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OR/MS journals evaluation based on a refined PageRank method: an updated and more comprehensive review

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Abstract The purpose of this research is to furnish the OR/MS research community with an updated assessment of the discipline's journals set with refinements that also highlight the various characteristics of OR/MS journals. More specifically, we apply a refined PageRank method initially proposed by Xu et al. (2011) to evaluate the top 31 OR/MS journals for 2010, and report our findings. We also report the shifts in the rankings that span 5 years, from 2006 to 2010. We observe that *Manufacturing and Service Operations Management*, indexed by the SCI only in 2008, is a specialized journal that is consistently highly regarded within the discipline. The rankings also suggest that *Management Science* is more established as a generalized journal as it has more external impact. In general, our ranking results correlate with expert opinions, and we also observe, report and discuss some interesting patterns that have emerged over the past 5 years from 2006 to 2010.

Keywords Journals evaluation · Citations analysis · Journal influence · Journal impact · Impact factor · Influence index · OR/MS · PageRank

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Introduction

Before the turn of the new century, the field of Operations Research/Management Sciences (OR/MS) became established as a key discipline in most business schools. Off this backdrop surfaced a growing body of literature that evaluates the impacts of OR/MS journals. This phenomenon is apparently due to two circumstances: that journal evaluations provide the constant need for expedient information to a diverse set of academic stakeholders (Dubois and Reeb 2000; Xu et al. 2011); and given the vastly diverse and continually evolving nature of OR/MS related research, new journals have been formed while older journals have changed either in terms of their status or their research directions so as to remain relevant (Olson 2005). Indeed, a review of past studies supports this observation: for example, Barman et al. (1991, 2001) conducted journal evaluations a decade apart and observed that *Production and Operations Management*, a new journal entrant within that time frame, had "established itself as a major player", faring very well in terms of its peer-perceived relevance and quality. Similarly, we observe that in recent years, having published its first issue in 1999, *Manufacturing & Service Operations Management* (*M&SOM*) was not only considered for evaluation despite it being a relatively new journal, it also fared exceptionally well in studies conducted by Olson (2005) and Gorman and Kanet (2005, 2007). But with that being said, the most recently published OR/MS journals evaluation study we found is a citations-based study by Xu et al. (2011) using data from 2004.

And as if methodological validity and reliability are not complex enough, there is a growing consensus that different academics perceive the prestige of journals differently (Seglen 1997; Pendlebury 2009; Rousseau 2002; Weingart 2005). Thus, a journal's prestige, impact, or influence can hardly be derived based on a single metric (Moed et al. 2012).

Ergo, the motivation of this paper is to furnish the OR/MS research community with an updated review of the discipline's selected journals set using methodological refinements to highlight the multifaceted characteristics of the selected OR/MS journals. In particular, we extend upon a refined PageRank method originally proposed by Xu et al. (2011) to evaluate and report our findings of 31 OR/MS journals from cross-sectional and longitudinal perspectives, and where appropriate, we also compare and contrast our findings with those of other approaches.

The remainder of this paper is structured as follows: "Literature review" Section is a literature review of relevant existing and emerging approaches to journal ranking. "Methodology" Section describes the underlying methodology for implementation, describes how differentiating the citations types can refine our journal evaluations, and describes the delimitations of our study. In "Results and Discussion" Section, we present the ranking results and analyses for our cross-sectional evaluation for 2010, as well as four different 5-year rolling reviews from 2006 to 2010. We conclude our paper in Section 5.

Literature review

Although peer surveys have been conducted in the past,[1] journal evaluations based on citations data appear to be the more common approach today (Olson 2005; Vokurka 1996).

[1] Past studies based on peer surveys include Saladin (1985), (Barman et al. 1991), (Barman et al. 2001), (Olson 2005).

According to Xu et al. (2011), citations-based evaluations generally refer to journals being ranked *"based on the frequency with which journal articles are cited in subsequent issues of the same journal or in a set of discipline-specific journals"* (p. 375). In this approach, scientometricians may rank journals according to their specified evaluation criteria, such as taking total citations into consideration, excluding self-citations of articles, and so on. However, although earlier citations-based studies include Goh et al. (1996, 1997) and Vokurka (1996), the most widely used is that originally proposed by the E Garfield Institute for Scientific Information (ISI), which has since been acquired by Thomson-Reuters and is now more widely known as Thomson's Science Citation Index (SCI). The SCI recognizes over 12,000 journals today, and through its annual Journal Citation Report (JCR), the agency provides the rankings of journals based on a two-year rolling impact factor (IF) score for each indexed journal. The IF score for a given journal in year X is determined by the average number of citations received in year X to its articles during the previous 2 years; the premise of the IF is that the higher the IF score, the higher the journal impact or "quality" (Xu et al. 2011).

But in spite of their popularity, SCI's IF method has increasingly been derided as a fundamentally flawed ranking technique (Butler 2008; Pendlebury 2009; Seglen 1997). A recurring criticism of the method is that it merely ranks journals by citation frequency; that *citation quantity* and *citation quality* are hardly the same thing (Olson 2005). Furthermore, there is no differentiation of citations in the IF method. This means that each citation is regarded to be of equal "value" although it has been countered that citations by an article published in a renowned journal should outweigh citations by an article published in a mediocre one (Pinski and Narin 1976; Xu et al. 2011). Accordingly, numerous studies suggest that rank orders of journals derived from the IF method are often incongruent with peer perceptions (Seglen 1997; Rousseau 2002; Olson 2005; Weingart 2005).

The limitations of the IF method coupled with the constant need for reliable journals information by the various stakeholders have thus placed the onus on scientometricians to devise better journal ordering mechanisms (Leydesdorff 2008). Responding to this challenge, Gorman and Kanet (2005, 2007) recently interpreted and applied the Author-Affiliation Index (AAI) method originally devised by Harless and Reilly (1998). The concept, as proposed by Gorman and Kanet, is anchored on the premise that journal impact should correlate with the affiliation of authors that publish their articles in a given journal; that a journal's impact can be determined simply by taking into consideration the journals with which authors from leading universities publish (Xu et al. 2011). According to its proponents, the AAI method is cost-effective compared to peer opinion surveys, can simply be calculated in any given period, and appears to be an objective enough measure of journal influence as the ranking results appear to be congruent with those of opinion survey results (Chen and Huang 2007). However, its critics argue that because the rank order is determined based on publications from authors affiliated with leading institutions, the AAI is merely a coarse measuring tool. The contention is that while the prestige of a journal should be ascertained by the quality of their articles, the prestige of an institution is ascertained by numerous factors apart from the quality of publications by their faculty. This fundamental difference has since opened the door for critics who identified, challenged and cautioned the theoretical and statistical interpretations, assumptions and applications of the concept (Agrawal et al. 2011). Essentially, with potential bias being introduced in journal selection and sampling via the AAI approach, stakeholders cannot conclude with sufficient confidence that some journals are undoubtedly better than others (Xu et al. 2011).

Around the time the AAI approach was proposed and implemented, another group of scholars began experimenting with the application of the PageRank method as a journal ranking mechanism. Originally developed by Google's founders as a web-search approach to ordering webpages by their impact, PageRank had been based on Pinski and Narin's (1976) assertion as stated above (Page et al. 1999). Since then, Google's PageRank has been transposed and applied in at least three online bibliometric platforms and five journal-ranking studies. They are discussed in the following:

Bibliometric platforms

Newer online bibliometric platforms such as www.journal-ranking.com (developed by Lim et al. 2007), Eigenfactor (see http://www.eigenfactor.org/) and SCImago Journal Rank (SJR) (see http://www.scimagojr.com/) have apparently elected to implement their systems based on the PageRank method. Be that as it may, these platforms have included unique methodological refinements that set their systems apart from one another (please refer to Table 1 for a concise summary): First of all, while www.journal-ranking.com rank a journal's influence based on its *Quality Index* (QI), Eigenfactor use what they call the *Article Influence* (AI) score (West et al. 2008), and SCImago use *the SJR* (Gonzalez-Pereira et al. 2010) and *SJR2* (Guerrero-Bote and Moya-Anegón 2012); Secondly, all three platforms treat citation types differently. In the case of Eigenfactor, all self-citations are ignored (self-citations refer to journal articles that cite other articles from the same journal), while in the case of SCImago, self-citations are limited to a maximum of 33 % of a journal's total citations. As for www.journal-ranking.com, all citations are being considered; Thirdly and most notably, there are differences in the way the PageRank model is being customized among these platforms. Indeed, the PageRank algorithm (Brin and Page 1998) can be explained as computing the leading eigenvector of a stochastic matrix, and is defined as follows:

$$P = d * M + (1 - d) * a.e^T,$$

where d is the damping factor; e is row vector with all elements equal to 1 and a is the personalization vector. Further, $a.e^T$ is the matrix with identical columns a while M is the citation matrix, and P is the stochastic matrix. Eigenfactor and SCImago follow this approach, but with an added personalization vector, which is multiplied by (1—damping factor), and theoretically guarantee the uniqueness of the principle eigenvector of the stochastic matrix. That being said, although the damping factor and personalization vector may be used to determine the rankings, Bressan and Peserico (2010) point out that the rankings of journals can be very sensitive to both the damping factor and personalization vector. As for www.journal-ranking.com, they do not use personalization vectors or damping factors. Instead, by removing dangling journals, they construct a strongly connected citations graph and use a reiterative approach, and where convergence is guaranteed by this strong connectivity of citation graphs (Wen 2008).

PageRank-based journal ranking studies

There have been at least five PageRank-based studies on journal ranking (namely Palacios-Huerta and Volij 2004; Lim et al. 2007, 2009; Xu et al. 2011; Cheang et al. 2013). Of these, the study by Xu et al. (2011) produced the rank orders of a set of 31 OR/MS journals that were not only based on how influential the selected journals were among all SCI-

Table 1 Comparison of article influence, SJR, SJR2 and quality index

Differences		PageRank-based methods		
		Eigenfactor's article influence	SCImago's *SJR* and *SJR2*	www.journal-ranking.com quality index
Differences in non-PageRank aspects	Source database	Journal citation report (JCR)	Scopus	Journal citation report (JCR)
	Citing time window	1 year	1 year	1 year
	Cited time window	5 years	3 years	10 years
	Self-citations	Remove	Limited	Weighted by input parameter
	External-citations	N.A.*	N.A.	Weighted by input parameter
	Internal-citations	N.A.	N.A.	Included
	Considering citation Quality	Yes	Yes	Yes
Differences in PageRank Aspects	Damping factor	0.85	0.9	1.0
	Dangling Journals**	Included	Included	Removed
	Convergence of Iterative algorithm	Theoretically guaranteed	Theoretically guaranteed	Guaranteed by strong connectivity of the citations graph
	Sensitivity to damping factor	Yes	Yes	No
	Personalization vector (Brin and Page 1998)	Normalized article number	Two parts: • a minimum prestige value: $\frac{1-d-e}{N}$ • prestige given by the number of papers: $e^* \frac{\mathrm{Art}_i}{\sum_{j=1}^{N} \mathrm{Art}_j}$ where Art_i is the number of articles published by journal *i* during examined time period	N.A.

* *NA* Not Available

** Dangling journals: journals that do not cite other journals during time period examined

indexed journals, but also how influential the selected journals were particularly within the OR/MS domain. At the time, however, Xu et al. (2011) had elected to use data from 2004 to directly compare their results to those based on other existing methods. The authors also demonstrated that their application of the PageRank method was not only an improvement on traditional methods of citations analyses, they also showed that their approach enabled the discernment of different journal impacts compared to other existing methods. More

recently, Cheang et al. (2013) extended upon Xu et al.'s (2011) approach to order 39 selected management journals. In particular, the authors expanded on Xu et al.'s (2011) supposition that although PageRank is a reliable method in determining a journal's impact or quality, it does not distinguish the nature of a journal's influence or impact. Indeed, some journals may be highly influential by way of receiving substantial self-citations because they are highly specialized journals. On the other hand, some journals may be highly influential because they are (both) well cited within and outside their domains (in other words, they have significant internal and external citations, respectively). However, the nuances of particular journals would not come to light if the various citation types are undifferentiated or that certain types of citations are ignored (Cheang et al. 2013).

Thereupon, in view of the aforementioned theoretical and practical developments, and the assertion that journals evaluation is such a labyrinthine process that it "*cannot be captured in one single metric*" (Moed et al. 2012, p. 368), we adopt the same approach as Xu et al. (2011) and Cheang et al. (2013) to provide the OR/MS community with an updated and more comprehensive review of the discipline's selected journals set. Therefore, we not only provide a cross-sectional evaluation (1-year), we also provide a longitudinal (5-year rolling) review of the selected OR/MS journals to observe relevant trends and compare our analysis with those of other methods, where appropriate.

Methodology

Description of the PageRank method

As mentioned in the literature review, the PageRank method has also been transposed to harness citations data for journal ranking purposes (Cheang et al. 2013). It consists of two major parts. The first is the construction of a citations graph network where every node represents a journal and an edge represents a collection of citations from one journal to another.

After the citations network database is constructed, we can then proceed to determine the *quality* of each journal using PageRank's underlying principle where citations from a higher quality journal should be given higher weightage (Xu et al. 2011). The problem can be modeled by solving a set of linear equations whereby the impact value of each journal is treated as a variable of positive value (Lim et al. 2009). The linear equations compute the transitivity among the citations reiteratively until the values converge (Lim et al. 2007; Xu et al. 2011; Cheang et al. 2013). Thus, we can use the random walk method (Pearson 1905) or matrix multiplication approach since both methods are iterative in nature (Cheang et al. 2013). Summarily, the equation may be expressed as follows:

$$PR_i^{x+1} = \sum_{j=1}^{n} p_{ji} PR_j^x,$$

whereby the influence of journal i (PR_i) is the sum of the product of the influence (PR) of every journal j multiplied by the proportion (p) of citations from j to i (Lim et al. 2009; Xu et al. 2011; Cheang et al. 2013). Essentially, the method uses the *influence* of cited journals to gauge the impact of a citation. Subsequently, journal i's influence is divided by the number of articles they publish every year (to identify the average *impact/influence* of the journal's articles) to derive what is known as the QI as proposed by www.journal-ranking.com (Lim et al. 2007) For further technical explanations of the PageRank Method, please refer to the paper by Xu et al. (2011), pp. 4–5

Differentiation of citation types for more refined journal evaluations

The concept of journal evaluations is a contentious subject (Seglen 1997; Glanzel and Moed 2002; Harzing 2007). This is, in large part, due to the subjectivity and therefore complexity in establishing a journal's impact (Robey and Markus 1998; Cheang et al. 2013). For instance, while some may equate high citation count with being of high impact, others may view high self-citation count with being a manipulative journal (Rousseau 2002; Smith 2006; Weingart 2005). Nevertheless, this brought about the idea that varying viewpoints may be better captured if ranking techniques can be further refined to reflect it (Xu et al. 2011; Cheang et al. 2013). In particular, Xu et al. (2011) proposed that varying viewpoints could be captured via the differentiation of the various citation types.

To be clear, there are three citation types as shown in Fig. 1: *self-citations*—articles in a journal citing other articles from the very same journal; *internal-citations*—journals cited by core journals (core journals are journals within a specific domain); and *external-citations*—journals cited by non-core journals (non-core journals are journals outside a specific domain) (Cheang et al. 2013). Through this differentiation process, we can better ascertain what sort of influence or impact (i.e. external and/or internal influence) a journal possesses.

Now, let us also use Fig. 1 to quantify the various citation types: Let (*J1*) be *Operations Research* (*J2*) be *Journal of Scheduling* and (*J4*) be *Academy of Management Review*. We also define journals in discipline A as core journals and journals in discipline B as non-core journals in relation to discipline A. The citation relationships among these journals may be represented as shown in Table 2, where for examples, $C_{2,1}$ refers to the number of citations that *J1* received from *J2* (both journals are from the same core), $C_{4,1}$ refers to the number of citations *J1* received from *J4* (where J4 is not in the same core journals set as *J1*), $C_{1,1}$ refers to the number of citations that *J1* received from itself, and so on.

Applying the refined PageRank method: parameters and input values

The general application of the PageRank method is given in the following:

- First, we structure a core journals set, a universal list *J*.
- Next, we set parameters and input values including a year *t*, a length of time span *N*, the external-citation parameter γ and the self-citation parameter β.
- Then, we calculate the PageRank values and derive the QI for each journal.

Accordingly, we fix the parameters and inputs as described in the following:

- As our aim is to update the OR/MS journal rankings, we input all 10,625 journals indexed in the 2010 Journal Citation Report (JCR) to form the universal journals set *J*. Note that as the *International Journal of Flexible Manufacturing System* (*IJFMS*) ceased issue in 2008, the journal is thus delisted from our universal list *J*. However, we include *Manufacturing & Service Operations Management* (*M&SOM*) in our universal list as it was indexed by SCI in 2008.
- We set the year *t* to be 2010 and the period length *N* to be 10. Internal-citations have a default weight of 1. And the weight of external- and self-citations can be set relative to the weight of internal citations. With regards to the external citation parameter γ and self-citation parameter β, we consider all combinations of γ going from 0.0, 0.1, …, 0.9, 1.0 and β going from 0.0, 0.1, …, 0.9, 1.0. As such, there are 121 combinations of γ and β. Accordingly, we pay close attention to ($\gamma = 0.0$, $\beta = 0.0$), ($\gamma = 1.0$, $\beta = 1.0$), ($\gamma = 0.0$, $\beta = 1.0$) and ($\gamma = 1.0$, $\beta = 0.0$).

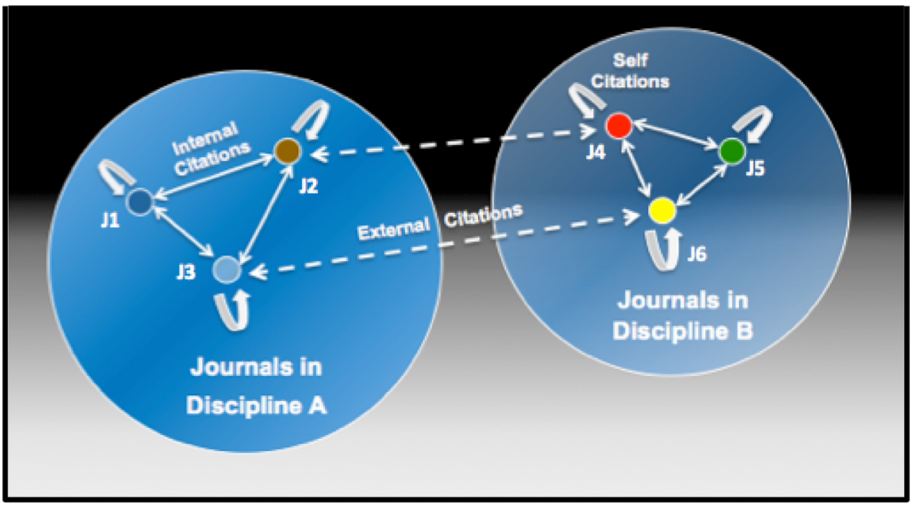

Fig. 1 Illustration of citation types

Table 2 Summary of quantifying the three citation types in Fig. 1

Journals		Internal citations	External citations	Self-citations
Core journals	*J1*, *Operations Research*	$C_{2,1}$	$C_{4,1}$	$C_{1,1}$
	J2, *Journal of Scheduling*	$C_{1,2}$	$C_{3,2}$	$C_{2,2}$
Non-core journals	*J4*, *Academy of Management Review*	0	$C_{1,4} + C_{2,4}$	$C_{4,4}$

- In order to obtain the QI for each journal, we obtain the number of articles published in every journal in the core set from t—$N + 1$ to t, which is from 2001 to 2010 for our case. However, we encounter one exception, *M&SOM*, which was indexed by SCI only after 2007. Thus, we multiply the average number of articles that were published in *M&SOM* from 2006 to 2010 by 10 to estimate the total number of articles published from 2001 to 2010. For other journals, we tally the number of articles published from 2001 to 2010.
- Due to the immense size of our universal set list, we also implemented the recursive algorithm by Page et al. (1999) to accelerate the computation of PageRank values with a time limitation of 3 min.
- Finally, we generate the QI for each journal for all sampled parameter values including the 121 value combinations of β and γ, and factor their average scores to derive the journal rankings.

Results and discussions

As Xu et al. (2011) have already conducted a series of analyses including statistical tests, sensitivity analyses and group tests to demonstrate the robustness, effectiveness, and reliability of their approach in terms of matching human perceptions, we omit reporting

these analyses unless where necessary as they are not the purpose of the study. In this section, we present and discuss the 2010 (cross-sectional) ranking results as well as provide four inherently different 5-year rolling reviews (2006–2010) of the evaluated journals.

2010 ranking results and analyses

Table 3 reports the results for 2010. Columns 1 and 2 show the journals' acronyms and their full names, respectively. Recall that the weight for internal-citations is set at 1. The weights for the other citation types are set relative to the weight set for internal-citations. Columns 3–10 display the respective scores and rankings by QI with the self-citations parameter β and the external-citations parameter γ set at either equal to 0 or 1. In general, the higher the internal-citations, the higher the impact a journal has within its discipline; that which also indicates that a journal is more specialized. The same principle applies to external-citations although in this instance, it concerns the impact of a journal outside of its discipline; that which also indicates that a journal is more generalized. Thus, a journal that scores equally high for internal and external citations indicates that it is not only a specialized journal that is highly regarded within its discipline, it is so far-reaching (impactful) that it is a highly recognized journal outside of its field as well.

From the results presented in Table 3, we highlight some interesting findings. In particular, we note that there are two top journals, *Manufacturing & Service Operations Management* (*M&SOM*) and *Management Science* (*MS*). Despite it being indexed by the SCI only in 2008, *M&SOM* has managed to rank first for when ($\beta = 0.0$, $\gamma = 0.0$) and when ($\beta = 1.0$, $\gamma = 0.0$), and is ranked fifth when ($\beta = 0.0$, $\gamma = 1.0$) and when ($\beta = 1.0$, $\gamma = 1.0$). What these rankings suggest are that despite it being a relatively new entrant, *M&SOM* is a specialized journal that is highly regarded within the discipline. On the other hand, *MS*, which is a well-established journal, is ranked first for when ($\beta = 0.0$, $\gamma = 1.0$) and when ($\beta = 1.0$, $\gamma = 1.0$), is ranked fourth when ($\beta = 0.0$, $\gamma = 0.0$), and is ranked second when ($\beta = 1.0$, $\gamma = 0.0$). These rankings suggest that *MS* has established itself as a generalized journal and therefore, has more external impact (outside its discipline) compared to *M&SOM*.

Next, we present in Table 4, the rankings as computed by Xu et al.'s QI, SCI's IF, and Eigenfactor's AI for 2010, and discuss the more significant ranking disparities. Thus, where there are significant ranking disparities between the QI and IF, the rows are highlighted in blue. And because SCI's IF method treats all citations equally, we elected to use QI's results for when ($\beta = 1.0$, $\gamma = 1.0$) so that all citation types are also taken into account.

From the table, what is most notable is that *Mathematics of Operations Research* (*MOR*), one of the most highly regarded journals in the domain, is only ranked 21st by the IF. Rankings of other traditionally well-regarded journals such as *Mathematical Programming* (*MP*) *and Transportation Science* (*TS*) also exhibit considerable disparities between the QI and IF. The significant disparity in the case of *MOR* highlights what we have argued earlier; that the weighting of journals based on impact affect their placements, and hence, transitive relationships should be taken into account when conducting citation analyses.

Another interesting point to note is that, with the exception of *Journal of Global Optimization* (JGO) and *Journal of Heuristics* (JOH) (as highlighted in yellow), the rankings computed by Eigenfactor's AI method appear to be closer to the results derived from Xu et al.'s QI. Indeed, while the QI and AI share similar methodological philosophies and roots, we believe the differences might be due to the several factors listed in Table 1 of

Table 3 Cross-sectional results via the differentiation of citation types for 2010

Journal		Quality index ($\beta = 0.0$, $\gamma = 0.0$)		Quality index ($\beta = 0.0$, $\gamma = 1.0$)		Quality index ($\beta = 1.0$, $\gamma = 0.0$)		Quality index ($\beta = 1.0$, $\gamma = 1.0$)	
Acronym	Name	Score	Rank	Score	Rank	Score	Rank	Score	Rank
AOR	Annals of Operations Research	0.019	18	0.021	18	0.013	24	0.018	21
CIE	Computers and Industrial Engineering	0.009	26	0.01	29	0.007	27	0.009	29
COR	Computers and Operations Research	0.023	15	0.022	16	0.018	18	0.021	17
DS	Decision Sciences	0.035	9	0.025	14	0.029	9	0.023	15
DSS	Decision Support Systems	0.006	29	0.015	25	0.009	26	0.015	25
EJOR	European Journal of Operational Research	0.019	17	0.025	13	0.022	11	0.028	9
IFACE	Interfaces	0.022	16	0.017	22	0.022	12	0.019	19
IIE	IIE Transactions	0.025	14	0.022	17	0.02	16	0.02	18
IJOC	Informs Journal on Computing	0.032	10	0.027	10	0.024	10	0.024	14
IJOPM	International Journal of Operations and Production Management	0.016	22	0.012	27	0.017	20	0.012	27
IJPE	International Journal of Production Economics	0.015	24	0.014	26	0.015	22	0.016	24
IJPR	International Journal of Production Research	0.007	27	0.008	30	0.007	28	0.009	30
JCO	Journal of Combinatorial Optimization	0.007	28	0.018	21	0.006	29	0.016	22
JGO	Journal of Global Optimization	0.013	25	0.026	12	0.018	19	0.026	10
JMS	Journal of Manufacturing Systems	0.002	30	0.003	31	0.001	31	0.003	31
JOH	Journal of Heuristics	0.018	20	0.015	23	0.012	25	0.013	26
JOM	Journal of Operations Management	0.06	5	0.042	7	0.094	3	0.047	6
JORS	Journal of the Operational Research Society	0.016	23	0.015	24	0.015	23	0.016	23
JOS	Journal of Scheduling	0.028	13	0.024	15	0.021	14	0.022	16
M&SOM	M&SOM-Manufacturing & Service Operations Management	0.148	1	0.069	5	0.125	1	0.071	5
MCM	Mathematical and Computer Modeling	0.001	31	0.011	28	0.002	30	0.01	28
MOR	Mathematics of Operations Research	0.04	8	0.086	2	0.038	8	0.08	3
MP	Mathematical Programming	0.045	7	0.073	4	0.069	6	0.083	2
MS	Management Science	0.07	4	0.143	1	0.105	2	0.142	1
NET	Networks	0.018	19	0.02	20	0.016	21	0.019	20
NRL	Naval Research Logistics	0.029	11	0.029	9	0.021	15	0.025	11

Table 3 continued

Journal		Quality index ($\beta = 0.0$, $\gamma = 0.0$)		Quality index ($\beta = 0.0$, $\gamma = 1.0$)		Quality index ($\beta = 1.0$, $\gamma = 0.0$)		Quality index ($\beta = 1.0$, $\gamma = 1.0$)	
Acronym	Name	Score	Rank	Score	Rank	Score	Rank	Score	Rank
OMEGA	Omega-The International Journal of Management Science	0.017	21	0.021	19	0.02	17	0.025	12
OR	Operations Research	0.095	2	0.075	3	0.089	4	0.077	4
ORL	Operations Research Letters	0.029	12	0.027	11	0.022	13	0.024	13
POM	Production and Operations Management	0.081	3	0.04	8	0.075	5	0.042	8
TS	Transportation Science	0.055	6	0.046	6	0.047	7	0.046	7

Section 2 (i.e. using damping factor for AI but not for QI, consideration of the cited time window, and/or the consideration or disregard for self-citations).

Further, based on the Kendall Rank-Order Correlation coefficients in Table 5, we observe that the AI is closer to the QI than the IF; where the value of QI ($\beta = 0, \gamma = 0$) and AI stands at 0.715 and the value of QI ($\beta = 1, \gamma = 1$) and AI stands at 0.723 with a significance level of 0.00000. These two values are significantly larger when comparing the QI with other methods.

2006–2010 Rolling reviews

Although our main purpose is to update the rankings of selected OR/MS journals, it is also interesting to observe the trends that have surfaced over the past 5 years leading up to the 2010 rankings since the most recent review was done with 2004 data. Thus, in this subsection, we not only present two 5-year rolling reviews based on the QI method of the 31 selected OR/MS journals from 2006 to 2010, we also present two five-year rolling reviews, one based on the AI method and one on the IF method, of the same set of OR/MS journals from 2006 to 2010.

We begin with Fig. 2, which illustrates the shifts in rankings of the top 31 journals only within the OR/MS discipline as the self-citation parameter β and external-citation parameter γ are both equal to 0. The numeric rank values for each journal can be found in Table 6 in Appendix.

The results show that *M&SOM*, indexed since 2008, is consistently being held in high regard; consistent with Olson's opinion survey in 2005, the journal clearly earned itself this reputation even before being indexed by SCI. As seen from the figure, with the exception of *JOM*, the rankings for the top five journals have been more or less consistent throughout the years. The bottom few journals are also quite consistently ordered.

However, the pattern in the rankings between the top and bottom five journals is quite interesting. We observe that from 2006 to 2008, the rankings within this segment are quite erratic, but which became much more consistent from 2008 to 2010. While we can speculate that perhaps a shift of some sort occurred in 2008, we are unable to scientifically pinpoint why

Table 4 Ranking Comparisons between QI, IF and AI Rank Orders for 2010

Journal		QI ($\beta = 1.0$, $\gamma = 1.0$)	IF 2010	AI 2010	Disparity (QI—IF)	Disparity (QI—AI)
Acronym	Name	Rank	Rank	Rank	Positions	Positions
AOR	Annals of Operations Research	21	30	19	−9	2
CIE	Computers and Industrial Engineering	29	14	28	15	1
COR	Computers and Operations Research	17	12	14	5	3
DS	Decision Sciences	15	3	9	12	6
DSS	Decision Support Systems	25	6	20	19	5
EJOR	European Journal of Operational Research	9	5	16	4	−7
IFACE	Interfaces	19	28	27	−9	−8
IIE	IIE Transactions	18	17	17	1	1
IJOC	Informs Journal on Computing	14	19	12	−5	2
IJOPM	International Journal of Operations and Production Management	27	18	23	9	4
IJPE	International Journal of Production Economics	24	9	22	15	2
IJPR	International Journal of Production Research	30	24	30	6	0
JCO	Journal of Combinatorial Optimization	22	27	25	−5	−3
JGO	Journal of Global Optimization	10	20	24	−10	−14
JMS	Journal of Manufacturing Systems	31	31	31	0	0
JOH	Journal of Heuristics	26	13	15	13	11
JOM	Journal of Operations Management	6	1	5	5	1
JORS	Journal of the Operational Research Society	23	22	26	1	−3
JOS	Journal of Scheduling	16	16	11	0	5
M&SOM	M&SOM-Manufacturing & Service Operations Management	5	7	2	−2	3
MCM	Mathematical and Computer Modeling	28	23	29	5	−1
MOR	Mathematics of Operations Research	3	21	8	−18	−5
MP	Mathematical Programming	2	10	3	−8	−1
MS	Management Science	1	4	1	−3	0
NET	Networks	20	25	18	−5	2
NRL	Naval Research Logistics	11	26	13	−13	−2
OMEGA	Omega-The International Journal of Management Science	12	2	10	10	2
OR	Operations Research	4	8	4	−4	0
ORL	Operations Research Letters	13	29	21	−16	−8
POM	Production and Operations Management	8	11	7	−3	1
TS	Transportation Science	7	15	6	−8	1

this pattern has emerged without conducting further analysis. As such, we note this observation as is and look to extend our research into this interesting observation in the near future.

Table 5 Kendall rank-order correlation coefficients among the various ranking methodologies

			Quality index ($\beta = 1, \gamma = 1$)	JCR (2010)		Xu et al. (2011)		(Olson 2005)	(Gorman and Kanet 2005)
				Impact factor	Article influence score	($\beta = 0$, $\gamma = 0$)	($\beta = 1$, $\gamma = 1$)		
Quality index	($\beta = 0, \gamma = 0$)	Coefficient	0.683	0.286	**0.715**	0.609	0.48	0.553	0.547
		Sig.(2-tailed)	0.00000	0.024863	0.00000	0.00000	0.00021	0.00001	0.00083
		N	31	31	30	30	30	31	20
	($\beta = 1, \gamma = 1$)	Coefficient		0.31	**0.723**	0.503	0.503	0.555	0.537
		Sig.(2-tailed)		0.015064	0.00000	0.00010	0.00012	0.00001	0.00105
		N		31	30	30	30	31	20
JCR (2010)	Impact factor	Coefficient			0.457	0.168	0.131	−0.0409	−0.0316
		Sig.(2-tailed)			0.00041	0.19895	0.31775	0.75965	0.87113
		N			30	30	30	31	20
	Article influence score	Coefficient				0.49	0.416	0.384	0.368
		Sig.(2-tailed)				0.00015	0.00132	0.00306	0.03007
		N				30	30	30	19
Xu et al. (2011)	($\beta = 0, \gamma = 0$)	Coefficient					0.669	0.49	0.532
		Sig.(2-tailed)					0.000000	0.00016	0.00164
		N					30	30	19
	($\beta = 1, \gamma = 1$)	Coefficient						0.508	0.462
		Sig.(2-tailed)						0.00009	0.00636
		N						30	19
Olson' Survey (2005)		Coefficient							0.663
		Sig.(2-tailed)							0.00005
		N							20

Bold value indicates that AI is closer to QI than other methods

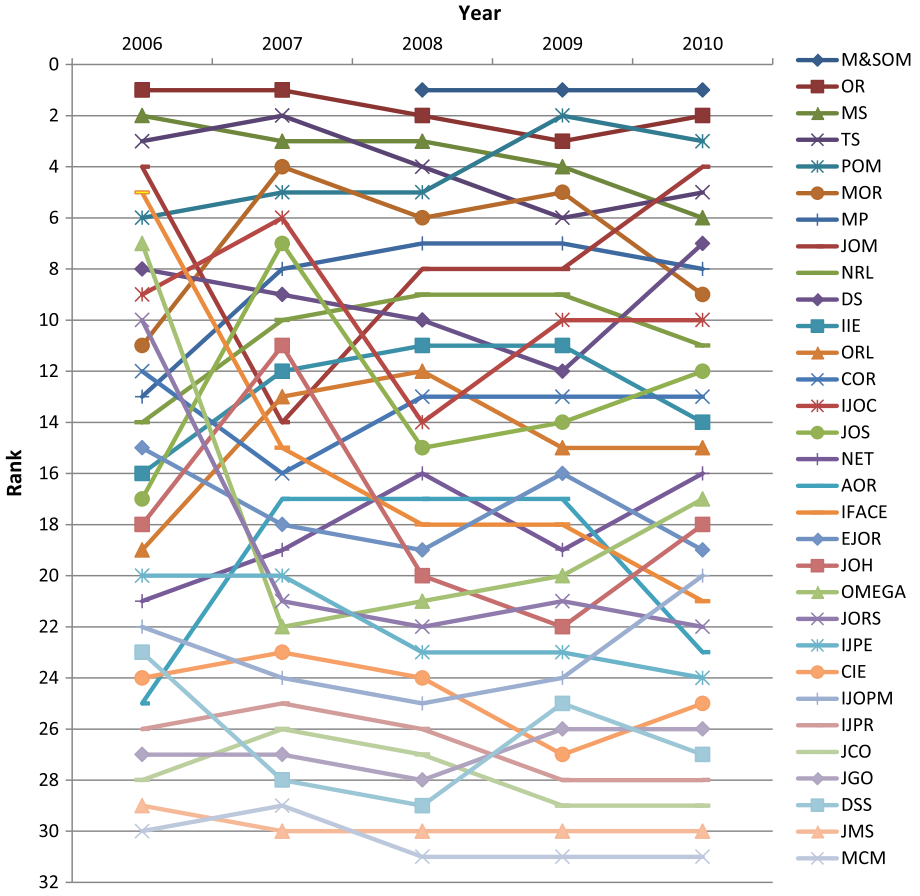

Fig. 2 Ranking trends of the selected 31 OR/MS journals for 2006–2010. All rank values used are generated with self-citation parameter $\boldsymbol{\beta}$ and external-citation parameter $\boldsymbol{\gamma}$ both equal to 0

Next, we look at Fig. 3, which illustrates the shifts in rankings of the top 31 OR/MS journals with the self-citation parameter β and external-citation parameter γ both equal to 1. The numeric rank values for each journal can be found in Table 7 in Appendix.

With the exception of the *Journal of Heuristics* (*JOH*), the rankings of the top and bottom five journals are rather consistent; much like when ($\beta = 0.0$, $\gamma = 0.0$). However, the pattern of the rankings of the bulk of the middle tier journals appears to be more volatile than ($\beta = 0.0$, $\gamma = 0.0$). We believe that a plausible explanation for this volatility is that journal influence for when ($\beta = 1.0$, $\gamma = 1.0$) is computed based on the universal journal list, which is well over 10,000 journals. Therefore, we postulate that the share of journal influence per journal is significantly lesser when ($\beta = 1.0$, $\gamma = 1.0$). This means that the QI of journals is extremely close, and the tiniest gap would significantly affect a journal's placement. This is unlike the ranking criteria of ($\beta = 0.0$, $\gamma = 0.0$), where a journal's influence is computed based on a journals set list specifically within the OR/MS discipline.

Overall, the mid tier patterns that have emerged when ($\beta = 0.0$, $\gamma = 0.0$) and ($\beta = 1.0$, $\gamma = 1.0$) are very interesting. These patterns could very well indicate that (1) expert perceptions are muddied after the top five journals or so, and/or that (2) newly appointed editors have tremendous influence on the structure of the journals, such that they subsequently attract or repel certain scholars to publish their research in those journals. There could very well be other explanations apart from those we have suggested. It is our intention to extend our research into these interesting observations in the near future.

Next, in Fig. 4, we discuss the shifts in rankings of the selected 31 journals based on Eigenfactor's AI method from 2006 to 2010. Unsurprisingly, the patterns observed in Fig. 4 are similar to those in Fig. 3. The ranks of top and bottom journals are relatively stable. Mid-tier journals vary largely with rankings. With that said, there are still some differences between these two methods. In particular, in Fig. 3, *MS* is consistently ranked 1st while *MSOM* is ranked 1st for 2008 and 2009 in Fig. 4. This reinforces our previous

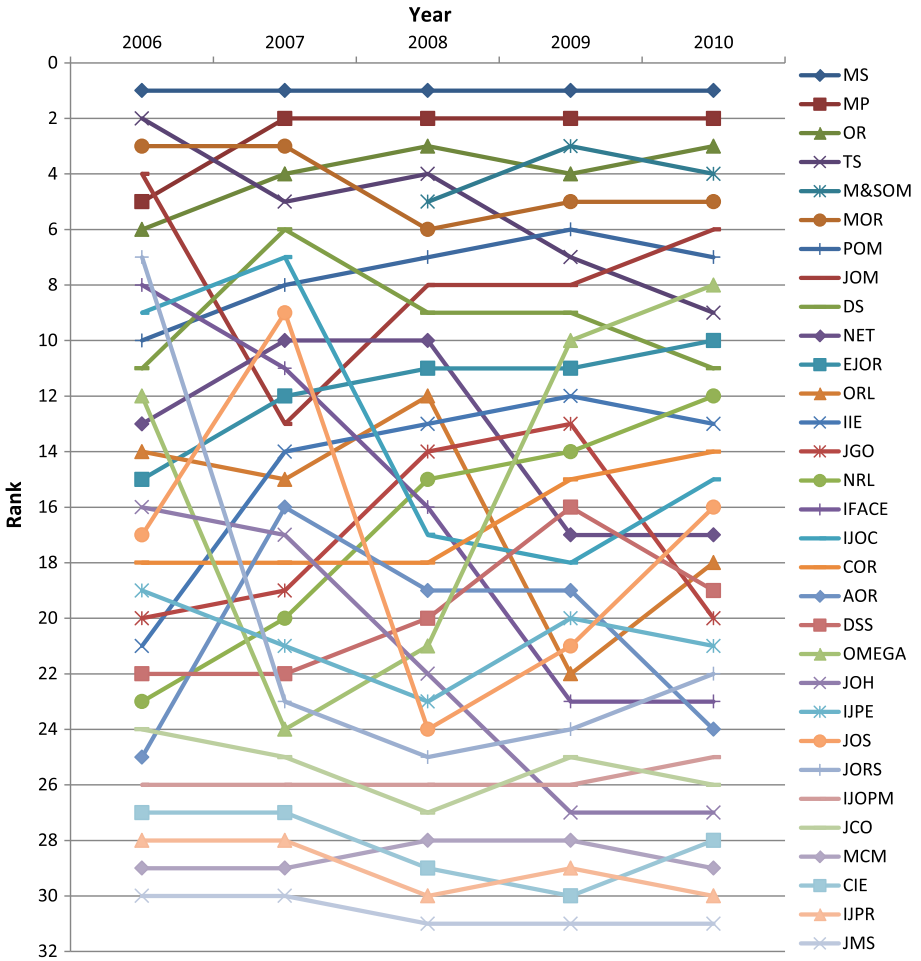

Fig. 3 Ranking trends of the selected 31 OR/MS journals for 2006–2010. All rank values used are generated with self-citation parameter β and external-citation parameter γ both equal to 1

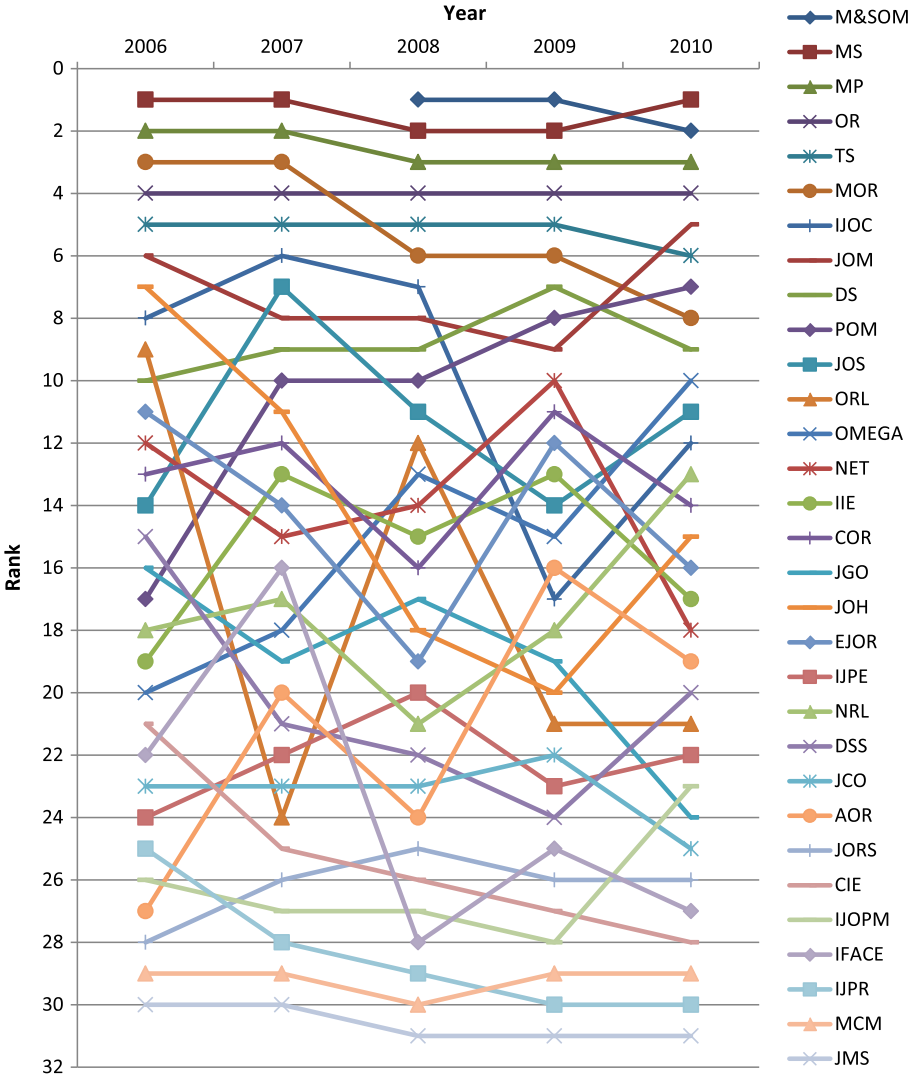

Fig. 4 Shifts in ranking of 31 OR/MS journals based on Eigenfactor's Article Influence method from 2006 to 2010

conclusion that the AI and QI share similar methodological roots but hold their own characteristics in terms of implementation.

Last but not least, we present Fig. 5, which illustrates the shifts in rankings of the same 31 OR/MS journals based on JCR's IF from 2006 to 2010. We observe that there are no discernible patterns; every segment of IF's rankings is volatile. This is not domain-specific. In fact, Gorraiz et al. (2012) reported similar findings in domains such as Polymer Science, Nanoscience and Nanotechnology, Political Science, and Library and Information Science. Gorraiz et al. (2012) contend that this is possibly due to the shorter citation time window that the IF is based on (2 years). However, Eigenfactor's AI uses a five-year time window

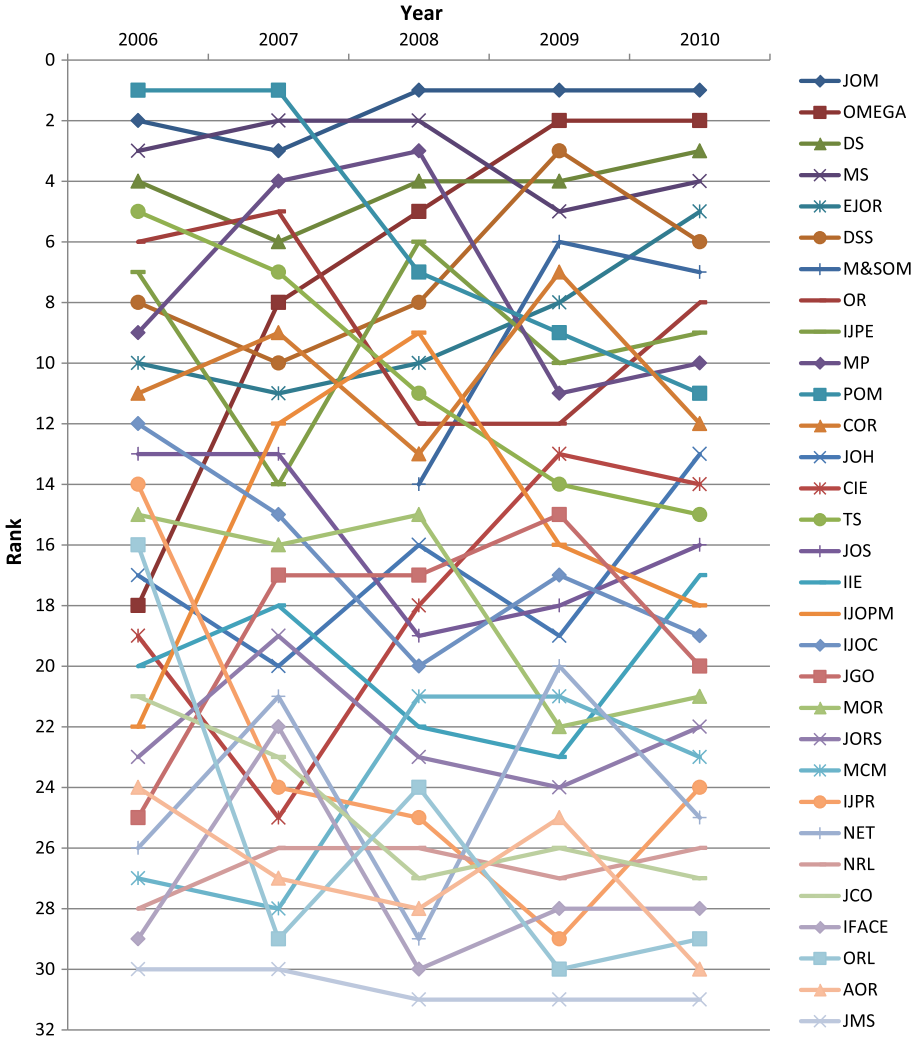

Fig. 5 Shifts in ranking of 31 OR/MS journals derived via JCR's IF from 2006 to 2010

while Xu et al.'s QI uses a ten-year time window. All in all, we posit that an article's impact may not be fully realized within the timeframe because articles can take longer than 2 years for their influence to be observed since journals typically have lengthy submission-review-revision-acceptance cycles (see Feng and Chen 2011). That as a result, the influence of articles cited after their two-year rolling timeframe is not only ignored, it appears to favor journals that have faster turnaround cycles, and also ignores articles that have longitudinal impact. These results strengthen our argument that not only is the IF method flawed because it does not differentiate among the citations, the fact that the method only considers a journal's impact factor for two rolling years would significantly affect the rankings of journals (positively for fast turnaround journals and negatively for slow turnaround journals). Apart from these observations, results derived via the IF method also

do not correlate with expert opinions (see Table 5). Finally, the numeric rank values for each journal can be found in Table 8 in Appendix for those who are curious about ranking comparisons between the QI and IF's five-year reviews.

Conclusions

This study not only presents an updated review of 31 selected OR/MS journals indexed by SCI, it also presents an emerging journals evaluation approach based on a refined PageRank method which differentiates the impacts of journals by citation types. Additionally, four longitudinal reviews are also provided to establish the trends or shifts in the rankings from 2006 to 2010.

In our 2010 cross-sectional analysis, we find that *M&SOM*, indexed by the SCI only in 2008, is a specialized journal that is consistently highly regarded within the discipline. The results also suggest that *MS* is more established as a generalized journal as it has more external impact compared to *M&SOM*. Additionally, not only do our results correlate better with expert opinions, but based on the Kendall Rank-Order Correlation coefficients, we also found that the results generated by Eigenfactor's AI method are significantly closer to ours than the results generated by SCI's IF. This is likely due to the fact that Eigenfactor's AI and the method we use (Xu et al.'s QI) share similar methodological roots.

As for the longitudinal analyses we conducted, we also observe some interesting patterns over the past 5 years (from 2006 to 2010). In particular, even though they have dissimilar characteristics in terms of implementation, we found that the patterns observed between the AI and QI are similar. This is likely because they share similar methodological roots. Nevertheless, the results of both methods show volatility in the mid-tier journals despite our results correlating with expert opinions. As for SCI's IF, there appears to be no discernible patterns; that every segment of IF's rankings is volatile. On that note, we intend to further our research to identify or determine the cause(s) for the volatility.

Finally, the findings, shifts and patterns observed in the selected OR/MS journal rankings lead us to affirm that cross-sectional and longitudinal analyses are essential to more comprehensively evaluate a journal's impact/quality. We also believe that with time and greater exposure, the proposed approach to evaluate journals based on more than one perspective could facilitate academic stakeholders in formulating and strengthening their opinions of journals of interest because they can refer to quantitatively derived information rather than rely on subjective perceptions. Summarily, we contend that this proposed model with further refinements paves the way for further research exploration and development in this relatively new research domain.

Appendix

See Tables 6, 7 and 8.

Table 6 Ranks of OR/MS journals based on PageRank ($\beta = 0.0$, $\gamma = 0.0$) (From 2006 to 2010)

Journal		Citation year					Average rank	Standard deviation
Acronym	Full name	2006	2007	2008	2009	2010		
AOR	Annals of Operations Research	25	17	17	17	23	19.8	3.49
CIE	Computers and Industrial Engineering	24	23	24	27	25	24.6	1.36
COR	Computers and Operations Research	12	16	13	13	13	13.4	1.36
DS	Decision Sciences	8	9	10	12	7	9.2	1.72
DSS	Decision Support Systems	23	28	29	25	27	26.4	2.15
EJOR	European Journal of Operations Research	15	18	19	16	19	17.4	1.62
IFACE	Interfaces	5	15	18	18	21	15.4	5.54
IIE	IIE Transactions	16	12	11	11	14	12.8	1.94
IJOC	Informs Journal on Computing	9	6	14	10	10	9.8	2.56
IJOPM	International Journal of Operations and Pduction Management	22	24	25	24	20	23	1.79
IJPE	International Journal of Production Economics	20	20	23	23	24	22	1.67
IJPR	International Journal of Production Research	26	25	26	28	28	26.6	1.20
JCO	Journal of Combinatorial Optimization	28	26	27	29	29	27.8	1.17
JGO	Journal of Global Optimization	27	27	28	26	26	26.8	0.75
JMS	Journal of Manufacturing Systems	29	30	30	30	30	29.8	0.40
JOH	Journal of Heuristics	18	11	20	22	18	17.8	3.71
JOM	Journal of Operations Management	4	14	8	8	4	7.6	3.67
JORS	Journal of the Operational Research Society	10	21	22	21	22	19.2	4.62
JOS	Journal of Scheduling	17	7	15	14	12	13	3.41
M&SOM	M&SOM-Manufacturing & Service Operations Management			1	1	1	1	0.00
MCM	Mathematical and Computer Modeling	30	29	31	31	31	30.4	0.80
MOR	Mathematics of Operations Research	11	4	6	5	9	7	2.61
MP	Mathematical Programming	13	8	7	7	8	8.6	2.25
MS	Management Science	2	3	3	4	6	3.6	1.36
NET	Networks	21	19	16	19	16	18.2	1.94
NRL	Naval Research Logistics	14	10	9	9	11	10.6	1.85
OMEGA	Omega	7	22	21	20	17	17.4	5.46
OR	Operations Research	1	1	2	3	2	1.8	0.75
ORL	Operations Research Letters	19	13	12	15	15	14.8	2.40
POM	Production and Operations Management	6	5	5	2	3	4.2	1.47

Table 6 continued

Journal		Citation year					Average rank	Standard deviation
Acronym	Full name	2006	2007	2008	2009	2010		
TS	Transportation Science	3	2	4	6	5	4	1.41

The table lists the ranking of the top 31 OR/MS journals from 2006 to 2010. Columns 1 and 2 show the acronym and full name of the journals, respectively. Columns 3–7 show their rankings from 2006 to 2010. The self-citation parameter β and the external-citation parameter γ are both equal to 0. Columns 8 and 9 are the average rank and the rank value's standard deviation, respectively

Table 7 Ranks of OR/MS journals based on PageRank ($\beta = 1.0$, $\gamma = 1.0$) (From 2006 to 2010)

Journal		Citation year					Average rank	Standard deviation
Acronym	Full name	2006	2007	2008	2009	2010		
AOR	Annals of Operations Research	25	16	19	19	24	20.6	3.38
CIE	Computers and Industrial Engineering	27	27	29	30	28	28.2	1.17
COR	Computers and Operations Research	18	18	18	15	14	16.6	1.74
DS	Decision Sciences	11	6	9	9	11	9.2	1.83
DSS	Decision Support Systems	22	22	20	16	19	19.8	2.23
EJOR	European Journal of Operations Research	15	12	11	11	10	11.8	1.72
IFACE	Interfaces	8	11	16	23	23	16.2	6.11
IIE	IIE Transactions	21	14	13	12	13	14.6	3.26
IJOC	Informs Journal on Computing	9	7	17	18	15	13.2	4.40
IJOPM	International Journal of Operations and Production Management	26	26	26	26	25	25.8	0.40
IJPE	International Journal of Production Economics	19	21	23	20	21	20.8	1.33
IJPR	International Journal of Production Research	28	28	30	29	30	29	0.89
JCO	Journal of Combinatorial Optimization	24	25	27	25	26	25.4	1.02
JGO	Journal of Global Optimization	20	19	14	13	20	17.2	3.06
JMS	Journal of Manufacturing Systems	30	30	31	31	31	30.6	0.49
JOH	Journal of Heuristics	16	17	22	27	27	21.8	4.71
JOM	Journal of Operations Management	4	13	8	8	6	7.8	2.99
JORS	Journal of the Operational Research Society	7	23	25	24	22	20.2	6.68
JOS	Journal of Scheduling	17	9	24	21	16	17.4	5.08
M&SOM	M&SOM-Manufacturing & Service Operations Management			5	3	4	4	0.82

Table 7 continued

Journal		Citation year					Average rank	Standard deviation
Acronym	Full name	2006	2007	2008	2009	2010		
MCM	Mathematical and Computer Modeling	29	29	28	28	29	28.6	0.49
MOR	Mathematics of Operations Research	3	3	6	5	5	4.4	1.20
MP	Mathematical Programming	5	2	2	2	2	2.6	1.20
MS	Management Science	1	1	1	1	1	1	0.00
NET	Networks	13	10	10	17	17	13.4	3.14
NRL	Naval Research Logistics	23	20	15	14	12	16.8	4.07
OMEGA	Omega	12	24	21	10	8	15	6.32
OR	Operations Research	6	4	3	4	3	4	1.10
ORL	Operations Research Letters	14	15	12	22	18	16.2	3.49
POM	Production and Operations Management	10	8	7	6	7	7.6	1.36
TS	Transportation Science	2	5	4	7	9	5.4	2.42

The table lists the ranking of the top 31 OR/MS journals from 2006 to 2010. Columns 1 and 2 show the acronym and full name of the journals, respectively. Columns 3–7 show their rankings from 2006 to 2010. The self-citation parameter β and the external-citation parameter γ are both equal to 1. Columns 8 and 9 are the average rank and the rank value's standard deviation, respectively

Table 8 Ranking comparisons between quality index (QI) and SCI's JCR IF (IF) (From 2006 to 2010)

Journal acronym	QI 2006	IF 2006	QI 2007	IF 2007	QI 2008	IF 2008	QI 2009	IF 2009	QI 2010	IF 2010
AOR	25	24	16	27	19	28	19	25	24	30
CIE	27	19	27	25	29	18	30	13	28	14
COR	18	11	18	9	18	13	15	7	14	12
DS	11	4	6	6	9	4	9	4	11	3
DSS	22	8	22	10	20	8	16	3	19	6
EJOR	15	10	12	11	11	10	11	8	10	5
IFACE	8	29	11	22	16	30	23	28	23	28
IIE	21	20	14	18	13	22	12	23	13	17
IJOC	9	12	7	15	17	20	18	17	15	19
IJOPM	26	22	26	12	26	9	26	16	25	18
IJPE	19	7	21	14	23	6	20	10	21	9
IJPR	28	14	28	24	30	25	29	29	30	24
JCO	24	21	25	23	27	27	25	26	26	27
JGO	20	25	19	17	14	17	13	15	20	20
JMS	30	30	30	30	31	31	31	31	31	31
JOH	16	17	17	20	22	16	27	19	27	13
JOM	4	2	13	3	8	1	8	1	6	1
JORS	7	23	23	19	25	23	24	24	22	22
JOS	17	13	9	13	24	19	21	18	16	16

Table 8 continued

Journal acronym	QI 2006	IF 2006	QI 2007	IF 2007	QI 2008	IF 2008	QI 2009	IF 2009	QI 2010	IF 2010
M&SOM	N/A	N/A	N/A	N/A	5	14	3	6	4	7
MCM	29	27	29	28	28	21	28	21	29	23
MOR	3	15	3	16	6	15	5	22	5	21
MP	5	9	2	4	2	3	2	11	2	10
MS	1	3	1	2	1	2	1	5	1	4
NET	13	26	10	21	10	29	17	20	17	25
NRL	23	28	20	26	15	26	14	27	12	26
OMEGA	12	18	24	8	21	5	10	2	8	2
OR	6	6	4	5	3	12	4	12	3	8
ORL	14	16	15	29	12	24	22	30	18	29
POM	10	1	8	1	7	7	6	9	7	11
TS	2	5	5	7	4	11	7	14	9	15

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