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Scholarly journal evaluation based on panel data analysis

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ABSTRACT

This paper proposes a new method for indicator selection in panel data analysis and tests the method with relevant data on agricultural journals provided by the Institute of Scientific & Technical Information of China. An evaluation exercise by the TOPSIS method is conducted as a comparison. The result shows that panel data analysis is an effective method for indicator selection in scholarly journal evaluation; journals of different disciplines should not be evaluated with the same criteria; it is beneficial to publish all the evaluation indicators; unavailability of a few indicators has a limited influence on evaluation results; simplifying indicators can reduce costs and increase efficiency as well as accuracy of journal evaluation.

1. Introduction

Research on journal evaluation methods is an important component of bibliometric studies. It tries to disclose regularities in the distributions of publications in disciplinary journals and quantitatively analyses developments and growth trends of scholarly journals so as to improve journal utilization. Journal evaluation exercises can, moreover, improve the quality of scholarly journals and promote their healthy development. In the 1960s Eugene Garfield, the founder and one-time president of the Institute for Scientific Information, conducted several large-scale statistical analyses of journal citations and reached the conclusion that the majority of citations were attributed to relatively few journals, while a minority of citations was spread over many journals. His work can be viewed as the origin of journal evaluations.

The journal impact factor was first proposed in 1963 as a spin-off from the science citation index (SCI) which was launched that year by Garfield (1972, 1976). Studies on performance evaluation often focus on the identification of research of the "highest quality", "top research" or "scientific excellence". This focus on top quality has led to the development of a whole series of bibliometric methodologies and indicators (van Leeuwen, Visser, Moed, Nederhof, & van Raan, 2000). Representative indicators are the Relative Citation Rate (Schubert, Glänzel, & Braun, 1983), the Relative Subfield Citedness (Vinkler, 1986), the Normalized Mean Citation Rate (Braun & Glänzel, 1990), the Field Citation Score (Moed, De Bruin, & van Leeuwen, 1995), the Hirsch Index (Hirsch, 2005), the Article-Count Impact Factor (Markpin et al., 2008), etc.

Methods of journal evaluation usually consist of single index evaluation or Multiple Attribute Evaluation (MAE). As research performance is multidimensional it is clear that it cannot be evaluated by a single indicator (Martin, 1996). In MAE, indicators are combined into a single index. Such an approach is widely used by statistical officers and national or international organizations to convey information in many fields. Examples of well-known MAE include the UN's Human

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Development Index (Sagar & Najam, 1998) and the environmental performance index produced by a joint effort of Yale, Columbia, the World Economic Forum and the Joint Research Center of European Commission (Esty et al., 2006). MAE is essentially concerned with the problem: how to evaluate and rank a finite set of alternatives in terms of a number of decision criteria. Most popular MAE methods currently used are: Weighted Sum Model (WSM), Weighted Product Model (WPM), Technique for Order Preference by Similarity to Ideal Solutions (TOPSIS), Data Envelopment Analysis (DEA) and ELECTRE. Yue and Wilson (2004) constructed a framework for the analysis of journal impact based on the principle of structural equations. Although composite indicators are frequently used for analyzing social or economic activities, they are seldom used in the scientometric literature (Vinkler, 2006).

In those evaluations, people often pay a lot of attention to the comparison of different indicators in the same year. In our opinion they, however, fail to consider the variation of indicators as time evolves. They also fail to notice how the gap in indicator values between excellent journals and ordinary journals may influence the selection of indicators. This paper explores the indicator selection issue by using the CSTPC (China Scientific and Technical Papers and Citation) database built by ISTIC (the Institute of Scientific & Technical Information of China). For more information about this database the reader is referred to (Wu et al., 2004). An improved method of Panel Data Analysis is presented for indicator selection. Then an evaluation exercise using the TOPSIS method is conducted as an illustration of our approach.

2. Data selection

Data used in this paper are derived from ISTIC's CSTPC database. Evaluation is performed on agricultural journals as an example. Since 1987 ISTIC has been doing annual statistical analyses on the quantity and quality of publications by Chinese scientists and has maintained the CSTPC database ever since. The Chinese Scholarly Journals Citation Report is released every year. In order to analyze the dynamic change of journal evaluation indicators, relevant data for agricultural journals over the period 2005–2006 are selected. Our analysis is based on panel data of a total of 96 agricultural journals. For these journals, data for 13 indicators in 2005 and 2006 are available. For instance, the impact factor in 2005 is equal to the number of citations received in 2005 to articles published in 2003–2004, divided by the total number of articles published in 2003–2004. The impact factor in 2006 is the number of citations in 2006 of articles published in the period 2004–2005, divided by total number of articles published in 2004–2005.

For each journal the following 13 evaluation indicators are examined: Total Cites, Impact Factor (standard two year synchronous impact factor), Immediacy Index, Ratio of Other Citations, Diffusion Factor (number of cited periodicals divided by number of citations per 100 times, Disciplinary Impact Indicator (ratio of number of within-discipline journals citing the evaluated journal over the total number of journals within the same discipline as to which the evaluated journal belongs, Disciplinary Diffusion Factor (ratio of number of all journals citing the evaluated journal to total number of journals within the same discipline as to which the evaluated journal belongs), Citing half-life, Cited half-life, Ratio of Funded Papers (ratio of papers sponsored by funds to total papers), Average Number of Authors per Paper, Average Citations per Article, Share of Overseas Contributions in Total Papers. The indicators mentioned above are the main CSTPC indicators. They reflect the different aspects of journal quality and impact. Here it should be noticed that overseas contribution refers to the articles whose first author does not have a Mainland China institutional address. The *h*-index is not taken into account because data needed for its calculation are unavailable for calculation.

How should indicator selection be conducted? As some indicators are neither 'good' or 'bad' (they can considered to be neutral), are influenced by many factors and have little practical value, it is difficult to accept or reject them theoretically. In this paper indicator selection is conducted according to the following two criteria: the yearly data change and the relative data gap in the same year.

In order to evaluate scholarly journals properly data must be normalized. The maximum value of each indicator is set to be 100 and other normalized values are calculated accordingly. Since Cited half-life and Citing half-life are "negative" indicators (the smaller the better for the evaluation result), an appropriate adjustment process is needed. The adjustment method we adopt is that the normalized values for these indicators are subtracted from 100, and then the difference is normalized again. In this way, the two indicators are changed into positive indicators (the larger the better for the result).

3. Indicator selection

3.1. Dynamic selection of indicators

As a rule, one expects that the results of an evaluation exercise performed on scholarly journals increase gradually (unless there is a clear outside reason), similar to the growth of the national economy or the income of the inhabitants of a country. Certainly, individual indicators for some journals may occasionally decrease. Such a decrease should, however, be considered a normal phenomenon provided the decrease is not heavy. On the contrary, if an indicator shows a sudden drastic decrease over time, the reason behind this must be carefully analyzed. If this happens frequently such indicators should not be selected for evaluation. It should be noticed that Citing half-life and Cited half-life are two "negative" indicators so that the method for judging whether their development trend is normal or not is just opposite to the method for positive indicators. Table 1 shows the changes of 13 evaluation indicators for 96 journals in the years 2005–2006.

Table 1
Dynamic change of evaluation indicators.

Index	Total cites	Impact factor	Immediacy index	Ratio of other citations	Diffusion factor	Disciplinary impact factor	Disciplinary diffusion factor
Number of journals with increased indicator values in 2006 (A)	95	84	57	55	25	75	96
Number of journals with decreased indicator values in 2006 (B)	1	12	39	41	71	21	0
Percentage of B over total journals (%)	1.04	12.50	40.63	42.71	73.96	21.88	0.00
Selected or not	selected	selected	deleted	deleted	deleted	selected	selected

Index	Cited half-life	Citing half-life	Ratio of funded papers	Share of overseas contributions in total papers	Average number of authors per paper	Average citations per article
Number of journals for which the index value increased in 2006	49	51	76	60	72	75
Number of journals for which the index value decreased in 2006	47	45	20	36	24	21
Percentage of decreasing journals (%)	48.96	46.88	20.83	37.50	25.00	21.88
Result of selection	deleted	deleted	selected	deleted	selected	selected

The indicator with the largest decrease is the Diffusion Factor with 73.96% of the journals witnessing a decrease while indicators with the smallest decrease are the Disciplinary Diffusion Factor and Total Cites, for which less than 2% of the total number of journals have such a decrease. This leads us to the question: which threshold should be used to determine whether a decrease in indicator value is a drastic decrease or not? According to the Pareto principle (Pareto, 1897), the most important usually account for about 80%. In order to prevent giving up important indicators too carelessly, a conservative rule is adopted here and 1/3 is taken as the criterion for indicator deletion. Hence, if the decrease percentage of an indicator is larger than 33.33%, this indicator is not taken into consideration. So the following six indicators should not be selected as evaluation indicators: Immediacy Index, Ratio of Other Citations, Diffusion Factor, Cited half-life, Citing half-life, and Share of Overseas Contributions in Total Papers.

There are many reasons explaining a decrease of an evaluation indicator value. In our opinion the primary reasons are the following.

First, for some top journals the indicators' value is almost "perfect". Hence, an increase is very difficult and a small decrease may occasionally happen. This is considered a normal phenomenon.

Second, some indicators' value may be optimal in certain range, and any value beyond this range is not positive. An example is given by the Average Number of Authors. Nowadays scientific cooperation prevails increasingly throughout the world, and the best papers are very often coauthored. This, however, does not mean that it is always the case that the larger the number of authors, the higher a paper's quality. The Ratio of Other Citations is similar in this regard.

Third, due to the way certain disciplines develop, some indicators' value may show no change at all in a short time. For different sub-disciplines within the same discipline, certain indicators' values may change differently as time elapses. The Immediacy Index, Cited half-life and Citing half-life are examples.

Fourth, some indicators are new for the field under study and their value often fluctuates a lot in the initial stage. For instance, Share of Overseas Contributions in Total Papers in agricultural journals is generally very low, with some journals having no overseas contribution at all.

Fifth, some indicators' value is influenced by an expansion of a journal's number of pages or a change of the publication cycle.

However, in normal situation, the extent of decrease of an indicator value is small so it does not overturn the whole picture. However, if this decrease is large and its causes are difficult to identify, then use of this indicator should be abandoned.

3.2. Relative screening of indicators

The term *relative screening of indicators* refers to the process of determining if there is a significant difference in average value of certain indicators between excellent journals and ordinary journals. If the difference is very small or the average value of certain indicators of excellent journals is even less than that of ordinary journals, the related indicator is not suitable for journal evaluation. An implicit assumption here is that all indicators' values of excellent journals are excellent. We consider this assumption as common sense.

Which indicators could reflect excellent journals? As far as an individual indicator is concerned, Impact Factor is the generally accepted one before a composite evaluation index comes into existence. In this paper Impact Factors of 96 journals are ranked from high to low, and we regard the top 20% as excellent journals. Then average indicator values of both excellent journals and ordinary journals are calculated, and increase percentages of average value of excellent journals in comparison to that of ordinary journals are also given. The result is shown in Table 2.

For excellent journals, average value of Share of Overseas Contributions in Total Papers exceeds ordinary journals' value by a huge margin, with the ratio of value gap to the average value of ordinary journals reaching 252.63%. The second indicator showing a large difference is Total Cites. It is worth mentioning that for four indicators (Diffusion Factor, Disciplinary Diffusion Factor, Cited half-life and Ratio of Other Citations) average values of excellent journals are less than that of ordinary journals. Obviously, these four indicators are not suitable for evaluation. The next question is for indicator screening what value gap should be taken as the threshold? If the gap is too small, the indicator should not be selected for evaluation. The rationale here could be understood if we take students' examination scores as an example. In China, students' academic performances are evaluated on a 0–100-point scale. Usually a score above 85 points is excellent. Let us suppose that the average score of excellent students is 90 points, that of ordinary students is 75, then the gap between them is 20%. In this paper, in order to avoid getting rid of indicators by mistake and losing important information, we set the threshold at 15% for security, which means that the average indicator value of excellent journals should be at least 15% greater than that of ordinary journals.

After the above-mentioned *dynamic selection* and *relative screening*, four indicators, namely, Total Cites, Impact Factor, Ratio of Funded Papers and Average Citations per Article, are selected. We conclude that after panel data analysis only 4 of the original 13 indicators are left for evaluating agricultural scholarly journals.

4. Results of the evaluation exercise

4.1. Choice of evaluation method

Total Cites and Impact Factor are indicators of journal impact, while Ratio of Funded Papers and Average Citations per Article represent other aspects of journals. Considering that the weights of these indicators are difficult to assign and that the

Table 2
Relative screening result of evaluation indicators.

Index	Total cites	Impact factor	Immediacy index	Ratio of other citations	Diffusion factor	Disciplinary impact factor	Disciplinary diffusion factor
Average value of excellent journals	1575.63	1.15	0.11	0.81	13.75	0.64	2.31
Average value of ordinary journals	595.95	0.40	0.05	0.85	28.57	0.61	3.61
Increase %	164.39	190.77	129.34	−5.14	−51.86	5.75	−36.06
Selection result	selected	selected	selected	deleted	deleted	deleted	deleted

Index	Cited half-life	Citing half-life	Ratio of funded papers	Share of overseas contributions in total papers	Average number of authors	Average citations per article
Average value of excellent journals	5.25	7.17	0.90	0.04	4.43	16.43
Average value of ordinary journals	5.61	7.10	0.67	0.01	3.89	10.01
Increase (%)	−6.53	1.06	33.21	252.63	13.85	64.02
Selection result	deleted	deleted	selected	selected	deleted	selected

four indicators may partly reflect some of the information of the deleted indicators, we adopted the TOPSIS method for the evaluation exercise in this paper. We recall the main characteristics of the TOPSIS method. TOPSIS stands for Technique for Order Performance by Similarity to Ideal Solution and is one of the classical Multiple Attribute Decision Making methods. It was developed by Hwang and Yoon (1981) and is based on the concept that the chosen alternative should have the shortest distance to the Positive Ideal Solution (PIS), i.e. the solution that maximizes the benefit criteria and minimizes the cost criteria; and the farthest distance from the Negative Ideal Solution (NIS), i.e. the solution that maximizes the cost criteria and minimizes the benefit criteria. The calculation steps of TOPSIS are as follows:

4.1.1. Constructing indicator matrix and making normalization of the data

Suppose that the value of alternatives set A_i (i = 1, 2, . . ., m) is given as a_{ij} under indicators S_j (j = 1, 2, . . ., n). Hence an indicator matrix $A = (a_{ij})_{m \times n}$ is derived. Recall that in general there are many indicators involved, the relationship between them is intricate, some indicators are positive (the higher their value, the better), some indicators are negative (the higher their value, the worse), and dimensions of different indicators are not identical. In order to compare these indicators normalizing the indicator matrix is necessary.

4.1.2. Determining the optimum and worst point of solution set

Let:

$$x_j^+ = \max_{(j=1,2,\ldots,n)}\{x_{ij}\} \quad x_j^- = \min\{x_{ij}\} \tag{1}$$

Then:

The optimum point set is: $A^+ = (x_1^+, x_2^+, \ldots, x_n^+)$
The worst point set is: $A^- = (x_1^-, x_2^-, \ldots, x_n^-)$

The solution is found at that point which is closest to the optimum point set while being at the greatest distance from the worst point set.

4.1.3. Calculating the closest value of each solution

The closest value of solution A_i is:

$$C_i = d_i^+/d^+ - d_i^-/d^- \tag{2}$$

where

$$d_i^+ = \left[\sum_{j=1}^{n}(x_{ij} - x_j^+)^2\right]^{1/2} \tag{3}$$

$$d_i^- = \left[\sum_{j=1}^{n}(x_{ij} - x_j^-)^2\right]^{1/2} \tag{4}$$

$$d^+ = \min\{d_i^+\}, \quad d^- = \max\{d_i^+\} \tag{5}$$

The symbols d_i^+ and d_i^- stand respectively for the Euclidean distance between solution A_i and the optimum solution A^+ and the Euclidean distance between solution A_i and the worst solution A^-. The symbols d^+ and d^- stand respectively for the minimum value of the m distances of optimum points and the maximum value of the m distances of inferior points.

The value of C_i reflects the degree of deviation of the solution set from the optimum point. When $C_i > 0$, A_i deviates from the optimum point. The higher the value the larger the deviation. When $C_i = 0$, A_i is closest to the optimum point. If we take the value of C_i as the decision-making criterion, the solution we try to determine is the point with minimum C_i.

4.2. Result of the evaluation

Table 3 gives the evaluation indicators and results of the evaluation of the agricultural journals in the year 2006. Evaluation values of TOPSIS have been normalized. Limited by space, only results for the top 25 journals are given.

Table 4 gives the correlation coefficients between the four indicators based on all 96 periodicals. Because TOPSIS score is a comprehensive evaluation result, it is normal that both correlation coefficient of TOPSIS score with Ratio of Funded Papers, and that of TOPSIS score with Average Citations per Article are close to 0.9. One-to-one correlation coefficients among the four indicators are all less than 0.7, which reveals certain independence of every indicator, so all four indicators are proper for evaluation. If two indicators have similar content, they may be kept for the time being after indicator screening. Then

Table 3
Results of evaluation over agricultural journals in year 2006.

Journal	Total cites	Impact factor	Ratio of funded papers	Average citations per article	TOPSIS score	Rank
Soil sinica	2670	1.84	0.96	20.15	100.00	1
Scientia agricultura sinica	3942	1.247	0.99	21.05	99.40	2
Acta agronomica sinica	3511	1.253	0.99	19.62	96.22	3
Pedosphere	734	2.331	0.97	29.22	89.10	4
Journal of soil and water conservation	2693	1.328	0.98	12.03	82.30	5
Chinese Journal of Rice Science	1356	1.372	0.98	20.78	81.10	6
Plant nutrition and fertilizer science	1519	1.387	0.93	19.35	80.44	7
Soil	1344	1.378	0.88	21.31	79.46	8
Transactions of the Chinese society of agricultural engineering	2469	0.907	0.85	15.9	75.95	9
Acta phytopathologica sinica	2596	0.891	0.88	10.89	71.86	10
Journal of Soil	1402	0.633	0.91	17.54	66.97	11
Chinese Journal of Oil Crops Science	930	0.815	0.96	17.13	66.73	12
Chinese Journal of Plant Pathology	1107	0.868	0.97	13.46	65.39	13
Journal of Hunan Agricultural University	912	0.675	0.98	14.06	62.75	14
Journal of Nanjing Agricultural University	1110	0.641	0.94	13.88	62.33	15
Cotton Sinica	716	0.961	0.96	12	62.24	16
Chinese Journal of Biological Control	634	0.777	0.97	14.45	62.20	17
Journal of Triticeae Crops	838	0.801	0.91	14.3	61.84	18
Journal of Zhejiang University (Agriculture and Life sci)	1025	0.371	0.99	14.33	60.89	19
Journal of Huazhong Agricultural University	992	0.45	0.99	13.58	60.81	20
Journal of Maize Sciences	1340	1.272	0.59	13.18	60.16	21
Journal of Plant Protection	723	0.576	0.99	13.2	60.14	22
Journal of Yangzhou University (Agricultural and life science edition)	603	0.554	0.99	13.6	59.61	23
Journal of Northwest Sci-Tech University of Agriculture and Forestry	1405	0.465	0.84	14.18	59.57	24
Agricultural research in the arid area	1100	0.521	0.91	12.42	58.68	25

Table 4
The Matrix of 4 indicators and TOPSIS score.

	Total cites	Impact factor	Ratio of funded papers	Average citations per article	TOPSIS score
Total cites	1.000				
Impact factor	0.619	1.000			
Ratio of funded papers	0.459	0.550	1.000		
Average citations per article	0.515	0.753	0.709	1.000	
TOPSIS score	0.724	0.802	0.897	0.866	1.000

their correlation coefficients could be calculated. If the coefficient is very high, the indicator with less importance could be abandoned.

5. Conclusion and discussion

5.1. Panel data analysis is an efficient method for indicator selection of scholarly journal evaluation

Indicator selection is the cornerstone of scholarly Multiple Attribute Evaluation (MAE). Panel data can be used both in time series comparison among scholarly journal evaluation indicators and in relative comparison of indicators for journals in the same section. Through such comparisons robust journal evaluation indicators with strong separating power can be selected and unreasonable indicators eliminated so as to make the evaluation process more scientific and rational, leading to more reliable evaluation results. This indicator screening method can be generalized and applied to other fields. Furthermore it is easy to reject neutral indicators with the method presented in this paper. Of course, according to the principle of "comparing like with like", periodicals in different disciplines should not be pooled together for indicator screening.

5.2. Both panel data analysis and TOPSIS method are actually heuristic methods

Panel data analysis and TOPSIS method are actually heuristic methods. Most problems faced by the management are complicated. It is very difficult to conduct a precise and accurate analysis of those problems. It is often unreasonable to expect that they can be solved by pure logic and strict mathematical methods. In this situation, logical arguments derived from a rule of thumb can be regarded as the best method available. Perhaps the method is not absolutely accurate, but it is simple and practical. There are many methods in Multiple Attribute Evaluation (MAE) of scholarly journal evaluation. Different people have different views on indicator selection and weight assignment. Even if we are able to gather first-rate experts to be evaluators, it is not certain that a general consensus is reached. Consequently such a conundrum must be solved by a method that uses heuristics.

5.3. Journals of different fields should not be put together for evaluation

It is a basic evaluation principle to compare like with like. It must be noted that even scholarly journals do not evolve in identical ways in different disciplines. Some disciplines develop rapidly, some develop slowly; some are relatively homogenous, some contain a lot of sub-disciplines. Obviously, according to the selection method of panel data analysis, evaluation indicators selected from different disciplines are not always identical. Therefore it is unreasonable to evaluate scholarly journals of different disciplines with identical indicators using the same methods.

5.4. Some evaluation indicators are designed to influence behaviors and are meaningful in this sense

Although some bibliometric indicators are not necessarily suitable for Multiple Attribute Evaluation (MAE) over scholarly journals, these indicators are still meaningful. Indicators themselves implicate some value orientation. For example, release of data on Ratio of Other Citations is a warning to authors that they should not manipulate their impact factor by too many self-citations; disciplinary Impact Indicator shows the influence of a journal within a discipline; Cited half-life reflects fast response of journal papers to important topics. In addition, institutions conducting evaluation should release indicator data used for evaluation as much as possible so as to facilitate further research by other parties.

5.5. Removing temporal indicators has a limited influence

The three temporal indicators, Immediacy Index, Cited half-life and Citing half-life, are eliminated in our exercise. However, this may not be so serious, because both Total Cites and Impact Factor reflect the journal impact over certain time period. We think that the temporal indicators are inherently related to impact indicators. It seems safe to say that omitting some indicators has a limited influence on the final evaluation result.

Using panel data for indicator selection reveals the problem of indicator variance with time. For example, yearly indicators are quite unstable and fluctuate significantly because they reflect yearly citation information in a short time (one year). As to other indicators such as Citing half-life and Cited half-life, data in a much longer time window are needed to determine whether there are similar problems. There are micro and macro points of view for temporal indicators. As to a paper, it is difficult to consider temporal indicators as positive or negative. For dozens of journals in a discipline, however, temporal indicators could be effective and valuable to some extent.

5.6. Simplifying indicators can increase evaluation accuracy and efficiency

After the simplification process, the original 13 indicators were reduced to 4, so the future cost of journal evaluation is lowered while the evaluation accuracy and efficiency has increased. This simplification approach also presents a new problem-solving direction for other fields where data-collecting for evaluation is costly.

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