A New Method for Academic Journal Evaluation Based on the FDH Model: Postprint

Authors: Zhao Rongying, Wang Jianpin

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Abstract

[Purpose/Significance] This study explores different methods for evaluating academic journals to obtain more effective, equitable, and valuable information, thereby promoting the development of journal evaluation theory and practice. [Method/Process] The Free Disposal Hull (FDH) efficiency evaluation model from economics is introduced into bibliometrics, with adjustments made to the traditional FDH model to construct a novel journal evaluation method. Seven indicators are selected to evaluate 41 journals in the library and information science field, and correlation analysis is conducted between the evaluation results and other journal rankings. [Results/Conclusion] The FDH-based journal evaluation method yields more objective results that are significantly correlated with other journal rankings. This method integrates journal evaluation indicators, not only calculating scores for each evaluated journal but also providing additional valuable information to support decision-making for journal departments. For instance, the FDH model can identify "benchmark" and "control" journals for evaluated journals, enabling them to identify their own deficiencies and gaps through comparative analysis with journals exhibiting similar performance across various indicators, thereby achieving continuous improvement and even surpassing their peers.

Full Text

A New Method for Academic Journal Evaluation Based on the FDH Model

Zhao Rongying[1,2], **Wang Jianpin**[1,2,3]
[1]Research Center for China Science Evaluation, Wuhan University, Wuhan 430072
[2]School of Information Management, Wuhan University, Wuhan 430072
[3]School of Information Technology, Shangqiu Normal University, Shangqiu 476000

Abstract

[**Purpose/Significance**] This study explores different methods for evaluating academic journals to obtain more effective, fair, and valuable information, thereby promoting the development of journal evaluation theory and practice. [**Method/Process**] We introduce the Free Disposal Hull (FDH) efficiency evaluation model from economics into bibliometrics, adjust the traditional FDH model, and construct a new journal evaluation method. Seven indicators were selected to evaluate 41 library and information science journals, and the evaluation results were correlated with other journal rankings. [**Result/Conclusion**] The evaluation results based on the FDH model are more objective and significantly correlated with other journal rankings. This method integrates journal evaluation indicators, not only calculating scores for each evaluated journal but also providing additional valuable information for journal management decision-making. For example, the FDH model can identify "benchmarks" and "dominating journals" for evaluated journals, enabling them to discover their shortcomings and gaps through comparative analysis with journals having similar indicator performance, thereby achieving continuous improvement and even surpassing competitors.

Academic journal ranking (AJR) constitutes an important component of academic evaluation activities, with results directly used by relevant departments to evaluate research output of individuals or organizations, directly linked to promotion, bonuses, and allocation of academic resources. Therefore, AJR should be treated with caution. However, any AJR is to some extent the result of subjective decisions, as both indicator selection and calculation methods may produce completely different ranking results.

First, regarding indicators, academic journal evaluation is typically based on two major categories: citation-based bibliometric indicators such as total citations, impact factor, and H-index; and journal prestige indicators based on expert ratings. In some cases, composite indicators derived from both types are also used. For citation-based indicators, results depend on the selected database (e.g., Scopus, Web of Science, Google Scholar Citations), while for expert survey-based indicators, factors such as sample selection, sample size, and questionnaire validity and reliability may affect results. Second, regarding methods, AJR employs a wide range of approaches including fuzzy clustering, nested regression, and machine learning. Different rankings based on different methods and indicators yield different results.

No perfectly correct evaluation ranking exists, which means all published rankings should be treated with some degree of skepticism. The selection of methods should be based on their merits—fairness, usefulness, and generally accepted validity—rather than preconceptions. Based on this, we explore different methods for journal evaluation to obtain more effective, fair, and valuable information, promoting the development of journal evaluation theory and practice.

1. Academic Journal Evaluation Method Based on the FDH Model

1.1 The FDH Model

The FDH model was first proposed by D. Deprins et al. in 1984 when studying labor efficiency. FDH is a multivariate non-parametric estimation method commonly used to evaluate the relative performance of organizations or units in economic production. Currently, the most well-known non-parametric estimation models are Data Envelopment Analysis (DEA) and FDH. Both models share the same basic principle: each evaluated unit is treated as a Decision Making Unit (DMU), assuming each DMU exhibits certain economic significance—inputting certain production factors and obtaining certain outputs—while striving to achieve its decision-making objectives during the transformation process. Numerous DMUs constitute the evaluated group, using sample values of inputs and outputs to estimate the efficient production frontier, then measuring relative efficiency based on the distance between each DMU and this frontier.

However, FDH may provide results more suitable for management needs than DEA. DEA assumes the production possibility set is convex, a condition not easily satisfied in practical applications. FDH abandons DEA' s convexity assumption, offering greater flexibility in practice, and its frontier is composed of best-practice units actually existing in the sample. In journal evaluation, DEA' s frontier consists of efficient journals estimated from sample data, while FDH' s frontier comprises actually existing efficient journals from the sample. Thus, FDH provides real benchmarks for inefficient journals, facilitating easier comparison between journals. Therefore, we selected the FDH model for journal evaluation.

1.2 Adjustment of the Traditional FDH Model

FDH evaluation requires DMUs to be homogeneous: they must share the same fundamental objectives, operate in the same decision-making environment, and use identical evaluation indicators. Domestic journals in the same field meet these conditions. First, they share the same ultimate goal: maximizing their scientific influence by publishing high-quality papers. Second, each journal requires certain inputs (e.g., human resources, material resources) measurable by input indicators, and each produces outputs pursuing different performance objectives such as increasing publication quantity and quality or optimizing specialization, measurable by indicators like total citations, impact factor, and H-index. Therefore, in traditional applications, journals in the same field can be treated as DMUs for efficiency analysis using certain input-output indicators, thereby analyzing whether editorial departments utilize resources effectively.

Based on previous research, we adjusted the conventional output-oriented FDH model to obtain a bibliometric indicator based on efficiency analysis for academic journal ranking. Each academic journal in a field is treated as a DMU with only one input indicator valued constantly at 1, assuming they all use a constant

input of 1 to produce different outputs. Only output indicators are needed to calculate efficiency, creating a "pure output FDH model." This assumption is reasonable because, from a production perspective, each scientific journal itself represents an input whose goal is to optimize various output indicators. In this adjusted framework, the FDH model serves merely as a tool to integrate relevant output indicators and establish a new AJR, rather than as a traditional input-output efficiency analysis tool, thus requiring no explicit inputs. The model is as follows:

Max $_0 + (\ _1 s^+)$

Subject to: $_1\ \lambda y\ - s^+ = y_0$, r = 1, 2, ···, s λ {0, 1}; $s^+ \geq 0$, j = 1, 2, ···, N

Where r represents outputs, j represents DMUs, $_0$ is the efficiency score of unit 0, λ are weights equal to 0 or 1 used to identify benchmarks for DMU 0, s^+ are output slack variables, and is a non-Archimedean infinitesimal. If $_0 = 1$, the evaluated journal is efficient relative to others. If $_0 > 1$, the journal is relatively inefficient because the sample contains better-performing journals, and $_0$ shows the proportional increase needed in all output indicators relative to its benchmark. Larger values indicate greater distance from efficient journals. Therefore, journals can be ranked by values, with larger values indicating lower ranks.

The advantages of FDH-based journal ranking are: (1) Unlike other parametric evaluation methods, this model requires no assumptions about the production function' s specific form or specification of indicator weights, avoiding much subjectivity; (2) No need for dimensionless processing of input-output indicators, and results are unaffected by measurement units, avoiding computational complexity; (3) Most importantly, FDH models compare journals pairwise, not only producing rankings but also calculating relative efficiency values and quantitatively identifying competitors for each journal, providing additional decision-making reference information for journal management.

2. Indicator Selection and Sample Data Acquisition

2.1 Evaluation Indicator Selection

An important step in using the FDH model is determining input and output variables—that is, selecting evaluation indicators. This study designs input and output variables as follows:

(1) Input Variable: As mentioned above, the FDH model in this study has only one input variable with a constant value of 1.

(2) Output Variables: In journal evaluation, each single indicator has limitations. Scholars generally agree that multiple indicators should be used together to avoid risks from single-indicator defects. We selected seven indicators as FDH model output variables. Based on the development of citation evaluation

indicators for scientific journals and their application status in domestic and international journal evaluation, citation-based indicators hold absolutely important positions in quantitative journal evaluation, such as IF, H-index, SJR, ES, and SNIP. However, some international mainstream indicators have not been widely applied in domestic academic journal evaluation, and relevant data are difficult to obtain. Therefore, we primarily selected citation evaluation indicators widely adopted in domestic mainstream journal evaluation, representing current domestic trends. Additionally, considering the increasingly important dissemination role of the internet, we included one indicator reflecting internet dissemination.

The seven indicators are: (1) **Total Citations:** An objective evaluation indicator showing the degree of journal usage and attention, and its role and status in scientific communication. (2) **Journal Impact Factor (JIF):** An internationally recognized metric that fairly evaluates various journals as a relative statistic. (3) **5-Year Impact Factor (JIF5):** Solves the problem that IF cannot adequately measure the academic impact of journals with later citation peaks. (4) **Cited Journal Impact Factor:** Excludes the improper influence of self-citation on impact factor. (5) **Immediacy Index:** Characterizes the journal' s immediate response rate. (6) **H-index:** While JIF and JIF5 reflect average citation frequency, H-index reflects the number of high-impact papers published. (7) **Web Immediacy Download Rate:** The first six indicators are citation-based, while the last reflects internet dissemination.

2.2 Sample Data Acquisition

Another important step in FDH evaluation is determining DMUs. Data for six indicators—total citations, JIF, JIF5, cited JIF, immediacy index, and Web immediacy download rate—were obtained from the *Chinese Academic Journal Impact Factor Annual Report (Humanities and Social Sciences) 2016*. H-index data were obtained from the *Chinese Scientific and Technical Journal Citation Reports (Expanded Edition) 2016*. The former provides data for 42 Chinese library and information science journals, while the latter provides data for 44 such journals. We selected the 41 overlapping journals as our sample, treating these 41 journals as DMUs for evaluation. Table 1 presents the indicator data and descriptive statistics for these 41 journals.

3. Results Analysis

Using the pure output FDH model, we evaluated the 41 journals, with results shown in Table 2 , which also lists three other widely recognized rankings for comparison: (1) the ranking by *Chinese Academic Journals (CD-ROM Edition)* Electronic Magazine Co., Ltd. based on the Clout Index (CI); (2) the ranking by Wuhan University Research Center for China Science Evaluation (RCCSE) based on journal quality, level, and academic influence; and (3) the ranking by Chinese Social Sciences Evaluation Center (CECHSS) based on attractiveness, management, and influence.

To validate the FDH ranking, we calculated Spearman correlation coefficients between it and other rankings, shown in Table 3 . The FDH ranking shows significant correlations with the other three rankings, demonstrating that the FDH-based journal ranking method produces results similar to other well-recognized rankings while employing a simpler and more direct calculation process.

As previously mentioned, FDH provides additional information beyond other methods:

(1) It provides not only each journal' s rank but also an efficiency score (in Model 1). If the score equals 1, the journal is efficient. Table 4 lists additional information for the top 20 journals. Journals like *Chinese Journal of Library Science*, *Library and Information Service*, *Journal of Intelligence*, *Information Studies: Theory & Application*, and *Information Science* are all efficient.

(2) For journals with identical efficiency scores of 1, sorting is based on the "Benchmarks" column data. For efficient journals, this represents the number of inefficient units that use them as benchmarks. Since *Chinese Journal of Library Science* serves as a benchmark for 33 other journals, it ranks highest, followed by *Library and Information Service*.

(3) For efficient journals with identical benchmark counts, sorting proceeds by "Dominating Journals" count. When one journal outperforms another across all indicators, the former is said to dominate the latter, which becomes its "dominated journal." A journal and its dominated journals are most similar and likely to compete. For example, *Journal of Intelligence*, *Information Science*, and *Information Studies: Theory & Application* each have zero benchmarks, but *Journal of Intelligence* dominates 25 journals, meaning it outperforms 25 journals across all indicators, thus ranking third.

(4) Inefficient journals have efficiency scores greater than 1 and each has a benchmark, with the benchmark column showing the ID of that benchmark. For instance, *Modern Information* has an efficiency score of 1.250 with *Library and Information Service* (ID 2) as its benchmark, indicating it must improve all indicators by 3.7% relative to its benchmark to become efficient.

(5) FDH can identify not only how many journals a given journal dominates but also how many dominate it (Dominated Journals) and their IDs. For example, *Modern Information* (ranked 8th) dominates 16 journals while being dominated by 3 journals (IDs 2, 3, and 6).

Journals can use this information strategically. For example, by finding journals among its dominated set with very similar indicator performance and comparing indicators, a journal can target improvements. This "benchmarking" approach, known domestically as "learning from and surpassing benchmarks," is the most direct management method for narrowing gaps with advanced journals and gaining competitive advantages. Given resource limitations, journals cannot lead in all aspects through independent innovation alone but must learn and integrate key technologies and know-how to build lasting competitive advan-

tages. FDH quantitatively and scientifically helps journal departments select appropriate benchmarks, laying the foundation for implementing benchmarking management and improving performance.

Conclusion

This study introduces the FDH efficiency evaluation model from economics into bibliometrics, proposing a new journal evaluation method. Seven indicators were selected to evaluate 41 library and information science journals, with results correlated against other rankings. Key findings include: (1) FDH-based journal evaluation results are significantly correlated with other well-known rankings, proving its validity; (2) The method requires no assumptions about production function form, no specification of indicator weights, and no dimensionless processing of indicators, avoiding subjectivity and computational complexity; (3) The method integrates journal evaluation indicators, calculating scores for each journal while providing valuable information for benchmarking management and performance improvement. For example, FDH can identify "benchmarks" and "dominating journals," enabling journals to discover shortcomings through comparative analysis and achieve continuous improvement.

In summary, the FDH-based evaluation method is objective, effective, and provides valuable information with broad application prospects. Future research can explore its application in other scientific evaluations such as paper evaluation, scholar evaluation, and institution evaluation, expanding the research horizon of scientific evaluation theory and practice. Future studies should: (1) consider different indicators, particularly Altmetrics; and (2) explore combining FDH with other models to calculate ideal target values for each indicator, providing more specific improvement measures and decision support.

References

[1] Haddow G, Genoni P. Citation analysis and peer ranking of Australian social science journals[J]. Scientometrics, 2010, 85(2): 471-487.
[2] Benati S, Stefanis S. The academic journal ranking problem: a fuzzy-clustering approach[J]. Journal of classification, 2011, 28(1): 7-20.
[3] Currie R R, Pandher G S. Finance journal rankings and tiers: an active scholar assessment methodology[J]. Journal of banking & finance, 2011, 35(1): 7-20.
[4] Ennas G, Biggio B, Guardo M C D. Data-driven journal meta-ranking in business and management[J]. Scientometrics, 2015, 105(3): 1911-1929.
[5] Borger B D, Kerstens K. Cost efficiency of Belgian local governments: a comparative analysis of FDH, DEA, and econometric approaches[J]. Regional science & urban economics, 1996, 26(2): 145-170.
[6] Gupta S, Verhoeven M. The efficiency of government expenditure: experiences from Africa[J]. Journal of policy modeling, 2001, 23(4): 433-467.
[7] Qiu Zhaoxiang, Zhang Aiwu. Research on X-efficiency of Chinese commer-

cial banks based on FDH method[J]. Financial Research, 2009(11): 91-102.
[8] Dong Chenjing, Liang Xuan, Ding Jingjing. Parallel production system FDH model and its application in allocation problems[J]. Journal of Systems & Management, 2015, 24(4): 595-601.
[9] Fealing K H, Lane J I, Iii J H M, et al. The science of science policy[M]. Stanford: Stanford University Press, 2011.
[10] Deprins D, Simar L, Tulkens H. Measuring labor-efficiency in post offices[M]//Performance of public enterprises concepts & measurement. 1984: 285-309.
[11] Tulkens H. On FDH efficiency analysis: some methodological issues and applications to retail banking, courts, and urban transit[J]. Journal of productivity analysis, 1993, 4(1): 183-210.
[12] Lovell C A K, Pastor J T. Radial DEA models without inputs and with inputs[J]. European journal of operational research, 1999, 118(1): 46-51.
[13] Li Hao, Wang Gongbao, Song Yexin, et al. Improved DEA model with only outputs (inputs) and its application[J]. Fuzzy Systems and Mathematics, 2011, 25(3): 168-174.
[14] Halkos G E, Tzeremes N G. Measuring economic journals' citation efficiency: a data envelopment analysis approach[J]. Scientometrics, 2011, 88(3): 979-1001.
[15] Tüselmann H, Sinkovics R R, Pishchulov G. Towards a consolidation of worldwide journal rankings—a classification using random forests and aggregate rating via data envelopment analysis[J]. Omega, 2015, 51: 11-23.
[16] Lovell C A K. Measuring the macroeconomic performance of the Taiwanese economy[J]. International journal of production economics, 1995, 39(1): 165-178.
[17] García-Romero A, Santín D, Sicilia G. Another brick in the wall: a new ranking of academic journals in economics using FDH[J]. Scientometrics, 2016, 107(1): 91-101.
[18] Harnad S. Multiple metrics required to measure research performance[J]. Nature, 2009, 457(7231): 785.
[19] Wu Tao, Yang Yun, Chen Chen, et al. Research on comprehensive evaluation indicators of scientific journal citations based on factor analysis[J]. Chinese Journal of Scientific and Technical Periodicals, 2015, 26(2): 205-209.
[20] Li Xiaoyan. Research on benchmarking management theory and application based on data envelopment analysis[D]. Nanjing: Nanjing University of Science and Technology, 2010.

Author Contributions

Zhao Rongying: Supervised paper writing;
Wang Jianpin: Conducted literature review, wrote and revised the paper.

Note: Figure translations are in progress. See original paper for figures.