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New journal classification methods based on the global h-index

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ABSTRACT

In this work we develop new journal classification methods based on the h-index. The introduction of the h-index for research evaluation has attracted much attention in the bibliometric study and research quality evaluation. The main purpose of using an h-index is to compare the index for different research units (e.g. researchers, journals, etc.) to differentiate their research performance. However the h-index is defined by only comparing citations counts of one's own publications, it is doubtful that the h index alone should be used for reliable comparisons among different research units, like researchers or journals. In this paper we propose a new global h-index (Gh-index), where the publications in the core are selected in comparison with all the publications of the units to be evaluated. Furthermore, we introduce some variants of the Gh-index to address the issue of discrimination power. We show that together with the original h-index, they can be used to evaluate and classify academic journals with some distinct advantages, in particular that they can produce an automatic classification into a number of categories without arbitrary cut-off points. We then carry out an empirical study for classification of operations research and management science (OR/MS) journals using this index, and compare it with other well-known journal ranking results such as the Association of Business Schools (ABS) Journal Quality Guide and the Committee of Professors in OR (COPIOR) ranking lists.

1. Introduction

Journal evaluation is a heated topic in bibliometrics. Previous studies have concentrated on journal evaluation approaches. Two major approaches have been studied theoretically and applied practically. The first approach is called peer review, whereby a survey or questionnaire is designed for collecting opinions from experts in bibliometrics (Chandy, Ganesh, & Henderson, 1991). A series of well-known journal ranking lists have been generated using this approach, such as the recently published COPIOR journal list (COPIOR, 2011), which was produced by the UK Committee of Professors in Operations Research. In total, 68 journals in operations research and management science (OR/MS) were categorized into 4 groups from rank 4 (the highest quality) to rank 1 (the lowest quality).

The second journal evaluation approach consists of bibliometric methods, also known as quantitative methods. Journal impact factor (JIF), the most well-known and commonly used indicator to rank scientific journals, was suggested by Garfield (1972). The JIF indicator calculates the average number of citations for certain papers (articles, reviews and letters) published in specified journals over a two-year evaluation window. The JIF indicator has attracted much attention

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(Glänzel & Moed, 2002; Whitehouse, 2001; Yu, Wang, & Yu, 2005), and the well-known online database Web of Science's (WoS) Journal Citation Report (JCR) employs the JIF indicator to select journals for input into the JCR database.

More recently, the h-index was introduced. Currently regarded as a milestone method of research evaluation, h-index applications extend across multiple levels, from the assessment of individual researchers to academic journals. In 2006, (Braun, Glanzel, & Schubert, 2006) suggested and defined the h-index for journal evaluation as follows:

> "*Retrieving all source items of a given journal from a given year and sorting them by the number of times cited, it is easy to find the highest rank number which is still lower than the corresponding 'Times Cited' value. This is exactly the h-index of the journals for the given year.*"
>
> [Braun et al., 2006]

In practice, the h-index is widely used for journal evaluation and is studied extensively in the literature (Harzing & van der Wal, 2009; Saad, 2006). Although an h-index can be computed by using one's own publications of a person or a journal quite easily, its interpretation is clearer by using the so called h-core which has been much investigated in the literature. According to Burrell (2007), *the h-index seeks to identify the most productive core of an author's output in terms of most received citations. This most productive set we refer to as the Hirsch core, or h-core*. In other words, h-core refers to all the publications whose citations are greater than or equal to the h-index.

Clearly the problem with this kind of definitions is that the size of an h-core (e.g., the number of publications in an h core) may be greater than its h-index. In this paper unless specifically stated otherwise, we adopt the second kind definition: *All publications ranked between rank 1 and rank h form the Hirsch core. If there are several publications with the same number of citations, one ranks the articles with the same number of citations in anti-chronological order so that more recent articles have a larger probability to belong to the Hirsch core than older ones* (Cabrerizo, Alonso, Herrera-Viedma, et al., 2010; Liu & Rousseau, 2009). Thus an h-core consists of exactly *h* elements if using this kind of definitions.

Using the h-core, we can further discuss some issues of the h-index. The main purpose of using an h-index is to compare the index for different research units (e.g. researchers, journals, etc.) to differentiate their research performance. However let us note that an h-index is defined by only making comparison among the citations counts of one's own publications. This naturally raises one question: can h-index be reliably used for comparisons among different research units, like researchers or journals? For example, if two researchers or journals have the same h-index, does that mean that they will in fact be "equal" in terms of research quality? Clearly the answer is negative: Take an extreme example, unlike the other indexes such as citation counts, the h-index of a publication is always one! To make an h-index work, it needs peers for comparisons: the more and the better! Although its discrimination power gradually increases as the number of publications in the units does, this inherited weakness remains in the index. In this context we shall have a close examination of the citation distribution within the h-core. Suppose h-indexes of Journal A and B are 4 and 6 respectively, and their h-core papers have citations of 4;4;4;4 and 6;6;6;6;6;6 respectively. In this case clearly journal B dominates Journal A. However their h core papers could also have citations of 12;12;12;12, and 6;6;6;6;6;6 instead. In the 2nd case it is unclear that Journal B should dominate Journal A. Clearly h-index itself could not tell which cases they are. However if we gather those ten papers together (we call it the global set) and re-compute the h-index (we call it the global h index) and rebuild the h-core (we call it the global h core), we notice that in the 1st case the papers in the global h core have citations of 6;6;6;6;6;6 (12;12;12;12;6;6 in the 2nd case), all from Journal B (two from Journal B and four from Journal A in the 2nd case). Thus we may conclude that in the 1st case the qualities of the Journal A's h-core papers are lower than those of the Journal B's h-core papers, while in the 2nd case the qualities of the Journal A's h-core papers are higher than those of Journals B's h-core's. It occurs to us that by comparing the number of papers within the global h core and its own h core, one can more reliably differentiate research performance among different research units (e.g. researchers, journals, etc.). This motivates us to introduce the global h-index and global h-core for research assessment, which will be discussed in details in the follows.

This paper is organized as follows: in the next section, we discuss the definition and theoretical basis of the Gh-index; next, we extend the definition of the Gh-index to improve its discrimination power on large samples; we then consider how the Gh-index can be used for evaluating the quality of journals and carry out an empirical study of OR/MS journals, comparing our results with those generated by peer review in the ABS and COPIOR ranking lists. In particular we show how we can develop an automatic way of classifying journals into groups without having to specify arbitrary cut-off points by comparing the Gh-index with the h-index. A discussion and conclusion are given in the final section.

2. Introduction of the Gh-index

As mentioned before, by building the global set and the global h index and global h core, we can have a clearer understanding on the individuals' performance. Our idea is simply to integrate all assessed items (researchers or journals) as a global set and undertake the comparisons between the global h core and the original h core.

In particular, we define the Gh-index as follows:

Assuming all compared outputs are collected together and arranged in descending citation order, the global h-index and global h-core (i.e., the GH-index and GH-core) are calculated in the usual way. The Gh-index of unit i (i.e., Gh^i) is then the number of unit i's items included in the GH-core.

Taking individual researchers as an example, we can formally write the formula of the Gh-index as follows:
We assume

$\{p^i\}$ is the publication set of researcher i;
$\{c(p^i)\}$ is the citation set of $\{p^i\}$;
h^i is the h-index of researcher i;
h^i-*core* is the h-core of researcher i;
GH is the h-index of the global unit (i.e., $\cup_{i=1}\{p^i\}$);
GH-*core* is the h-core of the global unit.

Therefore, the Gh^{i}-core and Gh^{i}-index are defined as follows:

$$\mathrm{Gh}^i\text{-core} = \{\{p^i\} : c(p^i) \geqslant \mathrm{GH}\} \tag{1}$$

$$\mathrm{Gh}^i = \sum_{m=1}^{n} \sin g(c(p^i_m) - \mathrm{GH}), \text{ where } \sin g(x) = \begin{cases} 1, & x \geqslant 0 \\ 0, & x < 0 \end{cases}$$

where n is the total number of publications of researcher i.

Because all assessed units' publications are integrated into a global unit, all compared publications share the same comparison reference (the GH-core). Obviously, this idea can be applied to other assessed units as long as they share similar characteristics, such as scientific journals in the same field. In the following section, we present some observations and a theoretical analysis of the relationship between the Gh-index and the original h-index to clarify this idea. Properly speaking, therefore, the Gh-index is always defined only for a particular unit whereas the GH-index refers to all assessed units.

2.1. Some observations

In this section, we investigate the empirical properties of the Gh-index. We use previously applied data (Egghe, 2006; Glänzel & Persson, 2005) based on several Price Medalists in bibliometrics that were formerly used to examine well-known bibliometric indicators such as the h-index and g-index. With the data provided, we can construct the GH-core shown in Fig. 1.

Due to the large sample size, only part of the GH-core is visually presented in Fig. 1. From the definition of the GH-core and the graph, we see that the GH-core is actually built using publications from all assessed researchers. For this data, the GH-index is actually 60, i.e., taking all researchers into account, there are 60 papers with at least 60 citations. Fig. 2 shows the citation profile of the top 20 papers of four representative researchers: *Researchers* 1, 3, 7 and 11. Let us now have a closer examination of how to calculate the individual Gh-indexes.

At GH = 60, it is not surprising that *Researcher* 11's Gh-index is zero because his/her highest number of citations are below 60. On the other hand, the number of citations of each of the top 20 papers of *Researcher* 1 are higher than 60; therefore, these 20 papers are all included in the GH-core. We further calculated the Gh-index for each researcher as well as other indicators (e.g., the total publications N, the h-index and the g-index). The results are shown in Table 1, sorted in descending order of the h-index.

First, a larger value of Gh index of *Researcher* 1 indicates that this researcher has more "high standard" papers included in the GH core than *Research* 2 comparing globally, although they have the same h indexes. We also notice that some

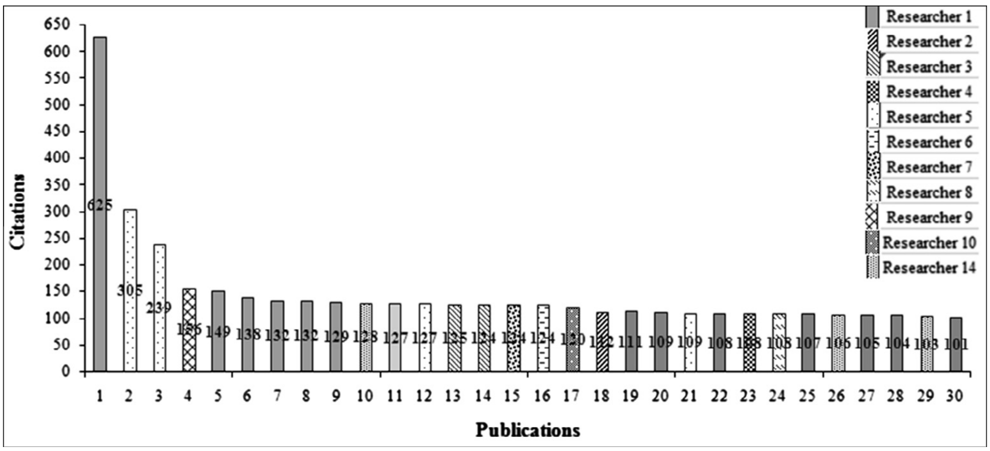

Fig. 1. Part of the GH-core for Price Medalists. *Note:* GH = 60.

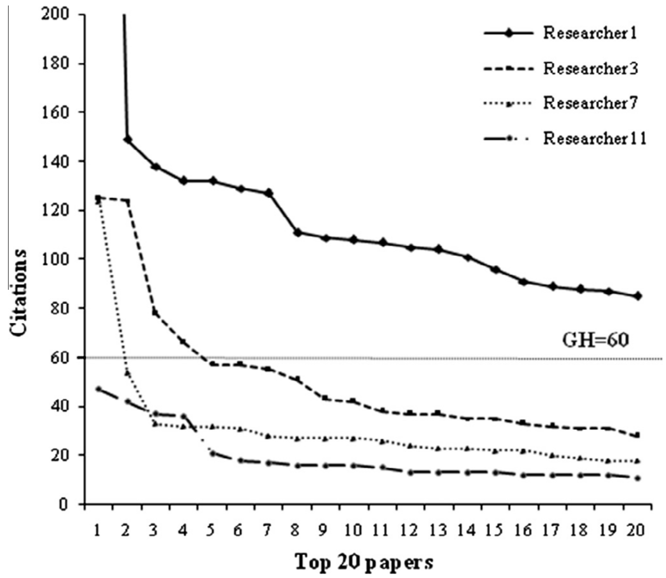

Fig. 2. Citation profiles of the top 20 papers of four representative researchers.

Table 1
Indicators of Price Medalists in bibliometric area (Egghe, 2006; Glänzel & Persson, 2005).

Researchers	N	Rank (N)	h	Rank (h)	g	Rank (g)	Gh	Rank (Gh)	Gh_{adj}	Rank (Gh_{adj})
Researcher 1	60	1	27	1	59	1	23	1	35	2
Researcher 2	41	2	27	1	40	2	8	3	32	3
Researcher 3	39	4	25	3	38	4	4	4	39	1
Researcher 4	28	6	19	4	27	6	1	9	21	4
Researcher 5	40	3	18	5	39	3	9	2	18	7
Researcher 6	31	5	18	5	30	5	3	6	19	6
Researcher 7	28	6	18	5	27	6	1	9	20	5
Researcher 8	28	6	18	5	27	6	1	9	17	8
Researcher 9	28	6	16	9	27	6	2	8	15	9
Researcher 10	27	10	13	10	26	10	4	4	10	10
Researcher 11	20	12	13	10	19	12	0	13	5	13
Researcher 12	20	12	13	10	19	12	1	9	7	12
Researcher 13	16	14	13	10	15	14	0	13	3	14
Researcher 14	26	11	12	14	25	11	3	6	9	11

researchers have more "less qualified" papers when comparing globally such as *Research* 7 and 8. On the other hand, we find that several researchers have low Gh-index, including zero. Note that these are top researchers; low values would be even more prevalent with a group of average researchers. Low values also occur very frequently when we apply the Gh-index to journals; indeed, many journals will share a zero value. The reason is that the number of publications may be significantly higher than the citation counts – an increasing number of papers are published, but the citation counts do not increase proportionally. This is partly because of the obsolescence effect – as they age, papers become less relevant and, thus, the number of citations decreases for these papers. The result is that the number of papers and the number of citations have different scales. For instance, for Price Medalists, the total annual publication number of the 14 researchers is 432, but the GH-index for these journals is 60, indicating that only 60 papers from 14 researchers are included in the global core. Thus, it is not surprising that many researchers have low Gh-indexes, including zero. One possible remedy is to reduce the rapid increase in the publication number by rescaling it. We can then introduce a modified Gh-index: the Gh_{adj}-index. We define the GH_{adj}-index as follows:

$$
\begin{aligned}
&GH_{adj} = n^* \\
&\text{iff } c(n^*) \geqslant (n^*)^\alpha \text{ and } c(n^*+1) < (n^*+1)^\alpha \\
&\text{where } 0 < \alpha < 1
\end{aligned}
\tag{2}
$$

Similarly, we can then define the GH_{adj}-core and the individual Gh_{adj}-index. The reason we use the parameter α is to allow us to alter the extent of the rescaling. Because α is between 0 and 1, it provides a way to reduce the speed of increase of the publication number and therefore leads to a larger Gh-index (the Gh_{adj}-index). There is obviously an issue concerning what value to give this parameter and our suggestion is to adjust the α so that the GH_{adj}-index is equal to the sum of the h-indices of all assessed units, so there is a fixed point related to the h-index values of the units under assessment. What we are essentially doing is reducing the number of citations that a paper needs to have in order to appear in the GH_{adj}-core, thereby increasing the number of papers that are actually in the core. In the Price Medalists case, we increase the number of papers until the corresponding GH_{adj} equals 250, the total of the h-indices of the researchers in Table 1. In this particular example, α is set to 0.5234, and the number of citations needed decreases to 18, see Table 1.

It is clear that the new index is more discriminatory in comparison to both the Gh-index and the original h-index – all of the researchers now have a different value of the Gh_{adj}-index. At the meantime, due to the increase of the adjusted GH core, more papers from individual researchers are included in the GH core by comparing globally, which are reflected from larger Gh_{adj} indexes for all researchers. Furthermore, we find out the interesting relationship between one's h index and Gh_{adj} index, some is larger (see *Researcher* 10), and some is smaller (see *Researcher* 1) and some is equal (see *Researcher* 5). This is not a coincidence and provides a mechanism for research output quality classification, which we will explore it in the following sections. Here let us emphasize that the main focus of this paper is not on the global h index itself but rather on combination of the global and the original h indexes to obtain extra performance information, as to be seen below.

2.2. Theoretical analysis

In this section, we explore the relationship between the h-index and the Gh-index and deduce the following two properties which are useful for our journal classification.

Property 1. For any two journals i and j, if $Gh^j < h^j$, $h^i < h^j$, we have $Gh^i \leqslant h^i$. The same relationship holds for the Gh_{adj}-index.

We will prove it by contradiction. We provide the proof for the Gh-index below; it also works for the Gh_{adj}-index.

Proof.

If $Gh^i > h^i$

$\Rightarrow h^i\text{-core} \cup \{p^{h^i+1}\} \subset \text{GH-core} \quad (1)$

According to the definition the h-index

$\forall p^i \in h^i\text{-core} \Rightarrow c(p^i) \geqslant h^i$

$\forall p^j \in h^j\text{-core} \Rightarrow c(p^j) \geqslant h^j$

Note that $h^i < h^j$. If $h^i = \min_{p^i \in h^i\text{-core}} c(p^i)$,

Then $\min_{p^j \in h^j\text{-core}} c(p^j) \geqslant h^j > h^i = \min_{p^i \in h^i\text{-core}} c(p^i) \quad (2)$

According to (1) and (2)

$h^j\text{-core} \in \text{GH-core}$

$\therefore Gh^j \geqslant h^j$, and this is a contradiction

If $h^i < \min_{p^i \in h^i\text{-core}} c(p^i)$, then $c(p^{h^i+1}) \leqslant h^i < h^j \leqslant \min_{p^j \in h^j\text{-core}} c(p^j)$

This and (1) imply $h^j\text{-core} \in \text{GH-core}$

This is in conflict with the assumption

End of Proof.

Property 2. For any two journals i and j, if $\mathrm{Gh}^{j}_{\mathrm{adj}} > \mathrm{h}^{j}$, $\mathrm{h}^{i} > \mathrm{h}^{j}$ we have $\mathrm{Gh}_{\mathrm{adj}}{}^{i} \geqslant \mathrm{h}^{i}$.

Proof.

According to the definition of h-index

$\forall p^{j} \in \mathrm{h}^{j}\text{-core} \Rightarrow c(p^{j}) \geqslant \mathrm{h}^{j}$
$\forall p^{i} \in \mathrm{h}^{i}\text{-core} \Rightarrow c(p^{i}) \geqslant \mathrm{h}^{i}$
Note that $\mathrm{h}^{i} > \mathrm{h}^{j}$. If $\mathrm{h}^{j} = \min_{j \in \mathrm{h}^{j}\text{-core}} c(p^{j})$

Then $\underset{p^{i} \in \mathrm{h}^{i}\text{-core}}{c(p^{i})} \geq \mathrm{h}^{i} > \mathrm{h}^{j} = \min_{j \in \mathrm{h}^{j}\text{-core}} c(p^{j}) \quad (1)$

$\because \mathrm{Gh}^{j}_{\mathrm{adj}} > \mathrm{h}^{j}$

$\therefore \mathrm{h}^{j}\text{-core} \in \mathrm{GH}_{\mathrm{adj}}\text{-core} \quad (2)$

According to (1) and (2)

we have h^{i}-core $\in \mathrm{GH}_{\mathrm{adj}}$-core, $\therefore \mathrm{Gh}_{\mathrm{adj}}{}^{i} \geqslant \mathrm{h}^{i}$

If $\mathrm{h}^{j} < \min_{j \in \mathrm{h}^{j}\text{-core}} c(p^{j})$, $c(p^{\mathrm{h}^{j}+1}) \leqslant \mathrm{h}^{j}$.

Since $\mathrm{Gh}^{j}_{\mathrm{adj}} > \mathrm{h}^{j}$, $\mathrm{h}^{j}\text{-core} \cup \{p^{\mathrm{h}^{j}+1}\} \in \mathrm{GH}_{\mathrm{adj}}\text{-core}$.

Then $\underset{p^{i} \in \mathrm{h}^{i}\text{-core}}{c(p^{i})} \geqslant \mathrm{h}^{i} > \mathrm{h}^{j} \geqslant c(p^{\mathrm{h}^{j}+1})$.

Thus we have h^{i}-core $\in \mathrm{GH}_{\mathrm{adj}}$-core
$\mathrm{Gh}_{\mathrm{adj}}{}^{i} \geqslant \mathrm{h}^{i}$
End of Proof.

The above proof shows the monotonic property of the Gh-index ($\mathrm{Gh}_{\mathrm{adj}}$-index) that will be applied later in our journal classification.

3. The $\mathrm{Gh}_{\mathrm{adj}}$-index and journal classification

3.1. The Global h-index for journal ranking

We next carried out an empirical study with a larger sample consisting of 64 journals in operational research and management science (OR/MS) using data from the Journal Citation Report (JCR2011). We collected five-year basic bibliometric data such as total publications (N), total citations (TC), the 5-year journal impact factor (JIF_5), the h-index and the g-index from Web of Science for a long-term investigation. The collection occurred during May 2012. Furthermore, we calculated the Gh-index and $\mathrm{Gh}_{\mathrm{adj}}$-index for each of the journals for comparison to well-known major bibliometric indicators. In our study, the sum of the h-indices of all 64 journals was 685, and α was adjusted to 0.4717. To ease the data collection, we adopted the first kind definition of the h-core. The results are shown in Appendix A, which is sorted in descending order of the JIF_5, currently one of the commonly used indicators for journal evaluation.

The Appendix A shows that the JIF_5-based rank and the Gh-index ($\mathrm{Gh}_{\mathrm{adj}}$-index)-based rank provide different views on journal quality assessment. In particular, the JIF_5, which is essentially a citations-per-paper measure, ignores the number of papers and thus the overall total contribution, while all the variants of the h-index favor journals with large numbers of papers. We have highlighted the top 5 in each case, and the only journal in common is *Management Science*. The top 5 according to the JIF_5 all have relatively few papers (less than 500), while four of the top 5 according to the $\mathrm{Gh}_{\mathrm{adj}}$-index all have over 1000 publications. Some journals are ranked considerably lower according to the $\mathrm{Gh}_{\mathrm{adj}}$-index, e.g., *Manufacturing & Service Operations*, *Transport Research E*, and *OR Spectrum*. We have calculated the correlation coefficients between well-known bibliometric indicators in Table 2.

This confirms that the h-indices are all highly correlated with the total citation number and each other but are less correlated with the JIF_5. The $\mathrm{Gh}_{\mathrm{adj}}$-index is the most highly correlated with the other indices, but it is less correlated with the JIF_5 than the others. We next compared the values of the h-index and the $\mathrm{Gh}_{\mathrm{adj}}$-index for each of the journals and the result is shown in Table 3, ranked in descending order of the h-index.

In terms of discriminatory power, we can see that the $\mathrm{Gh}_{\mathrm{adj}}$-index is better, at least for the higher ranked journals. The h-index begins to yield tied values from approximately rank 12 onwards, while the $\mathrm{Gh}_{\mathrm{adj}}$-index maintains discrimination until around rank 33 where the values approach zero.

Table 2
Correlations of some indicators of OR/MS journals.

		N	TC	JIF_5	h	g	GH	Gh_{adj}
N	Pearson correlation	1						
	Sig. (2-tailed)							
	N	64						
TC	Pearson correlation	.948(**)	1					
	Sig. (2-tailed)	.000						
	N	64	64					
JIF_5	Pearson correlation	.256(*)	.406 (**)	1				
	Sig. (2-tailed)	.046	.001					
	N	61	61	61				
h	Pearson correlation	.788(**)	.877(**)	.674(**)	1			
	Sig. (2-tailed)	.000	.000	.000				
	N	64	64	61	64			
g	Pearson correlation	.742(**)	.849(**)	.665(**)	.987(**)	1		
	Sig. (2-tailed)	.000	.000	.000	.000			
	N	64	64	61	64	64		
Gh	Pearson correlation	.801(**)	.904(**)	.274(**)	.729(**)	.731(**)		
	Sig. (2-tailed)	.000	.000	.032	.000	.000		
	N	64	64	61	64	64		
Gh_{adj}	Pearson correlation	.886(**)	.976(**)	.492(**)	.897(**)	.884(**)	.880(**)	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	
	N	64	64	61	64	64	64	64

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 3
The h- and Gh_{adj}-indices of OR/MS journals.

Abbreviated journal title	h	Rank (h)	Gh_{adj}	Rank (Gh_{adj})	Abbreviated journal title	h	Rank (h)	Gh_{adj}	Rank (Gh_{adj})	Abbreviated journal title	h	Rank (h)	Gh_{adj}	Rank (Gh_{adj})
EUR J OPER RES	34	1	138	1	INT J SYST SCI	10	23	7	22	OPTIM CONTR APPL MET	7	44	2	33
EXPERT SYST APPL	24	2	83	2	J QUAL TECHNOL	10	23	7	22	PROBAB ENG INFORM SC	7	44	2	33
MANAGE SCI	24	2	71	3	COMPUT OPTIM APPL	10	23	6	25	PROD PLAN CONTROL	7	44	1	41
INT J PROD ECON	22	4	52	5	ENG OPTIMIZ	10	23	6	25	CONCURRENT ENG-RES A	7	44	0	50
COMPUT OPER RES	21	5	56	4	J SCHEDULING	10	23	5	27	INT J TECHNOL MANAGE	7	44	0	50
SYST CONTROL LETT	20	6	32	7	TRANSPORT RES E-LOG	10	23	3	30	MATH METHOD OPER RES	7	44	0	50
OMEGA-INT J MANAGE S	19	7	36	6	MATH OPER RES	10	23	2	33	OPTIMIZATION	7	44	0	50
DECIS SUPPORT SYST	18	8	31	8	OPER RES LETT	10	23	2	33	APPL STOCH MODEL BUS	6	52	1	41
J OPER MANAG	18	8	22	9	INFORMS J COMPUT	9	31	4	28	NETW SPAT ECON	6	52	1	41
MATH PROGRAM	16	10	21	10	NETWORKS	9	31	4	28	ASIA PAC J OPER RES	6	52	0	50
OPER RES	16	10	17	13	QUEUEING SYST	9	31	3	30	DISCRETE EVENT DYN S	6	52	0	50
PROD OPER MANAG	15	12	18	11	INT J INF TECH DECIS	9	31	2	33	DISCRETE OPTIM	5	56	0	50
TRANSPORT RES B-METH	15	12	18	11	OPTIM ENG	9	31	2	33	INT J FLEX MANUF SYS	4	57	1	41
INT J PROD RES	15	12	17	13	M&SOM-MANUF SERV OP	9	31	1	41	INFOR	4	57	0	50
TECHNOVATION	15	12	16	15	QUAL RELIAB ENG INT	8	37	3	30	OPTIM LETT	4	57	0	50
RELIAB ENG SYST SAFE	14	16	12	16	SAFETY SCI	8	37	2	33	TOP	4	57	0	50
J GLOBAL OPTIM	14	16	10	20	INT J COMPUT INTEG M	8	37	1	41	J MANUF SYST	3	61	0	50
J OPER RES SOC	13	18	12	16	J IND MANAG OPTIM	8	37	1	41	J OPER RES SOC JPN	3	61	0	50
J OPTIMIZ THEORY APP	13	18	11	19	NAV RES LOG	8	37	1	41	MIL OPER RES	3	61	0	50
ANN OPER RES	13	18	7	22	OR SPECTRUM	8	37	1	41	RAIRO-OPER RES	2	64	0	50
TRANSPORT SCI	12	21	12	16	OPTIM METHOD SOFTW	8	37	0	50					
IIE TRANS	12	21	9	21	INTERFACES	7	44	2	33					

One can claim that there is no need to discriminate very closely between individual journals (or researchers) but that, rather, it is only necessary to categorize them into groups; thus, we will now introduce a method for doing this. By comparing the Gh_{adj}-index with the h-index, it is interesting to observe that the Gh_{adj}-indices of many top journals are larger than their h-indices. This indicates that their Gh-cores are larger than their h-cores due to the relatively higher quality of their publications in the global comparison. In other words, the better journals will have a greater proportion of the GH-core papers than the others. Thus, it should to possible to classify journals by the difference between their Gh_{adj}-indices and h-indices; this will be discussed in detail below.

Table 4
X_j journal classifications based on the Gh_{adj}- and h-index.

X_j journal classifications	Conditions
Class 4	$\{Gh^i_{adj} > h^i\}$
Class 3	$\{Gh^i_{adj} = h^i\}$
Class 2	$\{Gh^i_{adj} < h^i \text{ and } Gh^i_{adj} > 0\}$
Class 1	$\{Gh^i_{adj} = 0\}$

Table 5
Journal ranks in ABS2010 Journal Quality Guide (ABS, 2011).

Journal ranks	Meaning
Class 4	Those journals should publish the most original and rigors research. Normally they have high submissions, low journal acceptance rate and high citation impact within their fields
Class 3	Those journals publish original and well executed papers. Typically they have a good amount of submissions, well selection about publications, and a fair good citation impact within their fields as well, although some do not carry an impact factor currently
Class 2	Those journals publish original research which is at acceptable standards. Journals have modest citation impact or do not have one at all
Class 1	Journals in this category publish research in a recognized standard. Few journals carry a citation impact factor

Table 6
X_j Class, ABS and COPIOR journal ranking lists.

Abbreviated journal title	ABS Class	COPIOR Class	X_j Class	Abbreviated journal title	ABS Class	COPIOR Class	X_j Class	Abbreviated journal title	ABS Class	COPIOR Class	X_j Class
J OPER MANAG	4	na	4	RELIAB ENG SYST SAFE	3	3	2	OPTIM CONTR APPL MET	na	na	2
MANAGE SCI	4	4	4	TRANSPORT RES E-LOG	3	na	2	OPTIM ENG	na	na	2
OPER RES	4	4	4	COMPUT OPER RES	2	3	4	PROBAB ENG INFORM SC	na	na	2
TRANSPORT RES B-METH	4	4	4	ANN OPER RES	2	3	2	QUAL RELIAB ENG INT	na	na	2
DECIS SUPPORT SYST	3	3/4	4	INT J COMPUT INTEG M	2	na	2	QUEUEING SYST	na	na	2
EUR J OPER RES	3	4	4	INT J FLEX MANUF SYS	2	na	2	SAFETY SCI	na	na	2
EXPERT SYST APPL	3	na	4	INTERFACES	2	2	2	ASIA PAC J OPER RES	na	1	1
INT J PROD ECON	3	3/4	4	J OPTIMIZ THEORY APP	2	2	2	CONCURRENT ENG-RES A	na	na	1
INT J PROD RES	3	2	4	OPER RES LETT	2	1	2	DISCRETE EVENT DYN S	na	na	1
MATH PROGRAM	3	4	4	INT J TECHNOL MANAGE	2	na	1	DISCRETE OPTIM	na	na	1
OMEGA-INT J MANAGE S	3	3/4	4	IIE TRANS	1	na	2	INFOR	na	1	1
PROD OPER MANAG	3	na	4	SYST CONTROL LETT	na	na	4	J MANUF SYST	na	na	1
TECHNOVATION	3	na	4	APPL STOCH MODEL BUS	na	na	2	J OPER RES SOC JPN	na	na	1
TRANSPORT SCI	3	4	3	COMPUT OPTIM APPL	na	3	2	MATH METHOD OPER RES	na	2	1
INFORMS J COMPUT	3	3	2	ENG OPTIMIZ	na	na	2	MIL OPER RES	na	na	1
J OPER RES SOC	3	3	2	INT J INF TECH DECIS	na	na	2	OPTIM LETT	na	na	1
J SCHEDULING	3	3	2	INT J SYST SCI	na	na	2	OPTIM METHOD SOFTW	na	1	1
M&SOM-MANUF SERV OP	3	3	2	J GLOBAL OPTIM	na	na	2	OPTIMIZATION	na	1	1
MATH OPER RES	3	4	2	J IND MANAG OPTIM	na	na	2	RAIRO-OPER RES	na	na	1
NAV RES LOG	3	2	2	J QUAL TECHNOL	na	na	2	TOP	na	na	1
OR SPECTRUM	3	2	2	NETW SPAT ECON	na	na	2				
PROD PLAN CONTROL	3	na	2	NETWORKS	na	na	2				

Note: na here indicates that those journals were excluded in related journal ranking systems.

3.2. The introduction of X_j journal classification

Our idea for journal classification is to explore the relationship between the h- and Gh_{adj}-index. In general, given that the GH_{adj}-index is the same as the sum of the individual h-indices of all journals to be assessed, if *journal i* is a good one, it is likely that its Gh_{adj}-index will be larger than its h-index. That is to say, its $Gh_{adj}{}^{i}$-core is larger than its h^i-core by global comparison to the others. Under this assumption, we propose an approach to classifying assessed journals into the four groups in Table 4.

The advantage of this classification is that we do not need to artificially set up any cut-off points (like 5% of the total list).

It is interesting to note that the classes here are quite compatible with but not completely identical to the groups found by ranking via the h-index. For example, if journal *i* is in Class 4 and the h-index of journal *j* is larger than that of journal *i*, then journal *j* is likely to be in Class 4, but it could also be in Class 3 in some (artificial) cases based on Property 2. According to Property 1, the same is true for the journals in Class 2.

Table 7
Correlations among ABS, COPIOR, and X_j classes.

Spearman's rho correlation		ABS Class	X_j Class	COPIOR Class
ABS Class	Correlation coefficient	1.000		
	Sig. (2-tailed)			
	N	33		
X_j Class	Correlation coefficient	.546(**)	1.000	
	Sig. (2-tailed)	.001		
	N	33	64	
COPIOR Class	Correlation coefficient	.612(**)	**.778**(**)	1.000
	Sig. (2-tailed)	.002	.000	
	N	22	28	28

The bold value shows the highest correlation among those variables.
** Correlation is significant at the 0.01 level (2-tailed).

Table 8
Comparisons between X_j Class and L_j Class for OR/MS journals.

Abbreviated journal title	COPIOR Class	X_j Class	L_j Class	Abbreviated journal title	COPIOR Class	X_j Class	L_j Class	Abbreviated journal title	COPIOR Class	X_j Class	L_j Class
COMPUT OPER RES	3	4	4	J OPER RES SOC	3	2	3	QUEUEING SYST	na	2	2
DECIS SUPPORT SYST	3/4	4	4	J OPTIMIZ THEORY APP	2	2	3	SAFETY SCI	na	2	2
EUR J OPER RES	4	4	4	J QUAL TECHNOL	na	2	3	CONCURRENT ENG-RES A	na	1	2
EXPERT SYST APPL	na	4	4	J SCHEDULING	3	2	3	INT J TECHNOL MANAGE	na	1	2
INT J PROD ECON	3/4	4	4	MATH OPER RES	4	2	3	MATH METHOD OPER RES	2	1	2
INT J PROD RES	2	4	4	OPER RES LETT	1	2	3	OPTIM METHOD SOFTW	1	1	2
J OPER MANAG	na	4	4	RELIAB ENG SYST SAFE	3	2	3	APPL STOCH MODEL BUS	na	2	1
MANAGE SCI	4	4	4	TRANSPORT RES E-LOG	na	2	3	INT J FLEX MANUF SYS	na	2	1
MATH PROGRAM	4	4	4	INFORMS J COMPUT	3	2	2	NETW SPAT ECON	na	2	1
OMEGA-INT J MANAGE S	3/4	4	4	INT J COMPUT INTEG M	na	2	2	ASIA PAC J OPER RES	1	1	1
OPER RES	4	4	4	INT J INF TECH DECIS	na	2	2	DISCRETE EVENT DYN S	na	1	1
PROD OPER MANAG	na	4	4	INTERFACES	2	2	2	DISCRETE OPTIM	na	1	1
SYST CONTROL LETT	na	4	4	J IND MANAG OPTIM	na	2	2	INFOR	1	1	1
TECHNOVATION	na	4	4	M&SOM-MANUF SERV OP	3	2	2	J MANUF SYST	na	1	1
TRANSPORT RES B-METH	4	4	4	NAV RES LOG	2	2	2	J OPER RES SOC JPN	na	1	1
TRANSPORT SCI	4	3	3	NETWORKS	na	2	2	MIL OPER RES	na	1	1
ANN OPER RES	3	2	3	OPTIM CONTR APPL MET	na	2	2	OPTIM LETT	na	1	1
COMPUT OPTIM APPL	3	2	3	OPTIM ENG	na	2	2	OPTIMIZATION	1	1	1
ENG OPTIMIZ	na	2	3	OR SPECTRUM	2	2	2	RAIRO-OPER RES	na	1	1
IIE TRANS	na	2	3	PROBAB ENG INFORM SC	na	2	2	TOP	na	1	1
INT J SYST SCI	na	2	3	PROD PLAN CONTROL	na	2	2				
J GLOBAL OPTIM	na	2	3	QUAL RELIAB ENG INT	na	2	2				

Note: na here indicates that those journals were excluded in related journal ranking systems.

We can apply this approach to the same sample of journals for a new journal classification (denoted the *X_j Class*). We use the ABS journal ranking results (denoted the *ABS Class*), as shown in the ABS2010 Journal Quality Guide for reference purposes. The ABS Journal Quality Guide, produced by the Association of Business Schools in the UK, is the most well-known journal ranking system in Europe. Initial journal rankings are proposed based on the journal impact factor from the Web of Science database and modified by experts such as institute administrators, researchers, and journal editors (ABS, 2011). The 4 classes in the ABS2010 Journal Quality Guide are shown in Table 5.

Given that both the *ABS Class* and *X_j Class* results include journals divided into 4 classes, we were interested in observing the relationship and differences between these two ranking results. The results are shown in Table 6, arranged in descending order of the *ABS Class*. Recently, the Committee of Professors in Operational Research (COPIOR) published its own ranking for OR/MS journals because they were unhappy with the ABS ranking. The latest list can be viewed from their official website.[1] The COPIOR ranking result (noted as *COPIOR Class*) is included below for comparison purposes.

By comparing these two journal ranking systems, we see they are quite consistent with respect to journal classification, although the *ABS Class* has a very small number of category 4 journals, which is one of the concerns of COPIOR. The journals that ranked highly in the *ABS Class* are also in the top of the *X_j Class*. Journals absent from the *ABS Class*, which we assume are either irrelevant to the business field or not as important as the others, are all ranked lower in the *X_j Class*. These findings encouraged us to further explore the correlations between these two journal classifications. The results are shown in Table 7.

[1] http://www.copior.ac.uk/Journallist.aspx.

Table 9
Total and average rank differences.

		ABS Class	COPIOR Class	X_j Class	L_j Class
ABS Class	Total rank difference	0			
	Sample size	64			
	Average rank difference	0			
COPIOR Class	Total rank difference	10	0		
	Sample size	20	64		
	Average rank difference	0.5	0		
X_j Class	Total rank difference	23	15	0	
	Sample size	33	26	64	
	Average rank difference	0.697	0.5769	0	
L_j Class	Total rank difference	22	11	21	0
	Sample size	33	26	64	64
	Average rank difference	0.6667	**0.4231**	0.3281	0

The bold value shows the smaller average rank difference when L_j Class is compared with ABS Class and COPIOR Class.

We can see from Table 7 that the X_j *Class* is more consistent with the *COPIOR Class* than with the *ABS Class*, although the *COPIOR Class* does not cover some of the non-OR journals. This suggests that our new journal classification is quite consistent with the views of OR professors, at least those in the UK. We also note that smaller sample sizes may lead to larger correlations.

3.3. The introduction of L_j journal classification

By observing the X_j *Class* journals, it appears that only a few are classified as Class 3. This reminds us that the definition of this class may not be suitable, as the equation $Gh_{adj} = h$ is not very robust. Thus we propose a more robust method for journal classification (noted as L_j *Class*) below.

Using the X_j *Class* results, we remove all the journals in Class 4 from the total journal set. We then apply the above journal classification approach to the remaining journals. This time, the Class 4 journals in the remaining set are classified as Class 3 journals globally, and so on. Eventually, we can classify the journals into 4 separate classes and compare them with the X_j *Class* results, as shown in Table 8 below.

It is clear from Table 8 that the X_j *Class* and L_j *Class* results are consistent with each other. In fact, the Spearman correlation of the two classes is 0.88. Furthermore, Class 3 in the L_j *Class* seems to be more reasonable. It is clear that correlation analysis can provide information on the relationship trends of these rankings, but is not very detailed regarding the actual differences of these rankings. To this end, we carried out an analysis which examines the total difference (the absolute value) between two ranking systems and their average difference. For example, the journal EJOR is ranked 3, 4, 3, and 4 in *ABS Class*, *COPIOR Class*, X_j *Class* and L_j *Class*, respectively. The rank difference between the *ABS Class* and the rest of the three classes are 0, 1, 0, and 1, respectively. We repeat this counting for each of the 64 journals and calculate the total and average rank differences, as shown below in Table 9. Apparently, L_j *Class* and *COPIOR Class* are the most closely related. It seems that the L_j *Class* is more practical.

4. Conclusion

The main purpose of using an h-index is to compare the indexes for different research units (e.g. researchers, journals, etc.) to differentiate their research performance. However an h-index is defined by only comparing citations counts of one's own publications. This naturally raises one question: can h index be reliably applied for comparisons among different research units, like researchers or journals? In this paper, we introduced the global h index and combined it with the original h index to obtain extra performance information. Furthermore, we introduced some variants of the Gh-index in order to address the issue of discrimination power. New journal classification methods are then introduced by comparing the values of the two h-indexes of the journals, while OR/MS journals selected from JCR11 were used for empirical studies and comparison analysis. We found that our new journal classification methods are quite consistent with well-recognized journal ranking systems. We believe that our approach can provide useful insights regarding journal assessment and ranking in the future.

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Appendix A

Major indicators of OR/MS journals in a five-year evaluation window

No.	Abbreviated journal title	JIF_5	Rank (JIF_5)	N	Rank (N)	TC	Rank (TC)	h	Rank (h)	g	Rank (g)	Gh	Rank (Gh)	Gh_{adj}	Rank (Gh_{adj})
1	J OPER MANAG	6.012	**1**	244	34	1388	15	18	8	23	10	1	8	22	9
2	OMEGA-INT J MANAGE S	3.622	**2**	345	21	1880	9	19	7	26	7	1	8	36	6
3	TRANSPORT RES B-METH	3.393	**3**	281	26	1185	18	15	12	20	12	0	15	18	11
4	MANAGE SCI	3.304	**4**	700	7	3897	5	24	**2**	35	**2**	4	**3**	71	**3**
5	TECHNOVATION	2.760	**5**	420	19	1639	12	15	12	18	16	0	15	16	15
6	EXPERT SYST APPL	2.455	6	2452	2	6107	2	24	**2**	32	**3**	4	**3**	83	**2**
7	INT J PROD ECON	2.384	7	1266	4	4215	4	22	**4**	30	**5**	4	**3**	52	**5**
8	M&SOM-MANUF SERV OP	2.356	8	139	50	331	45	9	31	11	35	0	15	1	41
9	DECIS SUPPORT SYST	2.331	9	694	8	2576	6	18	8	25	9	1	8	31	8
10	OPER RES	2.285	10	455	16	1429	14	16	10	20	12	0	15	17	13
11	EUR J OPER RES	2.277	11	3329	1	11,999	1	34	**1**	45	**1**	18	**1**	138	**1**
12	PROD OPER MANAG	2.259	12	218	39	996	21	15	12	21	11	1	8	18	11
13	MATH PROGRAM	2.182	13	416	20	1861	10	16	10	26	7	3	6	21	10
14	RELIAB ENG SYST SAFE	2.170	14	614	10	1658	11	14	16	18	16	0	15	12	16
15	TRANSPORT RES E-LOG	2.126	15	220	38	564	27	10	23	14	27	0	15	3	30
16	TRANSPORT SCI	2.107	16	169	46	693	24	12	21	19	14	1	8	12	16
17	COMPUT OPER RES	1.984	17	1135	5	4221	3	21	**5**	28	6	2	7	56	**4**
18	J QUAL TECHNOL	1.860	18	136	51	404	37	10	23	15	23	0	15	7	22
19	SYST CONTROL LETT	1.718	19	582	12	2311	8	20	6	31	**4**	6	**2**	32	7
20	OR SPECTRUM	1.706	20	169	46	383	41	8	37	11	35	0	15	1	41
21	NETW SPAT ECON	1.658	21	107	58	175	53	6	52	8	48	0	15	1	41
22	SAFETY SCI	1.578	22	336	23	484	33	8	37	11	35	0	15	2	33
23	J SCHEDULING	1.497	23	162	48	403	38	10	23	14	27	0	15	5	27
24	IIE TRANS	1.469	24	434	18	1055	20	12	21	16	22	0	15	9	21
25	COMPUT OPTIM APPL	1.432	25	268	29	578	26	10	23	15	23	0	15	6	25
26	MATH OPER RES	1.398	26	276	28	599	25	10	23	12	31	0	15	2	33
27	J GLOBAL OPTIM	1.391	27	552	13	1326	16	14	16	19	14	0	15	10	20
28	INT J PROD RES	1.367	28	1462	3	2573	7	15	12	18	16	0	15	17	13
29	J OPER RES SOC	1.350	29	784	6	1465	13	13	18	17	20	0	15	12	16
30	NAV RES LOG	1.278	30	309	24	527	28	8	37	10	40	0	15	1	41
31	INFORMS J COMPUT	1.260	31	231	37	498	31	9	31	13	30	0	15	4	28
32	INT J SYST SCI	1.257	32	484	15	715	23	10	23	15	23	0	15	7	22
33	J OPTIMIZ THEORY APP	1.200	33	688	9	1274	17	13	18	18	16	0	15	11	19
34	INT J COMPUT INTEG M	1.113	34	342	22	431	35	8	37	10	40	0	15	1	41
35	ANN OPER RES	1.101	35	597	11	1143	19	13	18	17	20	1	8	7	22
36	ENG OPTIMIZ	1.077	36	280	27	510	29	10	23	14	27	0	15	6	25
37	TOP	1.067	37	64	63	53	60	4	57	5	60	0	15	0	50
38	INTERFACES	1.048	38	191	44	286	46	7	44	9	45	0	15	2	33
39	NETWORKS	1.022	39	263	31	448	34	9	31	12	31	0	15	4	28
40	OPTIM ENG	1.008	40	116	55	228	49	9	31	12	31	0	15	2	33
41	QUEUEING SYST	0.983	41	202	41	506	30	9	31	15	23	1	8	3	30
42	DISCRETE EVENT DYN S	0.979	42	91	60	166	55	6	52	8	48	0	15	0	50
43	J MANUF SYST	0.928	43	116	55	45	62	3	61	4	61	0	15	0	50
44	OPTIM LETT	0.908	44	134	52	107	58	4	57	6	57	0	15	0	50
45	OPTIM CONTR APPL MET	0.891	45	116	55	177	52	7	44	10	40	0	15	2	33
46	QUAL RELIAB ENG INT	0.842	46	263	31	487	32	8	37	12	31	0	15	3	30
47	PROD PLAN CONTROL	0.841	47	255	33	342	43	7	44	8	48	0	15	1	41
48	OPER RES LETT	0.821	48	537	14	849	22	10	23	11	35	0	15	2	33
49	J IND MANAG OPTIM	0.749	49	242	35	428	36	8	37	10	40	0	15	1	41
50	OPTIM METHOD SOFTW	0.744	50	265	30	399	39	8	37	9	45	0	15	0	50
51	APPL STOCH MODEL BUS	0.736	51	192	43	220	50	6	52	9	45	0	15	1	41
52	CONCURRENT ENG-RES A	0.710	52	128	54	212	51	7	44	8	48	0	15	0	50
53	INT J TECHNOL MANAGE	0.702	53	439	17	362	42	7	44	8	48	0	15	0	50

Appendix A (*continued*)

No.	Abbreviated journal title	JIF_5	Rank (JIF_5)	*N*	Rank (*N*)	TC	Rank (TC)	h	Rank (h)	g	Rank (g)	Gh	Rank (Gh)	Gh_{adj}	Rank (Gh_{adj})
54	DISCRETE OPTIM	0.696	54	156	49	122	56	5	56	6	57	0	15	0	50
55	MATH METHOD OPER RES	0.684	55	298	25	335	44	7	44	8	48	0	15	0	50
56	OPTIMIZATION	0.677	56	237	36	262	48	7	44	8	48	0	15	0	50
57	PROBAB ENG INFORM SC	0.627	57	176	45	283	47	7	44	10	40	0	15	2	33
58	INFOR	0.596	58	104	59	113	57	4	57	6	57	0	15	0	50
59	ASIA PAC J OPER RES	0.427	59	199	42	174	54	6	52	8	48	0	15	0	50
60	MIL OPER RES	0.314	60	84	61	31	63	3	61	4	61	0	15	0	50
61	RAIRO-OPER RES	0.278	61	73	62	25	64	2	64	2	64	0	15	0	50
62	INT J FLEX MANUF SYS	na	na	59	64	86	59	4	57	7	56	0	15	1	41
63	J OPER RES SOC JPN	na	na	130	53	50	61	3	61	3	63	0	15	0	50
64	INT J INF TECH DECIS	na	na	204	40	395	40	9	31	11	35	0	15	2	33

Note: na here indicates that this journal are not included in the Journal Citation Report in the year.
The bold values identify the top 5 when journals are ranked in different indicators.

References

ABS (2011). *ABS academic journal quality guide* (4th ed.).

Braun, T., Glanzel, W., & Schubert, A. (2006). A Hirsch-type index for journals. *Scientometrics, 69*, 169–173.

Burrell, Q. L. (2007). On the *h*-index, the size of the Hirsch core and Jin's *A*-index. *Journal of Informetrics, 1*(2), 170–177.

Cabrerizo, F. J., Alonso, S., Herrera-Viedma, E., et al (2010). Q2-Index: Quantitative and qualitative evaluation based on the number and impact of papers in the Hirsch core. *Journal of Informetrics, 4*(1), 23–28.

Chandy, P. R., Ganesh, G. K., & Henderson, G. V. (1991). Awareness and evaluation of selected accounting journals inside and outside the discipline: An empirical study. *Akron Business and Economic Review, 22*, 214–226.

COPIOR (2011). Committee of Professors in OR (COPIOR) OR Journal List. <http://www.copior.ac.uk/Journallist.aspx>.

Egghe, L. (2006). Theory and practise of the g-index. *Scientometrics, 69*, 131–152.

Garfield, E. (1972). Citation analysis as a tool in journal evaluation. *Science, 178*, 471–479.

Glänzel, W., & Moed, H. F. (2002). Journal impact measures in bibliometric research. *Scientometrics, 53*, 171–193.

Glänzel, W., & Persson, O. (2005). H-Index for price medalists. *ISSI Newsletter, 1*, 15–18.

Harzing, A. W., & van der Wal, R. (2009). A Google Scholar h-index for journals: An alternative metric to measure journal impact in economics and business. *Journal of the American Society for Information Science and Technology, 60*(1), 41–46.

Liu, Y., & Rousseau, R. (2009). Properties of Hirsch-type indices: The case of library classification categories. *Scientometrics, 79*(2), 235–248.

Saad, G. (2006). Exploring the h-index at the author and journal levels using bibliometric data of productive consumer scholars and business-related journals respectively. *Scientometrics, 69*(1), 117–120.

Whitehouse, G. H. (2001). Citation rates and impact factors—Should they matter? *British Journal of Radiology, 74*, 1–3.

Yu, G., Wang, X. H., & Yu, D. R. (2005). The influence of publication delays on impact factors. *Scientometrics, 64*, 235–246.