




A Study of Applying “Sustainable Impact Index” to the Evaluation of Academic Papers

Xinyu Song¹ (✉) , Jinyuan Zhou^{1,2}, Wenqing Zhao^{1,3}, and Duxin Shang¹

¹ Institute of Science and Technology Information, Jiangsu University, 301 Xuefu Road, Zhenjiang 212013, China
songxy0611@163.com

² Library of Jiangsu University, 301 Xuefu Road, Zhenjiang 212013, China

³ Periodicals Agency of Jiangsu University, 301 Xuefu Road, Zhenjiang 212013, China

Abstract. From the perspective of Niche Ecostate-Ecorole Theory (NEET), this paper puts forward the concept of sustainable influence, which enriches academic evaluation. The digital humanities papers in the Library and information journals of CNKI are selected as the samples, and the nine indicators of the time factors and usage data of nodal literature and citing literature are comprehensively considered. The index is weighted by combining the subjective judgment of experts and the objective CRITIC method, and “Sustainable Impact Index” (SII) of papers is constructed. It can provide more information than the classical influence index, has better discrimination and sensitivity. It will be an objective and reasonable method.

Keywords: Niche Ecostate-Ecorole Theory · CRITIC · academic evaluation · scientometrics · influence

1 Introduction

Paper is important form of scientific research results. The rational evaluation of papers promotes the efficient utilization of academic resources and supports the innovation and development. Under the environment of academic communication, papers influence each other, and influence evaluation becomes a key part of paper evaluation [1]. It is a realistic need in scientific research management to build and improve multi-dimensional, all-round and deep-seated paper influence evaluation system, and it is also an important measure to promote the reform of scientific research evaluation.

For a long time, influence evaluation have based on the citation and download of papers. After Garfield [2] proposed the concept of citation index, the correlation among papers became clearer. Individual papers influence each other more or less in the ecosystem of academic communication [3]. The citation relationships between papers reflect the flow and change of knowledge. Bibliometrics is the mainstream method to judge traditional influence. Citation frequency as a basic index plays an important role in influence evaluation [4]. Nowadays, network platform has become an important channel

for researchers to acquire knowledge, and downloads gradually have the function of evaluation. The contribution of a paper to knowledge flow and creation is mainly assessed by considering its citations and downloads. However, although this kind of index is easy to obtain and widely used, it still has some shortcomings. On the one hand, the difference of citing literature was not considered, and the scientific rationality of the evaluation results was doubtful due to the simple calculation of cited frequency. Many scholars began to judge the differentiation of citation based on content [5], but the simplicity of operation and the reusability of conclusion need to be improved. On the other hand, in most cases, download is the pre-action of citation. Previous studies have separated the correlation between download and citation, ignored the overlapped part of data, thus weakening the accuracy of evaluation. Therefore, this study added the measurement of the difference of citing literatures and the correlation between downloads and citations to make up for the defects in the past.

In recent years, researchers have gradually paid attention to the feasibility of adding the data of citing literature to the influence evaluation of nodal literature [6]. Citation literature is the continuation or application of nodal literature, which has the evaluation function. Citation is affected by the popularity of cited authors [7], while the subsequent performance of citing literature has little relationship with the authors of nodal literature. It is reasonable and objective to evaluate the influence by combining citing literature.

2 Theoretical Basis and Construction of “SII”

2.1 Niche Ecostate-Ecorole Theory

In 1997, Chinese ecologist Zhu Chunqian put forward NEET, in which “Ecostate” and “Ecorole” comprehensively reflect the relative position and functional role of biological units in ecosystems [8]. The theory is universal and universal. The Formula 1 is as follows:

$$N_i = \frac{S_i + A_i P_i}{\sum_{j=1}^n (S_j + A_j P_j)} \quad (1)$$

N_i is the niche of biological unit i , S_i and P_i are the “Ecostate” and “Ecorole” of biological unit i , S_j and P_j are the “Ecostate” and “Ecorole” of other biological units j in the system, A_i and A_j are dimensional coefficients. NEET has been gradually expanded and applied to disciplines other than ecology. It also provides a new idea for academic evaluation.

2.2 Construction of “SII”

The collection of papers is regarded as an ecosystem, and a single paper is an ecological unit. Define measures of current impact by time of release and first use (Ecostate), then accompanying citing literature was used, and the nodal literature gained continuous influence (Ecorole). The “Ecostate” and “Ecorole” of a single paper together constitute sustainable influence. See Fig. 1 and Table 1 for details.

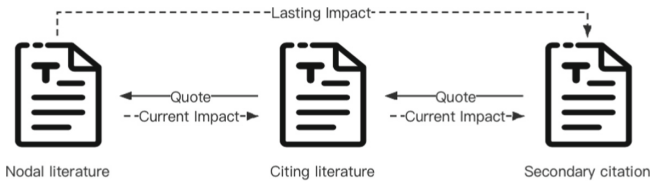


Fig. 1. Paper sustainable influence diagram

Table 1. The evaluation index system of sustainable influence

Attribute	Indicator	Meaning or method of calculation
Ecostate A (Nodal literature)	Publication time (A1)	–
	Downloads (A2)	–
	Citations (A3)	Amount of citing literature
Ecorole B (Citing literature)	Amount of cited literature (B1)	Amount of literature with subsequent citing in the citing literature
	Citation rate (B2)	B1/A3
	Downloads (B3)	–
	Citations (B4)	Amount of Secondary Citation
	Average downloads(B5)	B3/A3
	Average citations(B6)	B4/B1

3 Empirical Research

3.1 Data Sources

Selected papers of CNKI on the topic of “digital humanities” in journals in the field of library and information from 2012, with a total of 657 papers. As the basis of the academic communication ecosystem is the citation network, the paper as the research object should contain at least one citation. After screening, a total of 517 papers met the requirements. Retrieved September, 2022.

3.2 Data Preprocessing and Verification

The data are dimensionalized to preserve relative significance and facilitate comparison. The normalized processing is adopted to compress the data within the range of [0,1]. Such as Formula 2.

$$X' = \frac{X - X_{Min}}{X_{Max} - X_{Min}} \tag{2}$$

A1 had reverse meaning, so it was reverse-processed. Reliability test was constructed after processing, and Cronbach’s Alpha was 0.907 > 0.8, indicating good reliability.

Table 2. Descriptive statistics of each indicator of “SII”

Indicator	Mean	Median	Standard deviation	K-S <i>p</i>
A1	2018.956	2019	1.796	0.000**
A2	914.101	732	820.704	0.000**
A3	12.559	7	19.349	0.000**
B1	8.052	4	14.026	0.000**
B2	0.512	0.571	0.308	0.000**
B3	6949.538	3054	13297.341	0.000**
B4	63.426	14	160.108	0.000**
B5	476.634	474	243.028	0.000**
B6	4.273	3.57	3.706	0.000**

* $p < 0.05$ ** $p < 0.01$

The validity test was constructed. KMO value was $0.814 > 0.8$, Bartlett sphericity test value was 7156.520 ($df = 36$), $p = 0.000 < 0.001$, indicating that the 9 indicators were very suitable for information extraction. Then factor analysis was carried out, and the common degree (variance of common factor) of each index was between 0.757 and 0.976 . All of them were greater than 0.4 , indicating that the study was reasonable and meaningful, and the explanation rate of cumulative variance after rotation was $90.027\% > 50\%$. It means that the information can be extracted effectively.

3.3 Data Analysis

3.3.1 Descriptive Statistical Analysis

Statistical analysis showed that the centralization tendency was small, but the degree of dispersion was large. It was found that they did not obey the normal distribution through K-S test. The results are shown in Table 2.

3.3.2 Correlation Analysis

Spearman was chosen because all the indicators did not follow normal distribution. The results are shown in Table 3.

Papers need time to achieve better dissemination. A1 has a negative correlation with the other 8 indicators, while the others have a positive correlation with high correlation coefficients.

3.4 Weight Definition

Based on Yu Liping’s empowerment results in academic evaluation, the weights of the three first-level of download reading, citation and influence, and knowledge timeliness are set as 0.15 , 0.65 , and 0.20 [9]. In order to achieve the unity of subjectivity and

Table 3. Correlation analysis of “SII”

	A1	A2	A3	B1	B2	B3	B4	B5	B6
A1	1								
A2	-0.268**	1							
A3	-0.638**	0.666**	1						
B1	-0.732**	0.595**	0.934**	1					
B2	-0.627**	0.230**	0.473**	0.711**	1				
B3	-0.615**	0.675**	0.934**	0.929**	0.562**	1			
B4	-0.791**	0.556**	0.891**	0.967**	0.717**	0.910**	1		
B5	-0.275**	0.355**	0.342**	0.450**	0.505**	0.627**	0.491**	1	
B6	-0.775**	0.408**	0.701**	0.786**	0.653**	0.755**	0.911**	0.501**	1

* $p < 0.05$ ** $p < 0.01$

objectivity, the paper adopts CRITIC method as the objective weight assignment method to combine with it. CRITIC is to determine the weight according to the comparison strength and conflict of indicator data. The indicator data has fluctuation and correlation, so the weight method of CRITIC is suitable for application. After dimensionalizing, the specific steps of applying CRITIC and expert weight method are as follows:

First, calculate the variability within each indicator. Suppose there are a total of n papers, i is the paper i , and there are p evaluation indicator, j is the evaluation indicator j , X_j is the average value of the indicator j , X_{ij} is the value of the indicator j in the paper i , and S_j is the standard deviation of j . See Formula 3–6 for computational details. The weight result of CRITIC are shown in Table 4.

$$\begin{cases} X_j = \frac{1}{n} \sum_{i=1}^n X_{ij} \\ S_j = \sqrt{\frac{\sum_{i=1}^n (X_{ij} - X_j)^2}{n-1}} \end{cases} \quad (3)$$

Second, calculate the intensity of conflict between indicators. R_{ij} is the correlation coefficient among them, and R_j is the intensity of conflict between indicator j and the other indicators.

$$R_j = \sum_{i=1}^p (1 - r_{ij}) \quad (4)$$

Third, calculate the indicator j information C_j .

$$C_j = S_j \times R_j \quad (5)$$

Fourth, W_j' is the weight of the indicator j .

$$W_j' = \frac{C_j}{\sum_{j=1}^p C_j} \quad (6)$$

Table 4. The weight result of each indicator with CRITIC method

Indicator	variability	Conflict	Information	Weight
A1	0.180	11.844	2.127	29.15%
A2	0.090	4.092	0.367	5.03%
A3	0.084	3.700	0.313	4.29%
B1	0.084	3.604	0.304	4.17%
B2	0.308	6.215	1.911	26.20%
B3	0.077	3.571	0.275	3.76%
B4	0.090	3.719	0.336	4.60%
B5	0.120	6.137	0.735	10.08%
B6	0.181	5.125	0.928	12.72%

Fifth, combine with the expert method, assume that expert assigns the weight of the indicator j as W_j' , and add CRITIC method W_j'' to get the comprehensive result W_j . Formula 7 is as follows.

$$w_j = \frac{w_j' + w_j''}{\sum_{j=1}^p (w_j' + w_j'')} \tag{7}$$

After subjective and objective methods, the weight of each indicators are shown in Table 5.

Table 5. Comprehensive weight of each indicator

Indicator	Comprehensive weight	Attribute	Weight
A1	10.03%	Ecostate	28.26%
A2	4.09%		
A3	14.14%		
B1	14.12%	Ecorole	71.74%
B2	18.61%		
B3	3.83%		
B4	14.20%		
B5	5.12%		
B6	15.86%		

Table 6. Descriptive statistics

Method	Mean	Median	Standard deviation	Kurtosis	Skewness	p
SII	0.234	0.24	0.093	2.655	0.692	0.018*
Ecostate	0.081	0.082	0.017	10.497	1.021	0.001**
Ecorole	0.154	0.159	0.096	0.128	0.192	0.001**
Downloads	914.066	732	820.71	31.966	4.543	0.000**
Citations	12.555	7	19.351	42.56	5.331	0.000**

* $p < 0.05$ ** $p < 0.01$

4 Analysis of Evaluation Results

4.1 Statistical Analysis

The “Ecostate”, “Ecorole” and “SII” of each paper were calculated, and the download and citation data of nodal literature were added to conduct descriptive statistics. See Table 6 for details.

“SII” contains the information of other single indicator, and provides irreplaceable information from more dimensions. It can be used as a useful supplement when the differentiation degree of paper downloads and citations is low. The five evaluation results do not have normal characteristics, but the mean and median of “SII”, “Ecostate” and “Ecorole” are very close to each other. When absolute value of kurtosis is less than 10 and the absolute value of skewness is less than 3, indicating that although the data are not absolutely normal, they can be accepted as normal distribution basically. In the case that many academic evaluation indicators do not follow the normal distribution, the indicators that follow the normal distribution have better evaluation function [10].

With the natural logarithm of the cumulative number of papers as the horizontal axis and the cumulative number of the sustainable influence index as the vertical axis, the scatter plot is obtained. It is found that it has Bradford dispersion characteristics to a certain extent. Result is shown in Fig. 2.

4.2 Correlation Analysis

Correlation analysis is conducted between “SII” and influence indicators, as shown in Table 7.

High correlation coefficient indicate that it is not a complete subversion of the traditional influence index, but a correction. In addition, 28.6% and 18.4% of the “SII” have not been explained by downloads and citations. This is the value of “SII”.

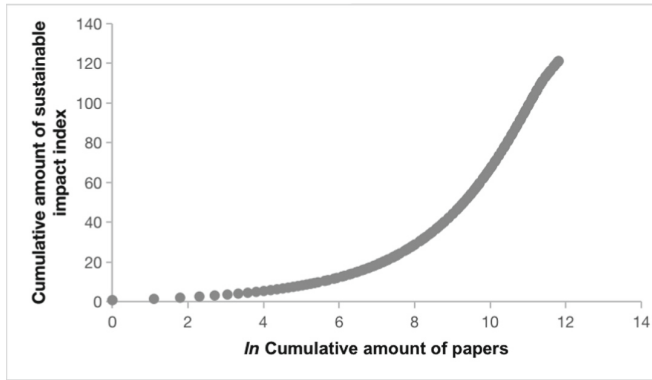


Fig. 2. Dispersion curve of “SII” of papers

Table 7. Correlation analysis of “SII”, downloads and citations

	SII	Downloads
SII	1	
Downloads	0.714**	1
Citations	0.816**	0.872**

* $p < 0.05$ ** $p < 0.01$

5 Conclusion and Discussion

Based on NEET, this paper placed a single paper in the academic exchange ecosystem, adopted the empowerment method combining subjective and objective methods to construct “SII”, and conducted empirical research, drawing the following conclusions:

- Compared with the classical influence index, “SII” can provide more information. The subsequent use of the article also be included to achieve the evaluation of the citing literature to a certain extent. The possibility of manual operation is low, and its design takes into account the time factor, in line with the law of academic communication.
- “SII” can be finely differentiated. This index greatly reduces the duplicate value, and its significant correlation with the traditional influence index indicates that this index is evaluated effectively on the basis of the tradition.
- “SII” has a good sensitivity. Each indicator has internal volatility, and there is correlation between indicators, when any indicator changes, the index can be perceptively described.
- Since "SII" basically follows the normal distribution, it has a good evaluation function. In the future, we can consider using the average value to complete the evaluation of journals or authors.

References

1. RongYing Zhao, Xuqiu Wei. Evaluation of Domestic Academic Papers'Influence from the Perspective of Citation: Based on CNKI Chinese Citation Database. *Information Studies:Theory & Application*, 2017, 40(08):55-60.
2. Garfield E. Citation indexes for science. A new dimension in documentation through association of ideas. *International Journal of Epidemiology*, 2006,35(05):1123–1127.
3. YanXin Pai, YanTing Zhou. Research on Impact Evaluation of Academic Papers from the Perspective of Niche Theory. *Information Studies:Theory & Application*,2022,45(12):119–127+145.
4. Liu Xueli, Guo Jia, Shen Lan, et al. Impact Factor Based on Logarithmic Correction for the Papers's Citations and the Studies on Its Category Normalization. *Journal of the China Society for Scientific and Technical Information*, Feb. 2021, 40(2): 125-134.
5. Xia Hongyu, Hu Qian and Wang Zhongyi. Tracing the Knowledge Flow Main Path Based on Important Citations.*Journal of the China Society for Scientific and Technical Information*, May 2022, 41(5): 451-462
6. Guo Qiang, Zhao Jin. The Necessity of Incorporating the Secondary Citation Literature Into the Paper 's Influence.*Library Theory and Practice*,2017(09):68–72+93.
7. Zeng A , Shen Z , Zhou J , et al. Increasing trend of scientists to switch between topics. *Nature Communications*, 2019, 10(01):1-11.
8. Zhu Chunquan.The Niche Ecostate-Ecorole Theory and expansion Hypothesis.*Acta Ecologica Sinica*.1997(03):324-332.
9. Yu Liping, Pan Weibo. Research on Individual Weight, Overall Weight and Pseudo Weight Problem in Academic Evaluation —Taking Linear Evaluation and JCR Economic Journal Evaluation as Examples.*Journal of Intelligence*.2022,41(10):163–169+198.
10. Yu Liping, Pang Ruchao and Zhou Juanmei.Evaluation of Academic Communication Level of Academic Journals: Journal Communication Factors.*Journal of Information Resources Management*.2021,11(04):133-140.

Open Access This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits any noncommercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.

