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HR Index and CHR Index: Two new literature measurement composite indexes–Taking the evaluation of academic journals as an example

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ABSTRACT

In academic evaluation, some composite evaluation indexes, for example, quantity, quality and prestige, have the advantages of a large amount of information and unique results. First, in this paper, two composite evaluation indexes are proposed, i.e., the HR index and the CHR index, where the HR index is based on the evaluation of prestige and quality, and the CHR index is based on the evaluation of prestige, quality and quantity. Second, two methods are proposed for testing the HR and CHR indexes. One is to test the principles, i.e., the self-interpretation degree of the results to the principle, by means of partial least squares regression. The other is the analysis of the evaluation results, including the relationships between the composite index and other bibliometric indicators, such as the order of magnitude and distinction and the data distribution of evaluation value, etc. Empirical studies are also conducted. The CSSCI periodicals of the CNKI Library Information and Document Science are employed to test the proposed HR and CHR indexes. Empirical analyses find that the HR index and the CHR index are good evaluation indicators that have broad application and can be used in many aspects, such as scholar, institutional and subject evaluations.

KEYWORDS

HR index; CHR index; Academic evaluation; Partial least squares regression

1 Introduction

Since Garmetric (1963) began the study of bibliometrics, single bibliometric indicators have primarily been used in performing academic evaluations, such as total citation frequency, impact factor, citation half-life, subject diffusion index, subject impact index, etc. Later, some composite indexes with more information were developed (Liu et al., 2021; Yu & Jiang, 2013). Compared with a single evaluation index, the composite indexes contain a large amount of information, and the evaluation perspective is multidimensional. Therefore, composite indexes, such as the h-index (Hirsch, 2005), the average number of citations per academic paper FCSm (Moed et al., 1995), the citation impact factor ACIF (Markpin, 2008), standard mean citation rate NMCR (Braun et al., 1990), and so on, are widely used in academic evaluation. In-

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vestigating composite indexes can optimize existing composite indicators and provide more evaluation methods, and this has important significance for academic evaluation.

In academic evaluation, quantitative assessment methods are divided into three categories (Figure 1): In the first category, a single index, such as impact factor, fund-to-paper ratios, annual indicators, citation half-life, overseas paper ratios, and so on, is used for evaluation. The advantage of the first category is that the information is relatively clear and easy to compare. However, the disadvantage is that the amount of information provided by each indicator is relatively limited.

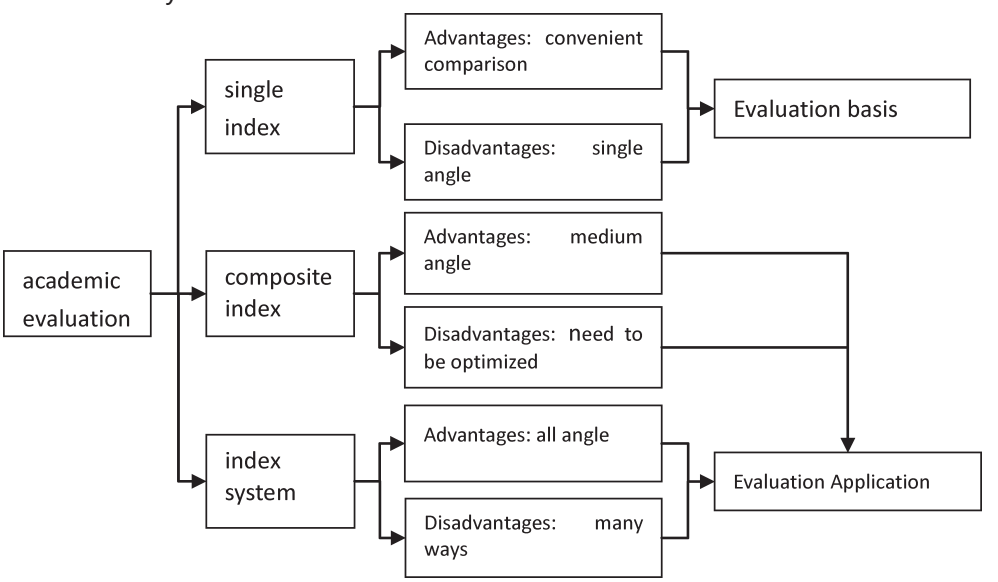

Figure 1 Comparisons of Periodical Quantitative Evaluation Methods

In the second category, a composite index is adopted for evaluation. Although the index is still a single one, it contains a large amount of information, or it expands the scope of application of a single indicator. The advantage of the second category is that it can carry out a wider perspective of academic evaluation. However, its shortcoming is that few composite indexes can provide very comprehensive information. In addition, they can always exhibit some deficiencies.

In the third category, an index system is used for evaluation. The advantage of the third category is that there are many evaluation indexes and the evaluation perspective is comprehensive. However, the shortcoming here is that there are dozens of methods for multiattribute evaluation and the evaluation results of each method are inconsistent. How to select an evaluation method is a difficult problem. In addition, when the multiattribute evaluation method is used in specific operations, different methods for standardizing the index data and selecting different indicators will have a greater impact on the evaluation results. In addition, when the multiattribute evaluation method is used in specific operations, different methods for normalizing the index data and selecting different indexes will have a greater impact on the evaluation results.

The single evaluation index is the basis of academic evaluation. Further, the single evaluation index and composite index are the basis for the evaluation of the index system. In the current comprehensive evaluation, the composite index and index systems have been widely applied and can provide relatively comprehensive information. Because each evaluation

method has its own advantages and disadvantages, whether it is a composite index evaluation or a comprehensive evaluation of an index system, its evaluation methods and technologies are continuously developing, and there is no single effective evaluation method.

The h-index is a typical composite indicator that contains not only quantity information about academic output but also quality information. There are many research results on the optimization of the h-index and its follow-up tracking. For example, in order to overcome the insufficiency of the h-index for highly cited papers, Kosmulski (2006) proposes the h(2) index, Egghe (2006) proposes the g index, Alonso et al. (2010) propose the hg index, Jin et al. (2007) propose the A index and R index, etc. To overcome the impact of low-cited papers on the h-index, Anderson et al. (2008) propose the ht index, which counts all cited papers. Nie and Wei (2010) propose the extended h-index, which strengthens the importance of the h-index on low-cited papers. To prevent the too-small article volume from reducing the index of the h-index, Rousseau (2006) proposes the relative h-index, which divides the h-index by article volume. Similarly, Sidiropoulos et al. (2007) propose the hn index, which divides the author's h-index by his or her total number of articles. To solve the problem of poor discrimination of the h-index, Ruane (2008) proposes the hrat index, which solves the comparable problem of scholars with the same h-index.

The evaluation principles of various composite indexes differ. Based on the Scopus database, Butler (2008) proposes the SJR (SCImago Journal Rank) index, which highlights the reputation of journals. Similar to the page rank algorithm for Google page rankings, its principle is to give higher weights to highly reputed journals in the course of iterative calculation until convergence. It is an indicator that measures the journal citation number and quality at the same time.

Also based on the page rank algorithm, Bergstrom et al. (2008) propose the Eigenfactor score and Article Influence Score, which takes into account the number of citations and the quality of journals and excludes self-citations; it also considers the differences in citations in different subject areas.

Prathap (2010) proposes the p index, which is the cubic root of the result of multiplying the citation frequency by the average number of citations per article. The p index is also called the prestige factor or prominence factor. Prathap (2014) later proposed the z-index, which includes the citation frequency reflecting the number of factors, the per-paper citations reflecting the quality factor, and the cited concentration reflecting the cited consistency in one index. The z-index is also called the quantity-quality-efficiency 3D performance evaluation index.

There are also some other composite indexes, each with its own characteristics, which can be selectively used according to one's needs. In 2015, the China Knowledge Network released the "Announcement of the Impact Factors of Chinese Academic Journals" and, for the first time, published the CI index of academic journals' influence index, which is also a composite index.

Judging from the existing studies, research on composite indexes is ongoing. Some scholars increasingly introduce new composite indexes. Overall, the following issues are worthy of further study:

First, the evaluation perspective of some composite indexes is still relatively similar to that of single indexes. Of course, this type of index is also valuable when one requires a relatively single perspective evaluation, but the composite index should generally focus on multiple perspectives.

Second, although there are some composite indexes based on quantitative and qualitative

perspectives, there are significant differences in the quantity and quality evaluation methods and the specific calculation methods. Some composite indexes provide poor evaluation results, so it is necessary to explore new composite indexes. In the meantime, in addition to the quantitative and qualitative perspectives, composite indicators should also provide more evaluation perspectives to meet the needs of different evaluations.

Third, the composite indexes lack a common test method. The authors put forward certain principles for the formulation of any composite index, but whether the evaluation results of the composite index follow those principles, the existing research is determined based on experience. In other words, there exist few scientific tests and determination methods for the composite index.

In this paper, we begin by proposing the design principles of composite indexes. Next, based on h-indexes, two new composite indexes are proposed, i.e., the HR index and the CHR index, as well as their testing methods. Next, based on the CSSCI journals in the China Knowledge Network CNKI library information and literature, the HR index and CHR index are employed in evaluation and the results are tested, while their applicability and application range are analyzed.

2 Design of the HR index and the CHR index

2.1 Evaluation Elements and Design Principles

The principle of composite index design is an index's basic premise. It is also an important index selection basis. In academic evaluation, one chooses a composite index so that the purpose of evaluation is consistent with the design principle of composite indexes.

(1) Evaluation elements of composite indexes

The main evaluation elements of composite indexes are quantity, quality, reputation, etc. There are multiple methods for measuring these elements.

In terms of academic quantity, the number of papers is a measure. The impact of the paper (i.e., the citation frequency) is also a measure. Because the quality of different academic papers varies, their influence will also vary greatly. Thus, most tend to use citation frequency as a measure of paper numbers.

In terms of academic quality, there are many methods of measurement, e.g., citation frequency per article, impact factor, 5-year impact factor, etc. One strives for concise, clear connotation, clear definition, and good representation.

In terms of academic reputation, this is a reflection of the comprehensive level of academic journals. Actually, there are similar indicators, for example, the h-index, NCI index (Glänzel et al. , 2008), and Crown Index (CPP/FCSm, Anthony et al. , 2005), with the h-index having the greatest influence.

The reason for introducing the reputation element on the basis of quantitative elements and quality elements is that the academic level cannot be fully reflected from the quantity and quality perspectives alone. Take mining as an example. Obtaining the same metal without considering the cost of smelting can be done in two ways: one is more ore and lower purity, and the other is that relatively few metals and a relatively high purity can achieve the same result. Therefore, we must introduce more factors to evaluate mineral deposits, such as mining and smelting costs.

(2) Design principles of composite indexes

Due to the limitations of bibliometrics, there are currently few elements in composite indexes. Thus, in this paper, quantity, quality and reputation are adopted as the basis for de-

signing the evaluation of composite indexes.

First, we focus on the evaluation of composite indexes based on reputation and quality, both of them important elements. Paying attention to these two aspects is very meaningful to carrying out academic evaluation. On one hand, carrying out an evaluation only from the perspective of quality alone is ineffectual, as sometimes very small evaluation objects are also likely to have higher quality. On the other hand, sometimes it is too indistinguishable to carry out the evaluation from the perspective of reputation alone; for example, the distinction of the h-index is not that high. In addition, reputation is usually related to scale. Thus, the evaluation from the perspective of reputation and quality can reduce the impact of scale.

Second, we focus on the evaluation of composite indexes based on quantity, quality and reputation, the major advantage being that the evaluation perspective is more comprehensive. It not only reflects the scale factor from a quantitative perspective but also the performance factors from a quality perspective. In addition, the comprehensive reputation factor is also reflected.

The reason for not choosing quantity and quality alone is that these two perspectives are not comprehensive. Since academic evaluation places greater emphasis on quality and reputation, an evaluation based on quantity and quality contains an insufficient amount of information and is of little value on many occasions.

Third, we prevent low-level expansion. Some bibliometric indicators have a tendency to rely on the number of articles. The higher the number of articles, the greater the index value. For example, citation frequency is easily affected by the number of articles. Waltman (2016) believes that the h-index is also scale-dependent. The journals with a higher volume of articles tend to obtain a larger h-index. It is possible to increase the scale to a higher level, but it should not be carried out at a low level.

2.2 Design of HR indexes and CHR indexes

(1) Selection of quantity, quality and reputation elements

Given the above discussion, quantitative indicators are measured using citation frequency. In academic evaluation, it is meaningless to use the number of articles to measure quantity. Relatively speaking, the overall effect of the citation frequency is better, and it reflects the value of the paper. The h-index is used to measure reputation, which is currently widely applied. The original intention of the h-index is to comprehensively reflect the influence of scholars. In terms of the measurement of quality indicators, this paper uses highly cited ratios, and its principle is shown in Figure 2.

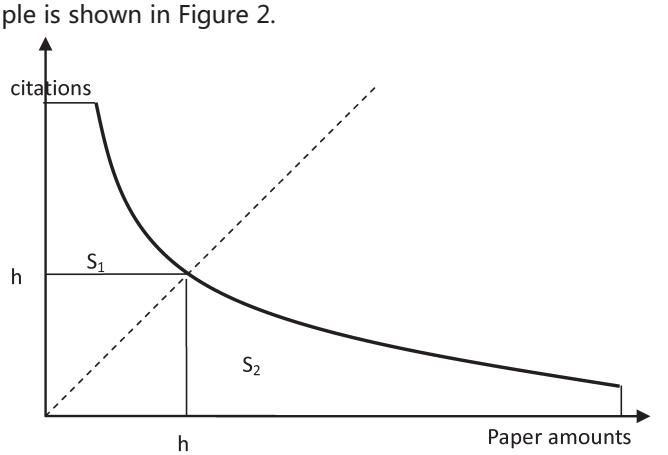

Figure 2 Principle of high citation ratio

Sorting academic papers cited from high to low, two cited areas are obtained. One is the high-cited area, i.e., the total citations for a single paper that has been cited more than or equal to the h-index and its area is S_1. The other is the low-cited area, i.e., the sum of the citations for a single paper that has been cited no more than the h-index and its area is S_2. The high-cited ratio is stated in (1).

$$R = \frac{S_1}{S_1 + S_2} = \frac{\sum_{i=1}^{h} c_i}{c} \tag{1}$$

In formula (1), R is the high-cited ratio, which is abbreviated as the R index. C is the total citations, and c_i is the citations per paper. Zhang (2009) proposes the idea of distinguishing the areas of different citation zones in the h-index, i.e., divide S_1 into two areas, e^2 and h^2, in other words, the high-cited area. In this paper, the high citation ratio is further calculated to reflect the quality of academic journals. The high citation ratio has the following characteristics:

First, it is a relative number that reflects the quality comprehensively. The larger the R index is, the higher the overall quality of the periodical.

Second, although outstanding journals have a high R index, the R index of a growing journal is also good. As long as the journals are carefully run, the R index will perform better if the quality of the journals is relatively good.

The third, carrying out the evaluation from the perspective of the R index is narrow, especially when the h-index is low. Even if the R index is relatively high, the value is not very large. Therefore, the R index can only be used as one of the evaluation factors of the composite index.

(2) HR and CHR indexes

We use the HR index when evaluating journal reputation and quality.

$$HR = hR = h\frac{\sum_{i=1}^{h} c_i}{c} \tag{2}$$

We use the CHR index when evaluating quantity, quality and reputation by means of multiplying them. Since the number of citations is often larger, in order to reduce the possible impact of its excessive magnitude, simply square it, as shown in (3).

$$CHR = \sqrt{c}hR = h\sqrt{c}\frac{\sum_{i=1}^{h} c_i}{c} \tag{3}$$

2.3 Testing method for the rationality of composite indexes

After determining the evaluation elements and design principles of composite indexes, the nest step is to design the composite indexes. However, for the test of composite indexes, there has not been thus far a general and relatively complete method. Usually, empirical studies are undertaken in the case of some kinds of academic evaluations. The applicability of the composite indexes is roughly judged based on the relationship between the evaluation results and other bibliometric indicators, which has some value but is not rigorous.

Testing from the composite index design elements is a relatively desirable method. Any composite index always embodies a design principle, which reflects its evaluation elements

and focuses. Judging the evaluation results using the degree of the reflection of the composite index evaluation elements is a kind of "self-sufficiency" test method.

The basic idea is to test by means of traditional multiple regression. However, in the composite indexes, there are often strong correlations among the indexes that reflect the nature of the quantity, quality, and reputation. For example, high quality journals often have a high reputation.

Journals with large article volumes tend to have a greater influence and can also increase their reputation to some degree. Good academic journals can balance both quantity and quality, while both show relatively good performance. This tends to result in multicollinearity, which can easily lead to biased regression results, smaller t-values, or even the wrong sign of regression coefficients. In addition, many bibliometric indicators do not obey the normal distribution and do not satisfy the preconditions of traditional regression.

The use of partial least squares (PLS) to test the rationality of the composite indexes becomes a better choice. Partial least squares is a multivariate regression tool proposed by Wold et al. (1983) Unlike traditional regression, PLS combines principal component analysis, canonical correlation analysis, and multiple regression. The partial least-squares method is not affected by several cases, such as the independent variable does not obey the normal distribution, there is multivariate collinearity, the basic data quantity is too small, etc. Specifically, the treatment of multicollinearity is better than principal component regression and ridge regression.

The principle of partial least squares is as follows: drawing on the idea of principal component analysis, extract component t_1 from independent variable X and extract component u_1 from dependent variable Y, while there is no multicollinearity because t and u are orthogonal to each other and irrelevant. The principle of extraction is to maximize the variance variation of t_1 and u_1 variances.

$$Var(t_1) \to \max \quad Var(u_1) \to \max \tag{4}$$

In addition, draw on the idea of canonical correlation analysis: t_1 must have the greatest ability to explain u_1, and the correlation coefficient between them is the largest.

$$r(t_1, u_1) \to \max \tag{5}$$

Considering the above two constraints comprehensively, partial least squares PLS seeks to maximize the covariance of t_1 and u_1.

$$Cov(t_1, u_1) = \sqrt{Var(t_1) \cdot Var(u_1)} \cdot r(t_1, u_1) \to \max \tag{6}$$

After t_1 and u_1 are extracted, perform the regression of *X* and *Y* to t_1 until the accuracy of Press is reached. If the accuracy of Press is not reached, extract t_2 from the residual data after extracting t_1 from X, and extract u_2 from the residual data after extracting t_2 from Y. Next, perform the regression again respectively until the accuracy of Press is reached.

If *m* components $t_1, t_2,...,t_m$ are extracted from *X*, and q components $u_1, u_2,..., u_q$ are extracted from *Y*, then perform the regression of Y_k to $t_1, t_2,...,t_m$, and, lastly, convert it to the equation of Y_k to $x_1, x_2,...,x_m$.

While testing the composite indexes, select the evaluation elements of the composite index as independent variables and the evaluation results of composite indexes as the dependent variable. After taking all their logarithms, the regression is performed using partial least squares, while the regression coefficient represents the elasticity of the evaluation elements.

If the regression coefficient does not pass the statistical test or if the elasticity coefficient is too small, this means that the evaluation element is not well represented. At this time, either

revise the composite evaluation index or make it clear whether the evaluation objective is consistent with the idea and focus of this composite evaluation index.

2.4 Statistical Analysis of Composite Indexes

In addition to testing composite indexes, further analysis of composite indexes is needed from a statistical point of view. The analysis perspective mainly involves magnitude, differentiation, data distribution characteristics, etc.

For example, in terms of magnitude, in the bibliometric indicators, the total citation frequency is often the largest, over ten thousand, and the indicators, such as the characteristic factor, are sometimes very small, sometimes even over four decimal places. As a composite evaluation index, both of these cases must be avoided. However, for the general bibliometric indicators, the maximum value of the evaluation should not exceed 1,000. If it can be controlled within 100, the evaluation minimum should not be less than 0.01.

Differentiating degree is also a very important indicator. Differentiating degree can be represented by a discrete coefficient or analyzed by drawing a scatter plot. A good composite indicator should have good differentiation.

The data distribution characteristics mainly refer to whether they are normally distributed, and many of the bibliometric indicators do not obey the normal distribution. However, as a composite evaluation index, whether or not to obey the normal distribution must also be judged in advance.

3 Data

To explain the applications and features of HR indexes and CHR indexes, based on the CNKI citation database, an empirical study is undertaken in this paper by selecting the CSSCI (Chinese social sciences citation index) journals in library information and literature, which have relatively more research.

There are approximately 20 CSSCI journals in library information and literature. As for the time window of HR indexes and CHR indexes, the annual impact factor is adopted as the method to calculate the HR indexes and CHR indexes of journal publications from 2018 to 2019. Because the citation data of the Journal of the China Society for Scientific and Technical Information in the CNKI database is incomplete, only 19 journals are chosen for the empirical study and the results are shown in Table 1.

Table 1 Statistics

Evaluation Indexes	Means	Maximum	Minimum	Standard deviation	JB test	p–value
Article volume	559.211	1620.000	208.000	343.882	13.516	0.001
Citation frequency	1157.842	3214.000	427.000	685.662	12.658	0.002
Impact factor	2.199	4.386	1.239	0.743	10.078	0.006
H index	19.632	28.000	13.000	4.219	0.701	0.704
R index	0.311	0.623	0.149	0.125	2.237	0.327
HR index	6.127	16.185	2.674	3.135	19.966	0.000
CHR index	198.378	520.704	76.215	104.029	12.962	0.002

4 Empirical Results

4.1 Evaluation results of the HR index and the CHR index

Table 2 Evaluation results and rankings

	Article Volume	Citation Frequency	Impact Factor	h–index	rank	R index	rank	HR index	rank	CHR index	rank
Journal of Library Science in China	236	1035	4.386	26	2	0.623	1	16.19	1	520.70	1
Library and Information	312	1016	3.256	22	5	0.400	5	8.81	4	280.79	2
Journal of Academic Libraries	295	911	3.088	20	8	0.449	3	8.98	3	271.15	3
Library and Information Service	1620	3214	1.984	28	1	0.170	18	4.75	12	269.35	4
Studies in Library Science	899	1847	2.055	24	4	0.254	12	6.10	9	262.06	5
Journal of the National Library of China	280	721	2.575	18	12	0.501	2	9.02	2	242.24	6
Library Journal	523	997	1.906	21	6	0.358	6	7.52	5	237.34	7
Journal of Intelligence	929	2241	2.412	26	3	0.183	17	4.76	11	225.11	8
Library Tribune	526	1081	2.055	20	9	0.320	8	6.40	8	210.44	9
Information and Documentation Services	327	682	2.086	19	10	0.346	7	6.57	7	171.47	10
Information Studies: Theory & Application	735	1585	2.156	21	7	0.197	15	4.14	13	164.75	11
Document, Information & Knowledge	208	531	2.553	16	16	0.427	4	6.83	6	157.38	12
Library Development	626	1008	1.610	17	14	0.286	10	4.86	10	154.18	13
Library Work and Study	769	1215	1.580	19	11	0.196	16	3.73	16	130.05	14
Library	577	1004	1.740	17	15	0.220	14	3.74	15	118.60	15
Information Science	720	1435	1.993	18	13	0.149	19	2.67	19	101.30	16
Data Analysis and Knowledge Discovery	456	565	1.239	14	17	0.294	9	4.12	14	97.95	17
Archives communication	312	484	1.551	14	18	0.254	13	3.55	18	78.11	18
Archives Science Study	275	427	1.553	13	19	0.284	11	3.69	17	76.22	19

The evaluation results of some indexes are shown in Table 2. The R index is a relative one, which has little to do with the article volume of journals. The journals with high article volumes will lower their R index if they do not pay attention to improving their quality. The top four journals are the Journal of Library Science in China, the Journal of the National Library of China, the Journal of Academic Libraries and Document, Information & Knowledge. The article volume of the four journals is not large, but their quality is relatively high.

In terms of the HR index, the top four journals are the Journal of Library Science in China,

the Journal of the National Library of China, the Journal of Academic Libraries, and Library and Information. The article volume of the four journals is not large, but their quality is high relatively.

In terms of the HR index and R index, it can be seen that the top three journals are the same, but that the HR index contains a greater amount of information.

In terms of the CHR index, the top four journals are the Journal of Library Science in China, Library and Information, the Journal of Academic Libraries, and Library and Information Service. The R index of Library and Information Service is low and ranked third in the penultimate row, but its H index is number one and its citation frequency is also number one. Therefore, it is ranked fourth overall, which indicates that the comprehensive adjustment effect of the CHR index is better.

4.2 Testing the HR index and CHR index

(1) Testing the HR index

The HR index is mainly affected by the H index and R index. Therefore, by means of the partial least squares regression of the h-index R index to the HR index, the explanation of the variance ratio is shown in Table 3. When the implied component is equal to 1, the goodness of fit is 0.999; thus, select the regression results when the hidden component is one.

Table 3 The explanation of the variance ratio of the HR index

Number of implied components	X variance	Accumulative X variance	Y variance	Accumulative Y variance (R^2)
1	0.483	0.483	0.999	0.999
2	0.517	1.000	1.000	0.999

The regression results of the HR index are shown in Table 4, where the regression coefficient of the H index is the largest, and the elastic coefficient is 1.256. The second one is the R index, with an elastic coefficient of 0.649. In other words, the HR index better reflects its reputation, but reduces the reflection of quality level. Thus, the selection of the HR index for evaluation can be selectively applied.

Table 4 Regression results of the HR index

Variables	implied component 1	implied component 2
H	0.649	0.650
R	1.256	1.256

(2) Testing the CHR index

The CHR index is mainly affected by Citation Frequency, the H index and the R index. Therefore, by means of partial least squares regression, the explanation of the variance ratio is shown in Table 5. When the implied component is equal to 2, the goodness of fit rises from 0.88 to 0.996, approaching 1. Thus, select the regression results when the hidden component is two.

Table 5 The explanation of the variance ratio of the CHR

Number of implied components	X variance	Accumulative X variance	Y variance	Accumulative Y variance (R^2)
1	0.510	0.510	0.880	0.880
2	0.482	0.991	0.116	0.996
3	0.009	1.000	0.003	1.000

The regression results of the CHR index are shown in Table 6, where the regression coefficient of the H index is the largest, and the elastic coefficient is 1.264. The second one is the R index, with an elastic coefficient of 0.942. The smallest is citation frequency, with an elastic coefficient of 0.751. In other words, the CHR index better reflects reputation and quality and is good enough even though it reduces the reflection of the quantity level. Thus, the selection of the CHR index for evaluation can be selectively applied.

Table 6 Regression results of the CHR index

Variables	implied component 1	implied component 2	implied component 3
C	0.765	0.751	0.753
H	1.343	1.264	1.263
R	0.782	0.942	0.941

4.3 Statistical Analysis of the HR index and CHR index

The correlation coefficients between HR index, CHR index and article volume, citation frequency, impact factor, H index, and R index are shown in Table 7.

Table 7 Table of correlation coefficients

Variable	CHR	HR	Article Volume	Citation Frequency	impact factor	H index	R index
CHR	1						
	——						
HR	0.903	1					
	0.000	——					
	0.007	–0.405	1				
	0.979	0.085	——				
Citation Frequency	0.284	–0.142	0.936	1			
	0.238	0.562	0.000	——			
Impact Factor	0.869	0.895	–0.297	0.033	1		
	0.000	0.000	0.217	0.893	——		
H index	0.760	0.427	0.585	0.803	0.535	1	
	0.000	0.069	0.009	0.000	0.018	——	
R index	0.652	0.907	–0.683	–0.484	0.740	0.042	1
	0.003	0.000	0.001	0.036	0.000	0.865	——

In terms of the correlation coefficients between the HR index and other indicators, the highest is the R index, which is 0.907, followed by impact factor, with the correlation coefficient being 0.895. The third-highest correlation coefficient is 0.427, which is with the H index. The indicators with the top three correlation coefficients all pass the statistical tests. The correlation coefficient between the HR index and citation frequency is -0.142, which does not pass the statistical test. In addition, the correlation coefficient between the HR index and article volume is -0.405, which does not pass the statistical test. Thus, the HR index focuses more on reputation and quality, which is normal.

In terms of the correlation coefficients between the CHR index and other indicators, the highest is impact factor, which is 0.869, followed by the H index, with a correlation coefficient of 0.760. The-third highest correlation coefficient is 0.652, which is with the R index. The indicators with the top three correlation coefficients all pass the statistical tests. The correlation coefficient between the CHR index and citation frequency is ranked fourth, at 0.284, which does not pass the statistical test. In addition, the correlation coefficients between the CHR index and article volume is the smallest, at 0.007, which does not pass the statistical test. This result is consistent with the results of partial least-squares regression. Thus, the CHR index better reflects reputation and quality, as well as reduces reflecting quantity.

The maximum of the HR index is 16.185, with the minimum being 2.674. The mean value of the HR index is 6.127, with a standard deviation of 3.135. The discrete coefficient is 51.17% and differentiation is better. The value range of evaluation is according to people's habit cognition. However, the HR index does not obey the normal distribution.

The maximum of the CHR index is 520.704, with the minimum being 76.215. The mean value of the CHR index is 171.467, with the standard deviation being 104.029. The discrete coefficient is 60.67% and differentiation is good enough. The value range of evaluation is slightly larger. The CHR index also does not obey the normal distribution.

5 Conclusions and discussion

(1) The HR index and CHR index are two good evaluation indicators

The HR index focuses on evaluating the prestige and quality of journals, and the CHR index focuses on evaluating the prestige, quality and quantity of journals. Both the HR index and CHR index are not relevant to the number of papers published by journals, which prevents the negative impact of a unilateral pursuit of the volume of articles. In addition, the HR index and CHR index pay more attention to reputation and present more reasonable results, while the size of the evaluation value and the degree of distinction are generally good.

(2) The HR index and CHR index have wide ranges of evaluation objects

Although this paper takes academic journals as examples to explore the application of the HR index and CHR index, the application of these two indexes is universal. The HR index and CHR index can not only be used to evaluate academic journals but also to evaluate scholars, disciplines, research institutions, etc.

In addition, the application of the HR index and CHR index should be based on the specific purpose of evaluations. If the focus is on prestige and quality, select the HR index; if the focus is on comprehensive evaluation, select the CHR index.

(3) The composite index has some advantages

In the evaluation of academic journals, a single indicator presents less evaluation information. Although the index system provides more comprehensive perspectives, there

are numerous multiattribute evaluation methods, and their evaluation results are inconsistent. It is difficult to select a suitable multiattribute evaluation method. Thus, the composite index has some advantages. In addition, there are generally not that many bibliometric indicators, which provides a convenient design for the composite evaluation index.

The design of composite indicators should be based on evaluation purposes and should meet actual evaluation needs.

(4) The rationality of the composite index must be tested

This paper presents two common methods for testing the proposed composite evaluation index. The first one is to test their principles, i.e., the self-interpretation degree of the results to the principle, by means of partial least squares regression. The second is the analysis of the evaluation results, including the relationships between the composite index and other bibliometric indicators, such as the order of magnitude and distinction, the data distribution of evaluation value, etc.

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