The Hirsch spectrum: a novel tool for analysing scientific journals

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Abstract

This paper introduces the Hirsch spectrum (*h*-spectrum) for analyzing the academic reputation of a scientific journal. *h*-spectrum is a novel tool based on the Hirsch (*h*) index and is easy to construct: considering a specific journal in a specific interval of time, *h*-spectrum is defined as the distribution representing the *h*-indexes associated to the authors of the journal articles. This tool allows to define a reference profile of the typical author of a journal, compare different journals within the same scientific field, and provide a rough indication of prestige/reputation of a journal in the scientific community. *h*-spectrum can be associated to every journal. Ten specific journals in the Quality Engineering/Quality Management field are analyzed so as to preliminarily investigate the *h*-spectrum characteristics.

Keywords: Hirsch index, Hirsch spectrum, journal's (co-)authors, citations, bibliometrics, Quality Engineering/Quality Management journals, journal qualimetrics.

1. Introduction

At the present time, there is a wide number of scientific journals with different status, prestige and diffusion, covering innumerable scientific disciplines. The most well-known tool to evaluate scientific journals is the ISI impact factor (ISI-IF), which was introduced by Garfield (1972). This indicator allows comparisons among different journals, provided that they belong to the same subject area [Amin and Mabe, 2000]. Although it shows some weak points, in many academic contexts it seems to be the main way for ranking journals [MacRoberts and MacRoberts, 1987; Seglen, 1992; Seglen, 1997; Jennings, 1998; Glänzel and Moed, 2002; Garfield, 2006; Brumback, 2008; Leydesdorff, 2009]. Some main drawbacks of ISI-IF are: (i) not all scientific journals are indexed by Thomson Scientific, (ii) the limited time span (only citations accumulated within two years after the publication are considered) and (iii) the lack of coverage (citations in books, conference proceedings and dissertations are not included in the ISI list) [Seglen, 1997; Harzing, 2008; Thomson Reuters, 2009]. Originally, ISI-IF was conceived to evaluate the diffusion of a journal but it had gradually become an indicator of prestige/reputation for the journal itself and, implicitly, for the authors of the papers there presented [Braun et al., 2007]. In practice, the larger ISI-IF, the more prestigious the journal.

For a potential author, the scientific reputation of the past and current authors of one journal is a reason of attraction. Reputation/prestige of the journal editor-in-chief and editorial board members, and presence of papers submitted by eminent scientists are some other possible reasons for preferring one journal to another. However, these evaluations are often subjective and not very reliable. Braun et al. (2006) proposed using the Hirsch (h) index for evaluating and comparing scientific journals. Specifically, h is defined as the number such that, for a general group of papers, h papers received at least h citations while the other papers received no more than h citations [Hirsch, 2005; Hirsch, 2007]. h was originally introduced by Hirsch in order to evaluate the quantity and the diffusion of one researcher's scientific production. Ever since its introduction, h received much attention. This indicator has many merits (i.e. it is synthetic, robust, simple to calculate and with immediate intuitive meaning) and some weak points; both have been abundantly pointed out in the literature [Moed, 2005; Egghe, 2006; Glänzel, 2006; Kelly and Jennions, 2006; Rousseau, 2006; Saad, 2006; Bornmann and Daniel, 2007; Costas and Bordons, 2007; Orbay et al., 2007; Schreiber, 2007; Van Raan, 2006; Wendl, 2007; Harzing and van der Wal, 2008; Mingers, 2008; Franceschini and Maisano 2009a]. Another tangible sign of the popularity of h is the appearance of many proposals for new variants and improvements, including the above-mentioned h-index for journals [Lehmann et al., 2005; Banks, 2006; Batista et al., 2006; Braun et al., 2006; Lehmann et al., 2006; BiHui et al. 2007; Burrell, 2007a; Burrell, 2007b; Castillo et al., 2007; Katsaros et al., 2007; Sidiropoulos et al., 2007; Schreiber, 2008; Antonakis and Lalive, 2008; Woeginger, 2008; Franceschini and Maisano 2009b].

Coming back to the h-index for journals, it is calculated taking into consideration the articles published by a specific journal in a precise time period (e.g. one year). Unfortunately, this indicator has a significant limitation. Considering a generic journal, the citation accumulation process of the papers requires a certain amount of time to become stable – according to some authors, this period is about five years in the engineering field [Amin and Mabe, 2000; Castillo et al., 2007; Harzing, 2008]. Thus, h for journals is not suitable to evaluate the most recently published journals and, much less, to compare them with other past journals. Besides, being sensitive to the number of papers per issue, this indicator – if calculated on a yearly basis – tends to favour journals with many papers/issues per year. In fact, a high number of articles per year is not necessarily an element in favour of a journal with respect to another.

The goal of this paper is to introduce the Hirsch spectrum (h-spectrum), a new tool that is derived from h and defined as the distribution representing the h-indexes associated to the authors of a specific journal, in a specific interval of time. The term "spectrum" is originated from the fact that this distribution provides an image of the author population of one journal for a period of interest. In our view, h-spectrum can be a different way for evaluating and comparing the reputation of journals (indexed by Thomson Scientific or not).

More in detail, h-spectrum can be used for several practical purposes, respectively:

- to make a comparison among journals within the same scientific field;

- to define the profile of the "typical authors" of a specific journal. This profile may represent a reference for other (potential) authors;
- extending the idea of the previous point, to define a reference of the "typical researcher" of a specific discipline (both in terms of productivity and diffusion, which are the basic reasons why we decided to use *h*);
- to help a journal's editorial board to periodically monitor the effect of the paper selection policy, from the point of view of the population of the journal authors. In this sense, *h*-spectrum may become an indicator of editorial strategy.
- to provide a rough indication on the prestige/influence of a journal on the scientific community.

To focalize our preliminary analysis, the *h*-spectrum study is circumscribed to a particular discipline. We analyzed some journals in the Quality Engineering and Quality Management area.

The remaining of the paper is organised into three sections. Section 2 illustrates the methodology used in the analysis and shows some preliminary results. Section 3 focuses on some peculiar aspects of the *h*-spectrum and makes a brief comparison with ISI-IF. Section 4 identifies several ideas for further research activities, which may originate from this work. Finally, the conclusions are given, summarising the original contribution of this paper.

2. Methodology and preliminary results

The *h*-spectrum analysis can be divided in two distinct activities:

1. construction and comparison of the *h*-spectra related to different journals in the same reference year, so as to investigate how the *h*-spectrum changes from journal to journal;
2. construction and comparison of the *h*-spectra related to the same journal(s) in different periods of time, so as to investigate how a journal's *h*-spectrum tends to change over time.

2.1 Comparison among different journals in the same year

The purpose of this activity is to make a comparison among journals published in the same year (for example in 2008). We selected ten different Quality journals, from the most popular and representative in this discipline [ASQ, 2009; Harzing, 2009; Thomson Reuters, 2009]. These journals have different publishers and only a small portion of them (see Tab. 1) is indexed by Thomson Scientific. Tab. 1 also reports the journals' acronyms.

For each journal, all the (co-)authors of a paper published in the reference year (i.e. 2008) are identified. Then, the corresponding *h*-index of each (co-)author is calculated. Finally, the distribution of the (co-)authors' *h*-indexes is constructed according to the following assumptions/conventions:

- For the purpose of simplicity, all the different (co-)authors of one journal have the same importance. Thus, their *h*-indexes are not weighted in inverse proportion to the number of (co-)authors of the corresponding paper(s).

- The *h*-index of a (co-)author, who publishes more than one article in a journal during the period of interest, is counted (only) once.
- For simplicity, the *h*-index of each author is calculated taking into account the scientific publications and citations accumulated up to the moment of the analysis (in our case, May 2009). In fact, it should be remarked that the *h*-index of a scientist tends to increase over time, because of the gradual accumulation of publications/citations. With a bit more effort – the analysis can be developed considering the publications/citations accumulated up to the journal publication date, excluding the subsequent ones. However, since the average time growth rate of *h*-index is relatively small (in engineering disciplines especially), the real variations in the *h*-spectra would be reasonably limited [Burrel, 2007b].

To avoid any misunderstanding with particular reference to the last point, when calculating a journal's *h*-spectrum two parameters have to be stated: (i) the period of interest in which the journal authors are identified (e.g. the whole year 2008) and (ii) the precise moment in which author *h*-indexes are calculated.

The output of the first analysis activity is illustrated in Fig. 1, showing the *h*-spectra related to the ten Quality Engineering/Quality Management journals reported in Tab. 1.

Journal name	Acronym	Publisher	Indexed by Thomson Scientific	Year(s) for which *h*-spectrum is calculated
Journal of Quality Technology	JQT	ASQ	Yes	2004 to 2008
Quality Engineering	QE	ASQ	No	2004 to 2008
Quality and Quantity	QQ	Springer	Yes	2008
Quality and Reliability Engineering International	QREI	Wiley	Yes	2008
Quality Management Journal	QMJ	ASQ	No	2008
Managing Service Quality	MSQ	Emerald	No	2008
Total Quality Management & Business Excellence	TQM	Taylor & Francis	No	2008
Journal of Quality in Maintenance Engineering	JQME	Emerald	No	2008
International Journal of Quality and Reliability Management	IJQRM	Emerald	No	2008
Quality Progress	QP	ASQ	No	2004 to 2008

Tab. 1 – List of the ten journals selected among the Quality Engineering/Quality Management area.

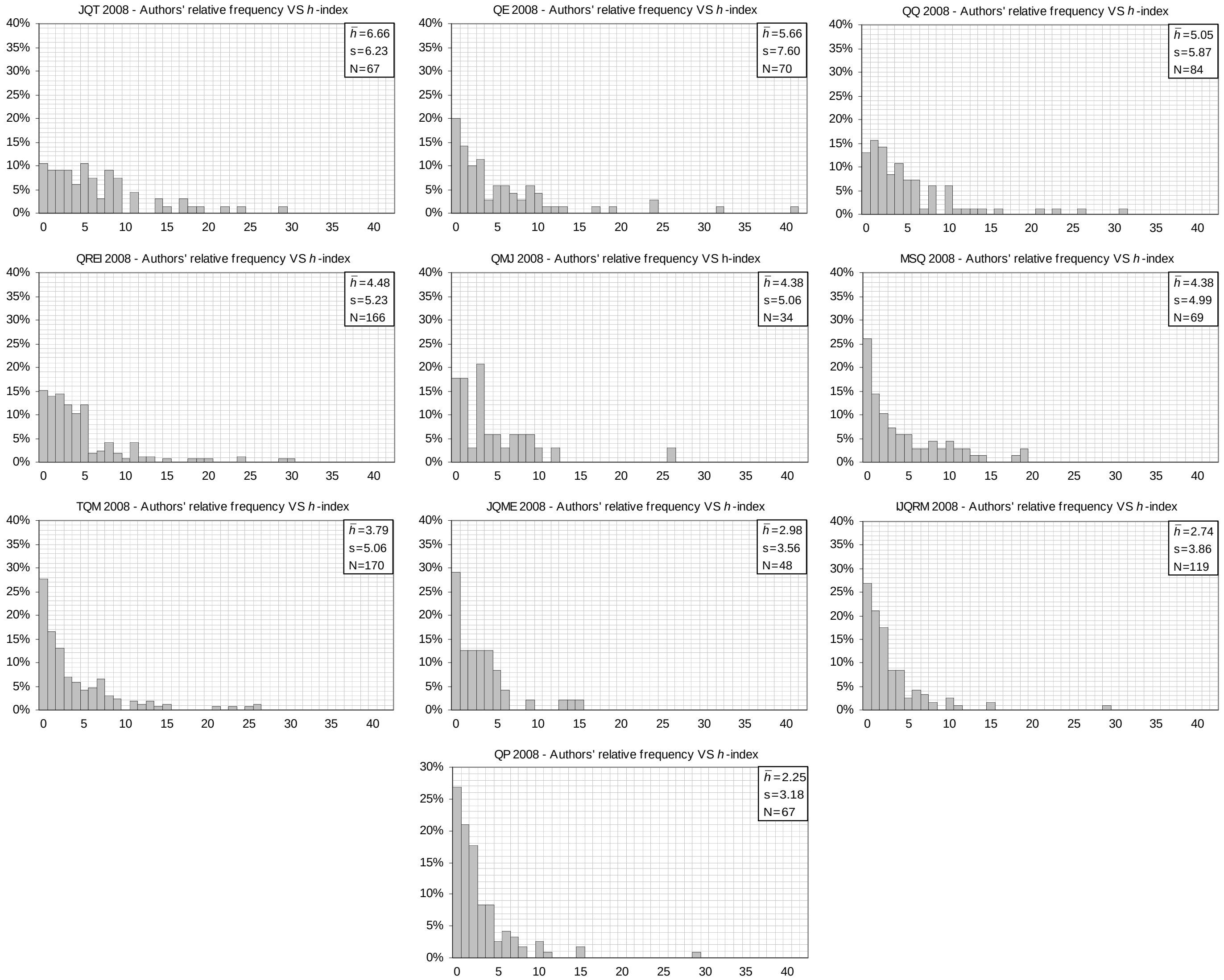
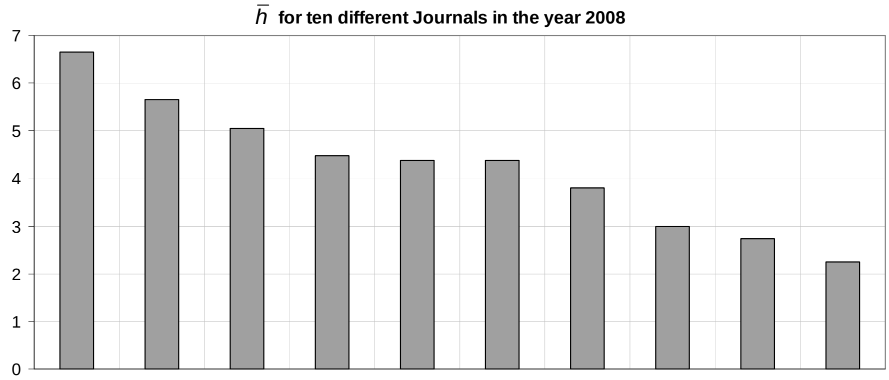


Fig. 1 − *h*-spectra (authors' relative frequency VS *h*-index) for ten Quality Engineering/Quality Management journals, in the year 2008. Journal acronyms are indicated in Tab. 1. For each journal, the authors' *h*-index average value ($\bar{h}$), the corresponding standard deviation (s) and the number of authors (N) are reported.

At a first glance, all these distributions are right-skewed and have a characteristic profile, which is approximately decreasing. Analysing the distributions in more detail, some interesting aspects emerge. Fig. 2 shows the *h*-index average value ($\bar{h}$), the corresponding standard deviation (s) and the number of authors (N) related to each journal. Journals are sorted in descending order with respect to $\bar{h}$. It can be noticed that, despite their similar shape, distributions are appreciably different in terms of values of $\bar{h}$ and s.



Journal	JQT	QE	QQ	QREI	QMJ	MSQ	TQM	JQME	IJQRM	QP
$\bar{h}$	6.66	5.66	5.05	4.48	4.38	4.38	3.79	2.98	2.74	2.25
s	6.23	7.60	5.87	5.23	5.06	4.99	5.06	3.56	3.86	3.18
N	67	70	84	166	34	69	170	48	119	67

Fig. 2 − Synthetic results of the analysis of ten Quality Engineering/Quality Management journals, in the year 2008. The table reports the authors' *h*-index average value ($\bar{h}$), the corresponding standard deviation (s) and the number of authors (N) related to each journal. In the graph, journals are sorted in descending order with respect to $\bar{h}$.

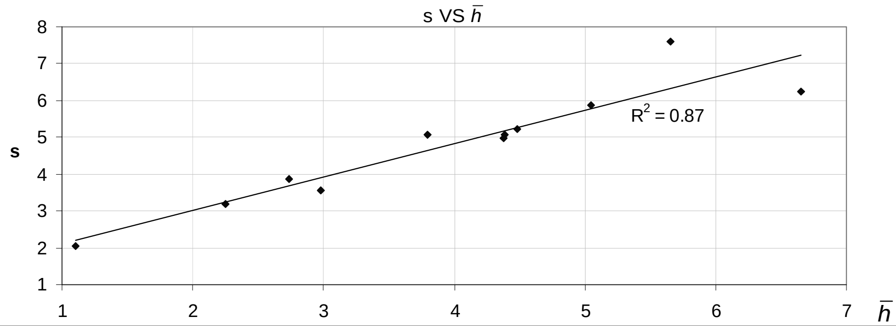


Fig. 3 – Relationship between s and $\bar{h}$ related to the *h*-spectra in Fig. 1, for ten Quality Engineering/Quality Management journals.

Furthermore, it is interesting to notice that – considering the same journal – $\bar{h}$ and s have generally similar values. Their empirical correlation is nearly linear with a relatively high coefficient of determination ($R^2 \approx 0.87$, see Fig. 3). On the other hand, there is no correlation between $\bar{h}$ and N or s and N ($R^2 \approx 0$).

On the basis of this result, it seems quite appropriate using $\bar{h}$ as a synthetic indicator to perform quick evaluations and comparisons among different *h*-spectra. Nevertheless, we want to emphasise the fact that the *h*-spectrum is more than a simple numerical indicator (like the ISI-IF or the *h*-index for journals); it is a distribution [Franceschini et al., 2007; Franceschini et al., 2008; Chapman, 2009].

2.2 Time evolution of the *h*-spectrum

This analysis is aimed at finding how the *h*-spectrum changes over time. Three of the previous ten journals are selected – i.e. JQT, QE and QP – extending the *h*-spectrum analysis to a period of five consecutive years (from 2004 to 2008). Fig. 4 reports the resulting *h*-spectra.

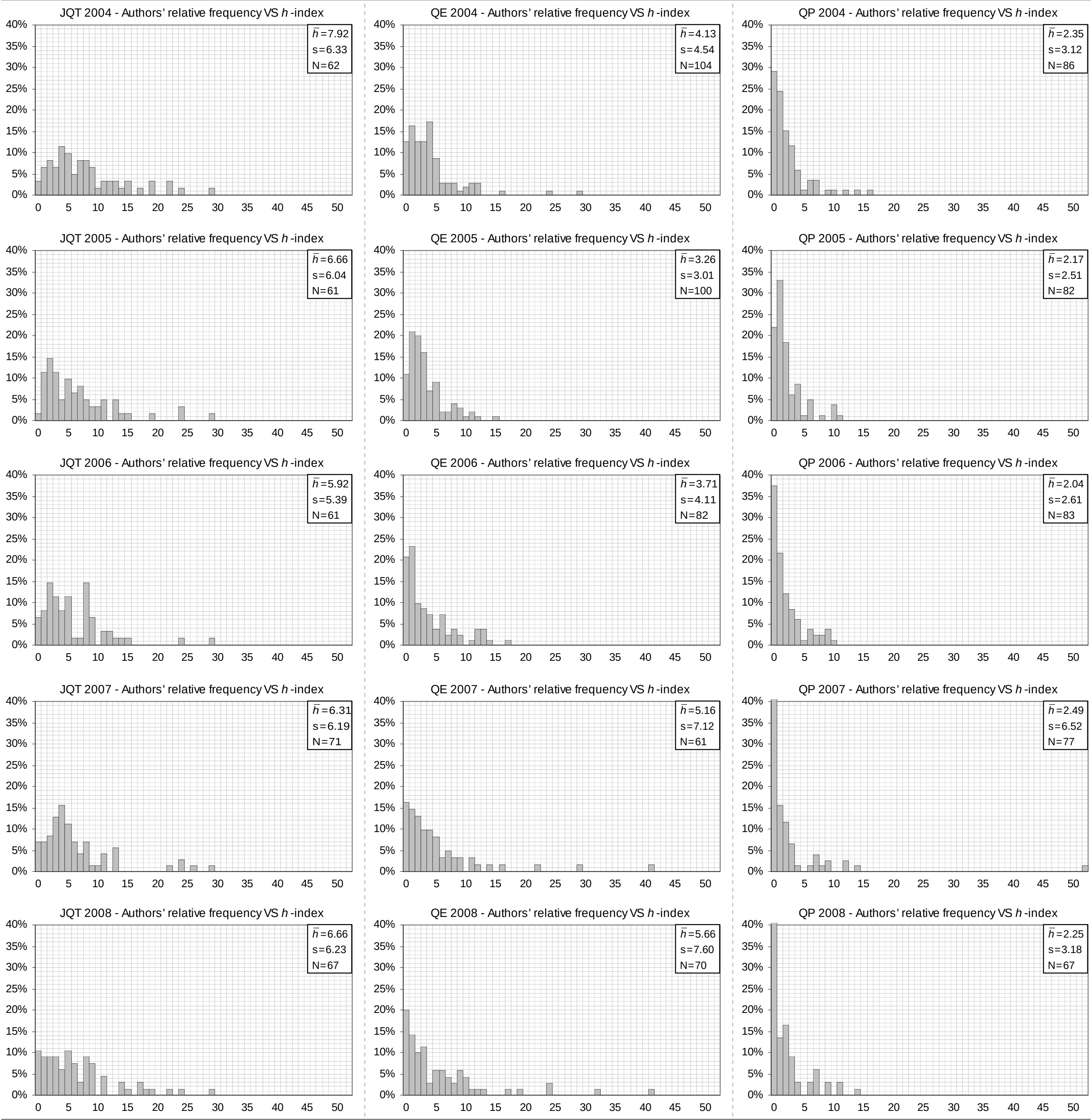
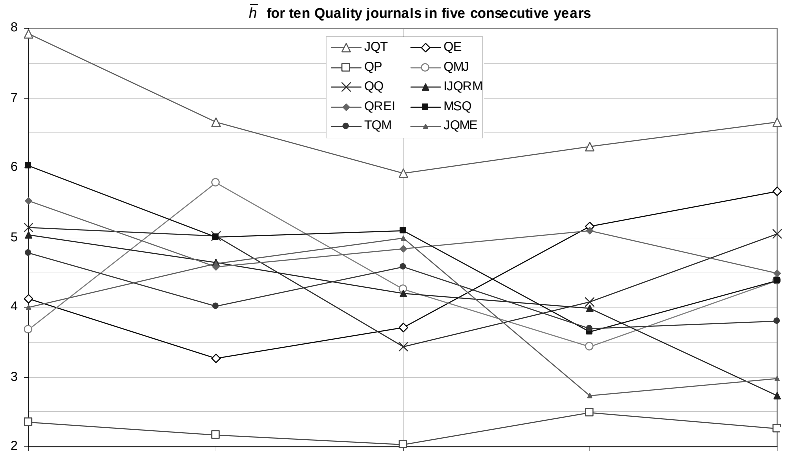


Fig. 4 – *h*-spectra for three Quality Engineering/Quality Management journals (JQT, QE and QP), in five consecutive years (from 2004 to 2008). For each journal, the authors' *h*-index average value ($\bar{h}$), the corresponding standard deviation (s) and the number of authors (N) are reported.

For each journal, the *h*-spectrum seems relatively robust and stable over the five examined years (see Fig. 5). Two possible reasons of this relative stability could be:

- authors of a particular journal tend to be "attracted" to it over the years;
- the editorial board policy tends to be consistent over time.



		2004	2005	2006	2007	2008
	$\bar{h}$	7.92	6.66	5.92	6.31	6.66
JQT	s	6.33	6.04	5.39	6.19	6.23
	N	62	61	61	71	67
	$\bar{h}$	4.13	3.26	3.71	5.16	5.66
QE	s	4.54	3.01	4.11	7.12	7.60
	N	104	100	82	61	70
	$\bar{h}$	2.35	2.17	2.04	2.49	2.25
QP	s	3.12	2.51	2.61	6.52	3.18
	N	86	82	83	77	67
	$\bar{h}$	7.92	6.66	5.92	6.31	6.66
JQT	s	6.33	6.04	5.39	6.19	6.23
	N	62	61	61	71	67
	$\bar{h}$	4.13	3.26	3.71	5.16	5.66
QE	s	4.54	3.01	4.11	7.12	7.60
	N	104	100	82	61	70
	$\bar{h}$	2.35	2.17	2.04	2.49	2.25
QP	s	3.12	2.51	2.61	6.52	3.18
	N	86	82	83	77	67

Fig. 5 − Time evolution of the *h*-index average value ($\bar{h}$), the corresponding standard deviation (s) and the number of authors (N) for three journals (JQT, QE and QP) in five consecutive years (from 2004 to 2008).

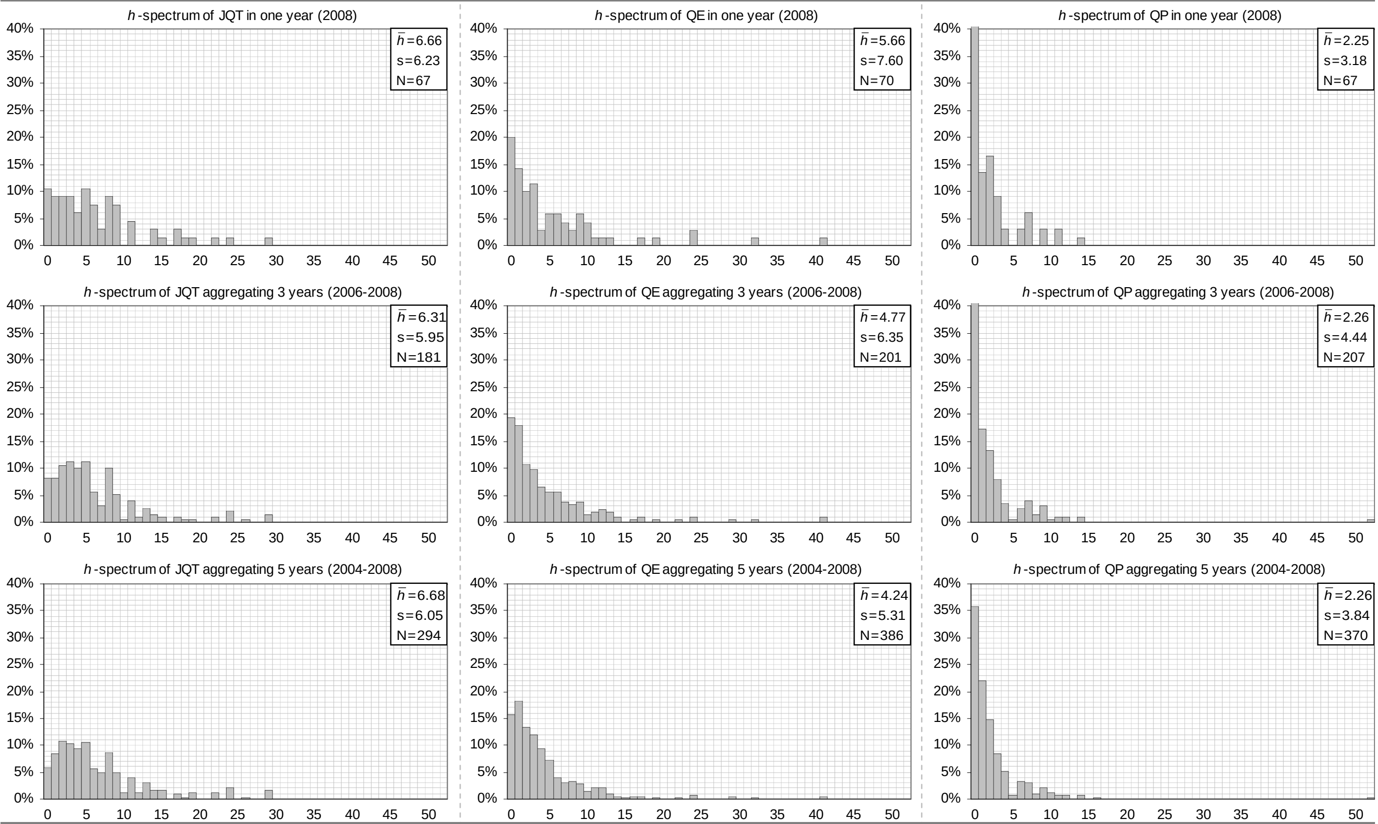


Fig. 6 – *h*-spectra for three Quality Engineering/Quality Management journals (JQT, QE and QP), calculated considering three different reference time periods (respectively, one year, three years and five years). For each journal, the authors' *h*-index average value ($\bar{h}$), the corresponding standard deviation (s) and the number of authors (N) are reported. It can be seen that the larger the time period, the more consolidated the journal's *h*-spectrum.

Since, there can be small variations from one year to the next, we noticed that the characteristic shape of a journal's *h*-spectrum becomes more and more consolidated by increasing the reference time period. This aspect is shown in Fig. 6, which reports the *h*-spectra of three journals (i.e. JQT, QE and QP), constructed considering three different periods of interest (one year, three years and five years, respectively). It can be seen that the difference among the journal $\bar{h}$ values becomes clearer when the reference time period increases. In this sense, *h*-spectrum can be used as an indicator of one journal's prestige.

2.3 Data source

Citation statistics are collected using Google Scholar (GS) as a search engine. It was decided to use this database (i) because of its grater coverage and (ii) because it can be easily accessed through the Publish or Perish (PoP) freeware software, specially designed for citation analysis with GS [Meho and Yang, 2007; Harzing, 2008; Harzing and Van der Wal, 2008]. Nevertheless, the analysis can be repeated using other databases, like Web of Science or Scopus.

One of the major problems encountered in our analysis is represented by homonym authors. In general, authors with common names or authors identified only by the surname and the first name initials – rather than full first name(s) – are subject to this kind of problem. The practical effect is that contributions of different homonym authors are erroneously added up, with the result of "inflating" one author's *h*. Luckily, these "suspected" authors can be detected and then excluded from the analysis quite easily. However, since they represent just a small part of the available information, the loss of information is not significantly relevant for our purpose.

3. Further considerations on the *h*-spectrum

3.1 Author's reputation

We think that *h*-spectrum can be a reliable tool for evaluating a journal at the very moment of the publication, despite the fact that it is based on the publications/citations accumulated before the publication of the examined journal. There are empirical proofs of the fact that citations that a new paper will receive in the future are generally consistent with the citations accumulated by previous papers of the same author, that is to say the *author's reputation* [Castillo et al., 2007]. Being the number of authors per journal quite large (typically more than fifty authors per year, as shown in Fig. 2), it is reasonable to assume that the authors' reputation will be generally respected.

3.1 information content of *h*-spectrum

h-spectrum represents a "snapshot" of the author population of a specific journal and can be a reference for researchers within the area of interest (Quality Engineering/Quality Management in this case). Assuming that an academic researcher with *h*=3 compares himself with the authors of a journal in 2008, what is the result? Using the *h*-spectra shown in Fig. 1, he will fall on the 32nd percentile of the JQT *h*-spectrum, the 50th percentile of the QE *h*-spectrum, the 37th percentile of the QQ *h*-spectrum and so on. Thus, *h*-spectrum can be interpreted as a kind of "identity card" for scientific journals, since it provides indications about the authors who populate it.

Examining the *h*-spectrum, we can observe some practical effects of the strategic choices of one journal's editorial board. For instance, in spite of being a very prestigious and popular journal in the Quality area, QP has a more left-adjusted *h*-spectrum than the other journals. The reason is that it is open to eminent professionals and industrial managers, with enviable professional careers in the industry, but with relatively low *h*-indexes.

3.2 *h*-spectrum as a complement to ISI-IF

It is worthwhile remarking the difference between *h*-spectrum, which is related to the reputation of one journal's authors, and ISI-IF (or other traditional bibliometric indicators), which is related to the citations effectively accumulated by one journal's articles. Generally speaking, the academic reputation of a journal's author group is not the equivalent of the reputation of the journal, as well as not the equivalent of the influence of the journal. For this reason, these different indicator typologies represent two complementary ways to evaluate/compare scientific journals. For example, a combined use of *h*-spectrum and ISI-IF can be performed for identifying the following situations:

1. Journals with average authors' reputation (in terms of $\bar{h}$ values) but few received citations. This can be the case of relatively recent journals which are still struggling to become popular in the scientific community. Otherwise, in a worse case, they can be "second-choice" journals, that is to say journals representing an "accessible deposit" for low-grade scientific works that other more scrupulous journals tend to reject.
2. Journals containing articles with a high number of citations, submitted by (co-)authors with low *h*-indexes. This can be the case of journals open beyond the academic world, for instance to professionals and industrial managers (like QP, as mentioned before). Alternatively, they can be journals with a relatively large group of young (co-)authors, consisting of brilliant young researchers with relatively low citation indexes.

Furthermore, the common points of critique on the ISI-IF do not necessarily hold for *h*-spectrum, due to the different nature of these indicators. Here is presented a brief description of the major ones.

- As well as ISI-IF, *h*-spectrum should not be used for comparing journals of different disciplines owing to the different citation rates [Amin and Mabe, 2000; Antonakis and Lalive, 2008].
- Differently from ISI-IF, *h*-spectrum can cover every journal (not only those indexed by Thomson Scientific).
- *h*-spectrum can be calculated at the very moment of the journal publication, while ISI-IF can not be calculated sooner than one-two years after the publication.
- The ISI-IF's variability is related to the size of the journal, in terms of articles published per annum. Small titles (less than 35 papers per annum) on average vary in ISI-IF by more than +/-40% from one year to the next, while larger titles (more than 150 articles per annum) have a smaller fluctuation of +/-15% [Amin and Mabe, 2000]. On the other hand, *h*-spectrum's variability does not seem to be influenced by the size of the journal. Fig. 3 show that s roughly depends on $\bar{h}$ (s is generally a bit larger than $\bar{h}$), which seems to be independent on the number of articles.

If on the one hand, *h*-spectrum does not suffer from many of the previous criticisms, on the other hand, it has the potential problem that – being based on *h*-index – it could be subjected to the criticisms made to *h*-index itself. Here follows a list of the most typical points. Many of them are generally true for any indicator in citation analysis.

- *h* does not take into account multiple co-authorship [Burrell, 2007a; Schreiber, 2008].
- *h* does not take into account self-citations [Schreiber, 2007; Burrell, 2007a].
- *h* is not useful for cross-disciplinary comparisons because citation rates and scholarly productivity vary considerably among disciplines (e.g. physics, medicine, engineering) [Antonakis and Lalive, 2008; Batista et al., 2006; Braun et al., 2006].

- *h* does not take into account the age of publications [Sidiropoulos et al., 2007]. In theory, it would make sense giving more weight to most recent articles of a scientist and less weight to the eldest [Sidiropoulos et al., 2007].
- *h* is unfavourable to young brilliant scientists with few highly diffused articles [Sidiropolous, 2007].
- *h* does not consider the publication type. For example review articles, open access articles, papers addressing "hot topics" or in fields shared by large communities will often receive far more citations than other papers, all other things being equal [Castillo et al., 2007].
- the *h*-index for a scientist can be easily calculated by using public databases like WoS or GS [Meho and Yang, 2007]. Unfortunately, their information can be affected by citation errors – for instance caused by homonymous author names, typographical errors in the source papers, or errors due to some nonstandard reference formats [Bornmann and Daniel, 2007; Harzing and van der Wal, 2008].

Being *h*-spectrum constructed considering a rather large number of (co-)authors (generally larger than 60, as seen in Fig. 5), most of the possible "distortions" – consequent upon the use of *h* – reasonably compensate each other. In other words, the effect of self-citation, multiple authorship, different age of publications, different age of authors and database should reasonably be spread over the (co-)authors, and there is no realistic reason why the *h*-spectrum of one journal should be more (un)biased than that of another journal. In our opinion, the extent of these problems become more important when evaluating and comparing a small number of scientists (e.g. 5-10), using *h* alone.

Due to its characteristics of robustness, easy calculation, immediate intuitive meaning and synthesis, *h* is the most suitable indicator for the construction of our journal-spectrum. The fact remains that it could be constructed on the basis of other indicators, which are not affected by (some) of the previous problems. For example, another spectrum could be based on the *h*-rate or AR-index – two *h*-based indicators, which do not favour scientists with long careers [Burrell, 2007b; BiHui et al., 2007].

4. Open issues

Several ideas for further research activities may originate from this work. Here follows a list of the most interesting ones:

- Repeating the analysis using other databases (i.e. Web of Science, Scopus or the DBLP digital library), so as to investigate possible differences in the results.
- Introducing a weighting system for author contribution, which takes account of multiple authorships and (co-)authors with multiple papers in the same period of interest, when determining the *h*-spectrum of a journal.
- Building a software application so as to automatically query GS and construct the *h*-spectrum for a specific journal and a specific year. This automatic procedure should include a proper filter to identify and remove "suspected" authors, with erroneous or nonsensical *h*-values.
- Building a mathematical model representing the *h*-spectrum.

- Extending the use of *h*-spectrum beyond scientific journals, so as to evaluate and compare academic research groups, university departments or – more in general – organizations made up of scientists, on the basis of their scientific reputation [Chapman, 2009].

5. Conclusions

The main novelty of this paper is the introduction and discussion of the *h*-spectrum, a new tool – based on the *h*-index – that can be used for three major purposes: (i) providing a reference for the (potential) authors of a scientific journal; (ii) performing rough comparisons between different journals within the same scientific field (journal academic reputation); (iii) helping a journal's editorial staff to periodically monitor the effect of the paper selecting policy.

The results of a preliminary analysis, which is carried out considering ten journals in the Quality Engineering and Quality Management field, are shown. It is interesting to observe that the *h*-spectrum has a peculiar shape and it is rather robust over the years.

Being based on the reputation of one journal's authors, *h*-spectrum can be used to complement other traditional indicators, such as the ISI-IF or the *h*-index for journals, which are related to the citations effectively accumulated by one journal's articles. The *h*-spectrum can be calculated for each journal (not necessarily those indexed by Thomson Scientific) at the very moment of the journal publication – differently from the ISI-IF, that is calculated one-two years after the publication.

Several ideas for further research activities may originate from this work. In particular, it would be interesting to extend the analysis to a wider set of journals, considering a wider time horizon, and to build a mathematical model representing the *h*-spectrum.

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