8-2009

Distinguishing Citation Quality for Journal Impact Assessment

Andrew LIM
University of Hong Kong

Hong MA
Singapore Management University, hongma@smu.edu.sg

Qi WEN
City University of Hong Kong

Zhou XU
Hong Kong Polytechnic University

Brenda CHEANG
Red Jasper Ltd

Citation

LIM, Andrew; MA, Hong; WEN, Qi; XU, Zhou; and CHEANG, Brenda. Distinguishing Citation Quality for Journal Impact Assessment. (2009). *Communications of the ACM.* 52, (8), 111-116. Research Collection Lee Kong Chian School Of Business.
Available at: https://ink.library.smu.edu.sg/lkcsb_research/1784

Distinguishing Citation Quality for Journal Impact Assessment

Using a revised PageRank model for citation analysis to determine the influence of journals in the field of MIS

Andrew Lim, Hong Ma, Qi Wen, and Zhou Xu
Department of Industrial Engineering and Engeering Management,
Hong Kong University of Science and Technology,
Clear Water Bay, Kowloon, Hong Kong
{iealim,hongm,vendy,xuzhou}@ust.hk
Brenda Cheang
Red Jasper Limited
No. 5 Science Park West Ave , Unit 210, 2/F
Hong Kong Science Park, Shatin
New Territories, Hong Kong

1 Introduction

The research community has long and often been fervently keen on debating the topic of journal impact. Well, just what is the impact of a journal? Today, the Science Citation Index (SCI) recognizes over 7,000 journals. The sheer number of available journals renders it pivotal for researchers to accurately gauge a journal's impact when submitting their papers, as it has become commonplace that researchers regard publishing their work in established journals to have significant influence on peer recognition. For journals in Management Information System (MIS), such research studies have continuously been published since the 1990s. Nine of them have been summarized by Carol Saunders [11], whereby seven were based on respondent perceptions by surveying experts, and two were based on the citation quantity to indicate the journal impact.

It is generally accepted that citation analysis is purported to be a more objective method than the expert survey [2]. The main reason is citation analysis uses objective measurements, which are based on the viewpoint that the influence of a journal and its articles is determined by their usefulness to other journals and articles, and where their usage can be reflected by citations that they have received. However, using citation quantity only is also considered to have bias to a certain degree, due to a widely-held notion that citation quantity does not represent citation quality. Regarding the impact in the MIS discipline for example, a citation by a paper published in a prestigious MIS journal should far outweigh a citation by a paper published in an unremarkable MIS journal or in an external journal outside the MIS field. Such intuition suggests that the citation quality can be divided into the following two aspects::

- Citation Relevance (CR): indicating how relevant the journal giving the citation is to the discipline we are interested in;

- Citation Importance (CI): indicating how important the journal giving the citation is in the discipline we are interested in.

However, these concerns about citation quality have not been properly addressed in citation analysis literature.

To address our concerns about citation quality for assessing journal impact, we propose a method, which first clusters "pure" MIS journals to identify relevant citations, and then score the impact for each journal, according to its citations that are received from "pure" MIS journals and weighted by citation importance. Although our method is only applied to MIS journals, it is general enough to evaluate the impact of journals in other disciplines.

2 Methodology and Results

2.1 Data Collection

The ISI Web of Science Database is one of the most popular citation databases for more than 7000 academic journals, among which 65 journals have appeared in at least one of the nine studies in the literature [11] on journal impact assessment for the MIS field. These 65 journals, including *Communication ACM (CACM), European Journal of Information Systems (EJIS), Information Systems Research (ISR), Information & Management (I&M), MIS Quarterly (MISQ)*, etc, are considered to be MIS-related and used in our study. For each journal, the frequency of its recent citations between 2001 and 2005, referenced to every other cited journal, was drawn from the *ISI* Web of Science and aggregated to form a 65 times 65 citation matrix. Coordinates along rows and columns of the matrix indicate the citing and the cited journals respectively.

With regard to the self-citation rates, we find that MIS related journals are widely self-cited and show a considerable dependence on the contribution of self-citations that can lead to significant changes in the assessment result. Neither a complete removal of self-citation nor a complete inclusion is viable. Therefore, we assigned each journal a ceiling of self-citation rates according to the number of non-self citations to a journal that it cited most. In the citation matrix, we then bounded every element in the diagonal by the maximum value of other elements in the same row. Due to the lack of space, the citation matrix is provided online only at "http://logistics.ust.hk/ranking/data/".

For the ease of our analysis, we further computed the citation proportion matrix, where each element represents the proportion of citations referenced to the cited journal, in terms of the percentage of the total citations from the citing journal.

2.2 Identifying Relevant Citations from "pure" MIS Journals

Besides those well-known MIS journals, our list of MIS-related journals, as well as other lists in the literature [2, 5], often include a few multidisciplinary journals, such as *Management Science* (MS), *Journal of the ACM* (JACM), *Operations Research* (OR), etc. There have been studies indicating the inclusion of these journals can pose a problem [4]. From the citation analysis view, the citations from the multidisciplinary journals are not accurate statistics in reflecting the influence of the cited journals on the MIS field. For this reason, the citation relevance study should be integral to any citation analysis study, which unfortunately has often been overlooked in the literature. Instead of excluding all multidisciplinary journals, as supported by some MIS scholars [4], we opt to remove the citations from multidisciplinary journals. Ideally, only citations referenced by "pure" MIS papers should be counted for impact assessment, but it is impossible to identify them due to the unavailability of paper classifications. As a reasonable approximation, we considered only citations from "pure" MIS journals, a categorization which was determined by clustering journals with similar citation patterns in the following manner:

To feature the citation pattern of each journal, we adopted a log multiplicative model [8] to provide the best fit for the citation data. Unlike the practice in the literature [6, 8], we applied the model to the citation proportion matrix rather than the citation matrix. This is regarding to the fact that some MIS journals, such as *CACM*, have restrictions on the number of references for each paper, putting them at a disadvantage if using the sheer citation numbers.

Details of the log multiplicative model and its usage for our study are explained in Appendix A1. Using a free software *l*EM [12], we achieved the best fit of the model for the citation proportion matrix, which includes five dimensions of association between citations sent and received by each journal. Such a five-dimension vector thus featured the citation pattern for each journal.

For every pair of journals, the distance between their feature vectors was used to measure their dissimilarity. We thus applied Ward's method [10], one of the most popular variants of the agglomerative hierarchical clustering procedures, to identify inherent clusters among all the 65 MIS-related journals. Six major clusters are summarized in Table 1. The one with fifteen journals, including *MISQ*, *ISR*, *I&M*, *EJIS*, etc., was considered to form the core set of "pure" MIS journals. Other than the core set, the cluster for the computer science and engineering discipline has the largest populations of 14 journals, including *CACM*, *IEEE Transactions*, *JACM*, etc. The complete hierarchical results of clustering were reported in the Appendix A2, due to lack of space.

2.3 Assessing Journal Impact by Revised PageRank Method

Given the core set of 15 "pure" MIS journals, we considered only citations from the core as relevant citations for our analysis. To further differentiate the importance of citations, we had to understand the relationship between citation importance and journal impact. Intuitively speaking, a citation from an influential journal should be considered more important than one from an unremarkable journal; while a journal receiving more of important citations should be considered more influential. Based on this idea, an invariant method was developed in the 1970s to evaluate the impact of physics journals [9]. It has recently been adopted, using the name of PageRank, to rank the impact of web pages by Google very successfully [7].

The PageRank method basically solves a set of linear equations by treating the impact of each journal as a variable taking positive value. These linear equations establish the intuitive relationship, as explained above, between the citation importance and the journal impact in a simplified manner:

- the impact of a journal *A* is equal to the sum of the product of the impact of every journal *B* multiplied by the proportion of citations from *B* to *A*.

As we can see, the PageRank method uses the impact of citing journal to indicate the importance of a citation.

It turns out that the impact of journals, defined by the PageRank method above, is exactly the eigenvector of the proportional citation matrix with a unit eigenvalue [1]. However, such an eigenvector may not exist if there is a pair of journals for which one cannot reach the other by following references [7]. Particularly for our study, ignoring irrelevant citations prevents every journal outside the core from reaching any journal inside the core.

For the reason above, we need to extend the PageRank method as follows to fit for citation matrix with a core. Since the "pure" MIS journals in the core can reach each other by following their references, we first applied the standard PageRank method on their proportional citation matrix to obtain the impact of every journal in the core. For a journal *A* outside the core, its impact was then redefined by the sum of the product of the impact of every journal *B* multiplied by the ratio of the citation number from *B* to *A* and the total citation number from *B* to the core.

We call the above extension for PageRank **revised PageRank**, and its results for journal impact as revised PageRank Score, or RPRS for short. It can be seen that the revised PageRank method still keeps the linear relationship between the citation importance and the journal impact, but uses the total citation number from each journal to the core, instead of that to all journals, to normalize each citation number. Therefore it is still able to distinguish the citation importance in assessing journal impact. Moreover, the new method guarantees a unique feasible valuation for impact of all MIS-related journals. In fact, it is always well defined for any citation matrix structured with a core journal set, as shown in Appendix A3.

For a better understanding of how to calculate RPRS, let us consider a simplified example as shown in Figure 1, whereby *MISQ, ISR*, and *I&M* represent three "pure" MIS journals in the core set, and *CACM* serves as an multidisciplinary journal outside the core. Figures along the arrows indicate the frequencies of citations from the core. Here self citations are ignored for simplification. Among the 607 and the 2036 citations from *ISR* and I&M to the core set, there are 89.16% and 82.78% going to the *MISQ*. This implies a linear equation for *MISQ*, i.e., "*RPRS of MISQ* = 89.16% of *RPRS of ISR* + 82.78% *of RPRS of* I&M". Similarly we can write down the other two linear equations by considering citations to *ISR* and *I&M*. By assuming the sum of *RPRS* of *MISQ*, *ISR*, and *I&M* to be one, the system of linear equations above has a unique positive solution for values of *RPRS*, i.e., 0.467 for *MISQ*, 0.401 for *ISQ*, and 0.132 for *I&M*. Based on that, *RPRS* of *CACM* can be assessed by taking (176/1062)×0.467+(155/607)×0.401+(428/2036)×0.132=0.208, whereby each ratio in the bracket is the ratio between citations to *CACM* and citations to the core from the citing "pure" MIS journals.

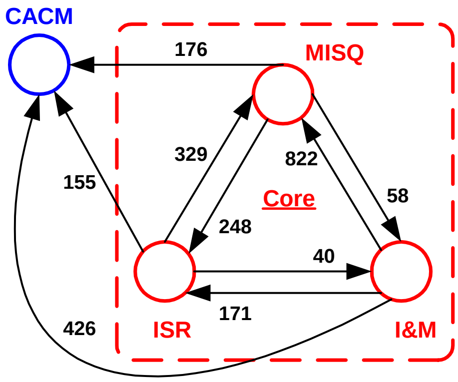


Figure 1. An example for calculating RPRS to assess the journal impact, where MISQ, ISR, and I&M form a core journal set.

Applying the revised PageRank method for all journals in this study, we obtained RPRS's for impact of "pure" MIS journals in the core set first, as shown in 2^{nd} rightmost column of Table 1. Based on that, RPRS's for impact of journals outside the core set were then calculated and are also reported in Table 1. Figures in the last column of Table 1 have numbered the ranks of all journals according to the increasing order of their RPRS's, which also determines the order for journals being listed within each cluster.

3 Discussion

3.1 RPRS for Journal Impact on the MIS Field

According to RPRS's shown in Table 1, we are able to identify which journals have high impact on the MIS field, as well as how influential they are. Among 15 "pure" MIS journals, the seven most authoritative journals, including *MISQ, ISR, JMIS, IM, EJIS, JSIS,* and *IJEC*, obtained more than 92% of the total RPRS for the core set. The top two ones, *MISQ* and *ISR*, obtained about 57% of the total RPRS for the core. It is worth noticing that these journals with high RPRS's are also well known for their good reputations in the MIS field, according to recent surveys of MIS scholars [5].

In addition to "pure" MIS journals, some journals in other professions also appear to have high impact on the MIS field in terms of their large RPRS's. For example, *MS*, *CACM* and *OS* have the highest RPRS among journals in the professions of Operations Research, Computer Science and Engineering, and Management respectively. RPRS's of these three journals are even higher than most "pure" MIS journals. They are among the top 5 of all 65 MIS-related journals, and the other two are *MISQ* and *ISR*.

Table 1. RPRS for the 65 MIS-related Journals in 6 Clusters

Cluster	Jcode	Journal Name	RPRS	Rank
"Pure" MIS Journals (core set)	MISQ	MIS Quarterly	0.3547	1
	ISR	Information Systems Research	0.2180	3
	JMIS	Journal Of Management Information Systems	0.1239	8
	IM	Information & Management	0.1158	9
	EJIS	European Journal Of Information Systems	0.0501	15
	JSIS	Journal Of Strategic Information Systems	0.0315	19
	IJEC	International Journal Of Electronic Commerce	0.0297	20
	JIT	Journal Of Information Technology	0.0278	21
	ISJ	Information Systems Journal	0.0118	28
	ISM	Information Systems Management	0.0113	29
	JOCEC	Journal Of Organizational Computing And Electronic Commerce	0.0101	32
	IJIM	International Journal Of Information Management	0.0096	33
	JCIS	Journal Of Computer Information Systems	0.0031	48
	ISF	Information Systems Frontiers	0.0025	51
	WIRT.	Wirtschaftsinformatik	0.0001	61
Communication Research	CR	Communication Research	0.0168	24
	JASIST	Journal Of The American Society For Information Science & Technology	0.0164	25
	ATIS	ACM Transactions On Information Systems	0.0154	26
	ISOC	Information Society	0.0102	31
	IJHCS	International Journal Of Human-Computer Studies	0.0093	34
	HCI	Human-Computer Interaction	0.0081	35
	CHB	Computers In Human Behavior	0.0054	38
	IPM	Information Processing & Management	0.0041	47
	JIS	Journal Of Information Science	0.0001	63
Aritificial Intelligence	DSS	Decision Support Systems	0.0496	16
	AI	Artificial Intelligence	0.0041	46
	ES	Expert Systems	0.0016	53
	ESA	Expert Systems With Applications	0.0007	54
	AIM	AI Magazine	0.0006	56
	KBS	Knowledge-Based Systems	0.0001	60
	IEEETSMC	IEEE Transactions On Systems Man And Cybernetics	0.0000	64
Computer Science and Engineering	CACM	Communications Of The ACM	0.2166	4
	ISYS	Information Systems	0.1575	6
	IEEESE	IEEE Software	0.0190	23
	IEEETSE	IEEE Transactions On Software Engineering	0.0132	27
	IBMSJ	IBM Systems Journal	0.0111	30
	IEEEC	IEEE Transactions On Computers	0.0052	40
	ACS	ACM Computing Surveys	0.0052	41
	IST	Information And Software Technology	0.0048	42
	ATDS	ACM Transactions On Database Systems	0.0044	45
	JSS	Journal Of Systems And Software	0.0028	49
	IEEETKDE	Ieee Transactions On Knowledge And Data Engineering	0.0028	50
	CJ	Computer Journal	0.0006	57
	JACM	Journal Of The ACM	0.0003	59
	JCSS	Journal Of Computer And System Sciences	0.0000	64
Operations Research	MS	Management Science	0.2729	2
	DS	Decision Sciences	0.0784	13
	OMEGA	Omega-International Journal Of Management Science	0.0199	22
	INTERFACE	Interface	0.0076	36
	EJOR	European Journal Of Operational Research	0.0062	37
	OR	Operations Research	0.0046	44
	COR	Computers & Operations Research	0.0006	55
	INFOR	Infor	0.0004	58
	IJOC	Informs Journal On Computing	0.0001	62
Management	OS	Organization Science	0.2039	5
	AMR	Academy Of Management Review	0.1373	7
	HBR	Harvard Business Review	0.1133	10
	ADSQ	Administrative Science Quarterly	0.1076	11
	AMJ	Academy Of Management Journal	0.1060	12
	OBHD	Organizational Behavior And Human Decision Process	0.0547	14
	CMR	California Management Review	0.0417	17
	JM	Journal Of Management	0.0377	18
	MSMR	MIT Sloan Management Review	0.0054	39
	IJTM	International Journal Of Technology Management	0.0048	43
	JETM	Journal Of Engineering And Technology Management	0.0020	52

Another interesting finding is that among journals with the top 20 highest RPRS's, there are eight journals from the Management field, even one more than from "pure" MIS journals. This reveals a strong impact of Management journals on the MIS field, which is also consistent with findings in the literature [3].

3.2 Comparing RPRS with other Citation Indices

As shown in above, the impact of a journal can be assessed by its RPRS, which, however, is likely to be affected by the number of papers published in a journal. In order to eliminate journal size effect, we calculated the RPRS per paper (RPRS/P) by averaging its RPRS over its size, whereby the size of a journal was approximated by the number of papers it published between 2001 and 2005. In order to examine the effectiveness of RPRS and RPRS/P, another four citation indices were calculated for comparisons, including the total citations (or per paper) that a journal received from the core set of "pure" MIS journals (or from all journals). Therefore, we we obtained in total six citation indices for every journal.

Due to the lack of space, Table 2 summarizes only the rank (instead of the value) for each of the six citation indices above, and only for the "pure" MIS journals or journals with RPRS's in the top 20 highest. A complete list of results is available online.

Table 2 clearly shows that with or without differentiating the citation relevance, the results of journal impact assessment appear to be very different. For example, *ISR* has an RPRS in the top 3 highest, but is only ranked as 16th in terms of its total citations received. Another convincing example is from *EJOR* and *OR*. Both of their RPRS's are excluded from the top 20 highest, but their total citations received are pretty high, ranked as 6th and 8th of all. However, among all the citations received by *EJOR* or *OR*, less than 1% is from "pure" MIS journals. Although *EJOR* and *OR* have good reputations among the Operations Research profession, neither of them has been ranked in the top in a recent survey of MIS scholars [5]. Thus it is more convincing to differentiate citation differences for the journal impact assessment, just as we did in calculating RPRS.

According to the ranks for RPRS, *MISQ* and *ISR* stand in the top. This may not be surprising for *MISQ*, since its total citations received are also ranked in top 1. However, the rank in top 3 highest RPRS's is significant to *ISR*, because its total citations received is ranked only as 6th. To understand whether or not such a change of the rank is reasonable, we have compared citations to *ISR* with those to the other journal *I&M*. Although *I&M* receives 50% more citations than *ISR*, the frequency of its citations from *MISQ* is only 58, much less than *ISR*, whose is 248. By amplifying the importance of citations from *MISQ*, which is quite natural, the RPRS of *I&M* is ranked only as 9th, much lower than *ISR*. This relative ranks between *ISR* and *I&M* is also consistent with the recent survey of MIS scholars [5]. We therefore believe RPRS is likely to provide a more reasonable assessment of journal impact than other citation indices that ignore citation importance.

Comparing RPRS in Table 2 with the frequency of total citations from the core also demonstrates the different effects of self citations. For example, JCIS is ranked as 17th for its frequency of total citations from the core, but only ranked as 49th for its RPRS. As we observed, 99% of the citations JCIS received are self citations, and it has only once been cited by *MISQ* and *ISR*. This goes to show that the revised PageRank method has reduced the importance of self citations for such journals, and therefore produced a more reasonable assessment for their impact.

Table 2. Comparisons of Ranks according to Six Different Citations Indices, where by journals outside the core set are highlighted

RPRS	JCode	RPRS/P	Citation from Core	(Citation from Core)/p	Citation	Citation/P
1	MISQ	1	1	1	5	2
2	MS	9	3	12	1	7
3	ISR	2	6	3	16	6
4	CACM	16	2	14	2	22
5	OS	6	8	10	9	5
6	ISYS	4	5	4	12	8
7	AMR	5	10	6	7	3
8	JMIS	7	9	5	19	15
9	I&M	12	4	8	11	20
10	HBR	19	7	18	10	26
11	ADSQ	3	13	2	4	1
12	AMJ	13	12	16	3	4
13	DS	15	11	17	14	25
14	OBHD	17	21	26	18	23
15	EJIS	10	14	9	34	24
16	DSS	11	15	11	20	9
17	CMR	14	19	15	27	19
18	JM	20	23	23	17	14
19	JSIS	8	14	7	48	21
20	IJEC	26	18	24	39	46
21	JIT	18	16	13	40	30
28	ISJ	23	28	19	55	38
29	ISM	32	29	29	58	58
32	JOCEC	24	31	20	59	40
33	IJIM	42	22	34	49	61
48	JCIS	49	17	21	44	53
51	ISF	43	52	45	65	65
61	WIRT.	62	42	39	63	63

Table 2 also shows some differences between ranks of RPRS and RPRS/P. For example, EJIS and JSIS, two “pure” MIS journals who publish fewer than 25 articles annually, have higher ranks (10th and 8th) for their RPRS/P than ranks (15th and 19th) for their RPRS. This implies a paper published in EJIS or JSIS is likely to have high impact in the MIS field, regardless of their small journal sizes. However, some multidisciplinary journals, such as *MS*, *CACM*, and HBR etc., have relatively higher ranks (2nd, 4th, and 10th) for RPRS than those (9th, 16th, and 19th) for RPRS/P. These three journals are large, each publishing more than 100 articles per year. Since quite a few papers they published are not related to the MIS field, it would be ideal if we could count only MIS-related articles for the calculation of RPRS/P. However, identifying MIS-related articles is very difficult for us to accomplish, due to the limited amount of available data.

3.3 Roles of Journals: Source, Hub, and Storer

Journals with high RPRS should be considered as more influential knowledge sources in the MIS field. As highlighted in Table 2, among the top 20 journals with the highest RPRS's, only seven are "pure" MIS journals, while 13, the majority, are not, with eight from Management, two from Operations Research, two from Computing, and one from AI. Therefore the "pure" MIS journals together with Management journals form the two major knowledge sources for the MIS field.

It is interesting to see that journals with high RPRS's have a significant difference in the proportions of citations they to the "pure" MIS journals. As shown in Figure 2, "pure" MIS journals in the core set have sent relatively higher proportions (above 30%) of their citations to "pure" MIS journals. For journals that are not "pure" MIS journals, only *CACM* (28.7%), *DS* (15.1%), and *DSS* (22.6%) cite journals in the core set frequently, but others, such as *AMR* (0.3%), *AMR* (0.2%), and etc, scarcely refer the "pure" MIS journals.

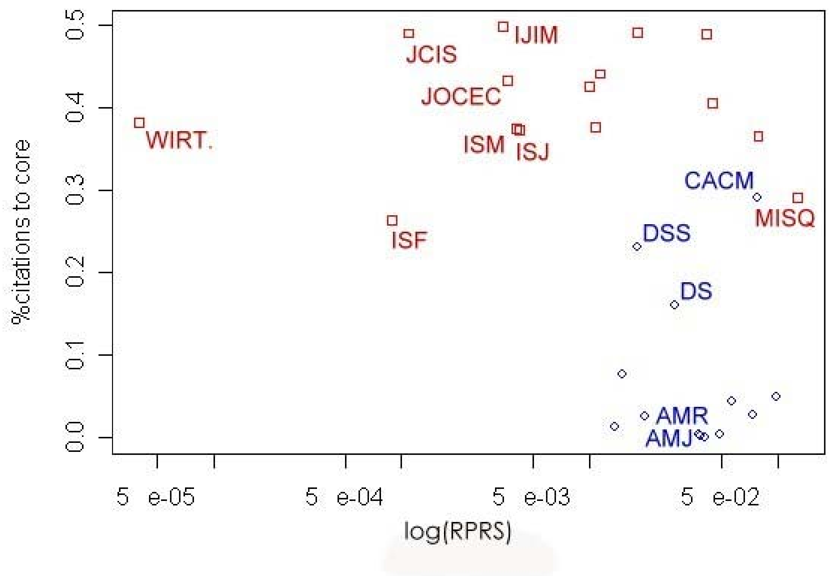


Figure 2. Plot for the proportion of citations referring to the core set, for journals with the top 20 highest RPRS's or in the core set

1. **red squares for "pure" MIS journals in the core set; blue circles for others;**

The observation above implies the roles of *CACM, DS, and DSS* are the hubs that exchange knowledge between the MIS and other disciplines. Journals, such as *AMR* and *AMJ*, serve as only a knowledge source for the MIS field. It is worth noticing that the reason for *HBR* to rarely cite the "pure" MIS journals is likely to be different from that for others, because most papers published in *HBR* have no references. Lastly, for pure "MIS" journals with small RPRS, such as *ISJ, ISM, JOCEC, IJIM, JCIS, ISF,* and *WIRT,* they still have large proportions (above 30%) of citations to the other “pure” MIS journals, implying their roles as knowledge storers only for the *MIS* field.

4. Conclusions

4.1 Summary

A new method is proposed to differentiate the citation quality for assessing journal impact. For applying the method application in the MIS discipline, we first identified a core set of “pure” MIS journals by clustering 65 MIS-related journals according to their citation patterns. Only citations from “pure” MIS journals are considered to be relevant, and their importance is thus differentiated by an extension of the standard PageRank method, revised PageRank, to assess each journal for its impact in the *MIS* discipline. Based on empirical results, we have demonstrated the effectiveness of our new method, and also revealed different roles that journals played in terms of their impact in the MIS discipline.

4.2 Limitations and Future work

It must be noted that the results are specific to the selection of journals. For some notable omissions, such as *DataBase*, whose citation records are not available in the ISI *Web of Science*, we are currently looking for another data source. The method we proposed relies on citations among journals. However, since the MIS field has some multiple disciplinary journals, it would be ideal to analyze the citations among articles, and understand the field that each article belongs to. This may require tremendous time and resources. Besides assessing journal impact within a fixed time period, our method can also easily be applied to citation data for varying time periods to capture the change of journal impact, as long as this data is accessible. Although results based on the current method may be far from judging the journal impact accurately, we believe that the insights behind the method as well as its findings can serve as a valuable base for further study. Finally, to facilitate the use of our method in assessing journals of other disciplines, our team collected citation data for 7000+ journals and established an on-line journal ranking system at *http://journal-ranking.com/ranking/web/index.html*, whose engine for assessing journal impact has been implemented using the revised PageRank method.

References

1. Horn, R.A. and Johnson, C.R. *Matrix Analysis*. Cambridge University Press, 1985.
2. Katerattanakul, P., Han, B. and Hong, S. Objective quality ranking of computing journals. *Communications of the ACM*, *46* (10). 111-114.
3. Katerattanakul, P., Han, B. and Rea, A. Is information systems a reference discipline? *Communications of the ACM*, *49* (5). 114-118.
4. Katerattanakul, P., Razi, M.A., Han, B.T. and Kam, H.J. Consistency AND Concern ON IS Journal Rankings. *The Journal of Information Technology Theory and Application (JITTA), 7* (2). 1-20.

5. Mylonopoulos, N.A. and Theoharakis, V. On site: global perceptions of IS journals. *Communications of the ACM*, *44* (9). 29-33.
6. Nerur, S., Sikora, R., Mangalaraj, G. and Balijepally, V.G. Assessing the relative influence of journals in a citation network. *Communications of the ACM*, *48* (11). 71-74.
7. Page, L., Brin, S., Motwani, R. and Winograd, T. The pagerank citation ranking: Bringing order to the web, Technical report, Stanford Digital Library Technologies Project, 1998, 1998.
8. Pieters, R. and Baumgartner, H. Who Talks to Whom? Intra-and Interdisciplinary Communication of Economics Journals. *Journal of Economic Literature*, *40* (2). 483-509.
9. Pinski, G.a.N., F. Citation influence for journal aggregates of scientific publications: Theory, with application to the literature of physics. *Information Processing and Management*, *12*. 297--312.
10. Punj, G. and Stewart, D.W. Cluster Analysis in Marketing Research: Review and Suggestions for Application. *Journal of Marketing Research*, *20* (2). 134-148.
11. Saunders, C. MIS Journal Ranking *ISWorld net*, http://www.isworld.org/csaunders/rankings.htm, Associations for Information System, 2006.
12. Vermunt, J.K. LEM: Log-Linear and Event History Analysis with Missing Data. *Tilburg, Netherlands: Tilburg University, version*, *1*.

Appendix

A1 Log-multiplicative Citation Model for Clustering

Considering n journals for our study, we use $\boldsymbol{C}=[c_{i,j}]$ to denote the n times n citation matrix, whereby $c_{i,j}$ indicate the frequency of citations referred by journal i to journal j. The proportional citation matrix is denoted by $\boldsymbol{P}=[p_{i,j}]$, where $p_{i,j} = c_{i,j} \Big/ \sum_{k=1}^{n} c_{i,k}$.

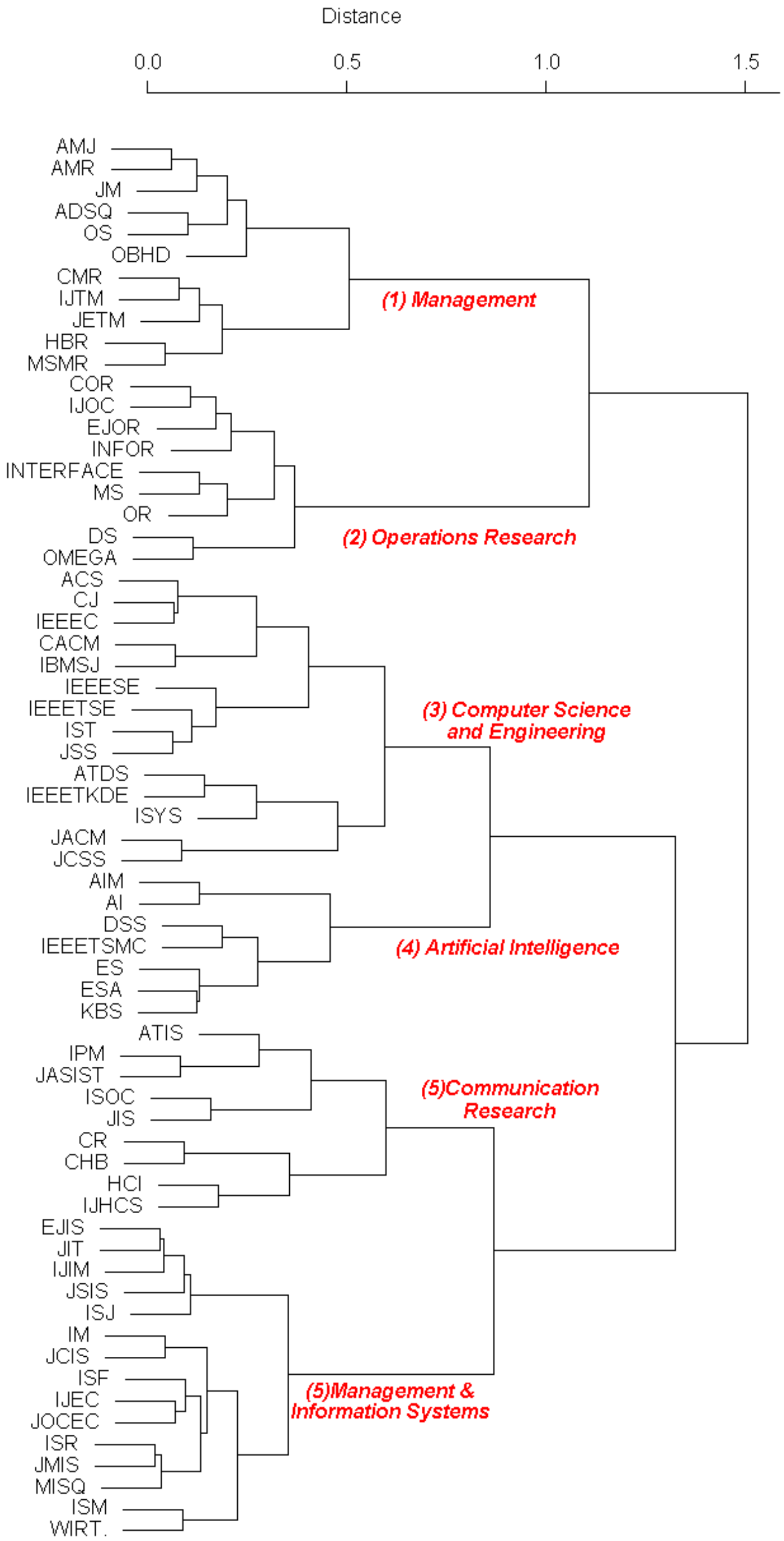
We used the symmetric log-multiplicative citation model to estimate $\boldsymbol{P}$:

$$\log \hat{p}_{i,j} = \mu + \mu_i^S + \mu_j^R + \delta_{i,j} + \sum_{m=1}^{M} \beta_i^m \psi^m \beta_j^m \ .$$

Here $\hat{p}_{i,j}$ is the estimated proportion of citations from journal i to journal j, and other parameters are illustrated as follows. The μ parameter is a constant, μ^S and μ^R parameters represent effects of overall citing and cited volume for each journal, $\delta_{i,j}$ accounts for effects of self citations, and $\sum_{m=1}^{M} \beta_i^m \psi^m \beta_j^m$ is the log-multiplicative term with M dimensions, which captures cohesion of citing and cited journals.

Using the *l*EM [12], a tool to estimate parameters for log-multiplicative model, we can obtain values for every parameter. By trying different numbers of dimensions for M, we eventually choose M=5, because it fits and interprets the data well. The corresponding M dimensional cohesion vector [β_i^m] was used to feature the citation pattern for every journal i. More details of the cohesive analysis by log-multiplicative model can be found in [8].

A2 Results of Journal Clustering



A3 Formulation of Revised PageRank Method

Given n journals, let J denote the core set of journals, and the citation matrix $\boldsymbol{C}$ is supposed to satisfy:

1. $c_{i,j} = 0$, for $i \notin J$;

2. the sub-matrix $C^J = \{c_{i,j} : i \in J,\, j \in J\}$ is irreducible.

The first condition implies that irrelevant references outside the core set are ignored. The second condition assumes journals in the core are strongly connected by their references. Both conditions are satisfied in our study for MIS-related journals.

For the given core set J, we can define $\boldsymbol{P}^J=[p^J_{i,j}]$ as the proportional citation matrix on J, whereby $p^J_{i,j} = c_{i,j} \Big/ \sum_{k \in J} c_{i,k}$, which will be used to derive the revised PageRank method as follows.

Let us use s_i to denote the impact of a journal i. We first applied the standard PageRank method to assess the impact of journals in core set, by solving the following linear equations:

$$\begin{cases} s_j = \sum_{i \in J} p^J_{i,j} s_i, \ \ for \ \ j \in J \\ \sum_{j \in J} s_j = 1 \end{cases} \qquad \text{(A-1)}$$

As we can see in the above equations, the citation importance is determined by the impact of the citing journal. The impact of a cited journal is assigned as a linear combination of the importance of all the citations received, weighted by the proportional citations on J. Since C^J is irreducible, the above equations must have a unique positive solution [1].

In the second stage, we decide the impact s_j for every journal j excluded in the core set J, by the same equation as that in (A-1), but here s_i for $i \in J$, in the right hand side of the equation, are given by the solution obtained in the first stage.

Accordingly, the two stages of our revised PageRank method can be summarized as one step, i.e., to solve the following linear equations:

$$\begin{cases} s_j = \sum_{i \in J} p^J_{i,j} s_i, \ \ for \ 1 \le j \le n \\ \sum_{j \in J} s_j = 1 \end{cases} \qquad \text{(A-2)}$$

As we have shown, (A-2) guarantees a unique positive solution, and therefore is well defined, for the citation matrix structured by a core set of journals.