar{h}$ and the average CPP for several IEEE journal categories in the year 2009. Since most of the notches overlap, significant differences are not likely. In the first boxplot, notches associated with O and X are incomplete, because of the very low number of journals analyzed. The symbol * (see the first boxplot associated with L) denotes the presence of a probable outlier, that is, an observation that is beyond the upper or the lower whisker.

- The study could be extended to journals outside the “IEEE galaxy” to see how IEEE journals are positioned with respect to external competitors;
- The study could be refined by removing simplifying assumptions in the calculation of authors’ h-indices, such as: (1) introducing a weighting system to give more importance to recent articles or to citations made by authoritative articles and (2) taking into account coauthorship;
- The study could be refined by normalizing the results for the subfields in IEEE, to avoid favoring journals whose communities have a higher propensity for citation. To divide journals into subfields with relatively homogeneous subjects, we would use information on the journals’ affiliations with IEEE societies and councils [55]. We are working on this issue, and it will be interesting to see how such a “correction” may affect the results presented in this paper.

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Flavio Canavero (F'07) received the Ph.D. degree from the Georgia Institute of Technology, Atlanta, GA, USA. Currently, he is a Professor of Circuit Theory at Politecnico di Torino, Torino, Italy. He is Vice President for Communication Services of the IEEE Electromagnetic Compatibility Society.

Fiorenzo Franceschini is Professor of Quality Engineering with the Department of Management and Production Engineering, Politecnico di Torino, Torino, Italy. He is the author of six books and many published papers in prestigious scientific journals. His current research interests are in the areas of quality engineering, bibliometrics, and performance measurement systems.

Domenico Maisano received the Ph.D. degree in "Systems for the Industrial Production" from Politecnico di Torino, Torino, Italy. Currently, he is an Assistant Professor of Quality Engineering, Politecnico di Torino. His research interests are quality management, metrology, performance indicators, and bibliometrics.

Luca Mastrogiacomo received the Ph.D. degree in "Systems for the Industrial Production" from Politecnico di Torino, Torino, Italy, where he is currently an Assistant Professor of Production Systems. His research interests are in the fields of industrial metrology, quality management, and statistical process control.