Multi-indicator Comprehensive Evaluation Method

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***Abstract*—A multi-indicator comprehensive evaluation method for scientific research is proposed. This paper interprets the process of establishing the evaluation method in detail. It selects the SCI Database as the data source, which embodies the papers of researches in Academy of Mathematics and Systems Science, Chinese Academy of Sciences. Seven indicators are selected in order to use of evaluation method for the comprehensive evaluation results. The evaluation method overcomes the shortcomings of single indicators. Meanwhile, the evaluation results are showed by the radar chart, which has strong readability, you can visually see the influence and the number of papers of research scientists, as well as help you identify potential researchers. The multi-indicator comprehensive evaluation method may contribute to carry out objective and fair assessment of scientific research.**

Keywords — Scientific research evaluation; Evaluation indicator; Evaluation method

1、 INTRODUCTION

Research evaluation is complex and important. Bibliometric evaluation is a popular scientific evaluation method. Evaluation criteria and method directly related to the evaluation results. At present, "Science Citation Index" database(SCI) is an international tool for research performance evaluation. SCI adopts citation frequency and other indicators to evaluate and connect scientific researchers and their work. It helps a lot in evaluating scientific research and judging the research results of a country, a region, or an institute. Moreover, it avoids human prejudice and subjective preference in scientific research evaluation. However, simply using the indicators and data in SCI database is usually one-sided and not fair. This paper puts forward a comprehensive and quantitative evaluation method which combines multiple indicators.

2、 MULTI-INDICATOR COMPREHENSIVE EVALUATION METHOD

The method we proposed consists of three sections (shown in Figure 1), individual indicator smoothing, individual indicator score calculation, and total score calculation. In the first section, the on the average and maximum score as well as the individual indicator weights in the individual indicator data series are all determined by experts. Therefore, the multi-indicator evaluation method is a combination of qualitative and quantitative evaluation. It integrates subjective evaluation and objective evaluation. Experts' experience, objective indicators, and quantitated score calculation are integrated dynamicly in order to derive quantitative accurate evaluation results.

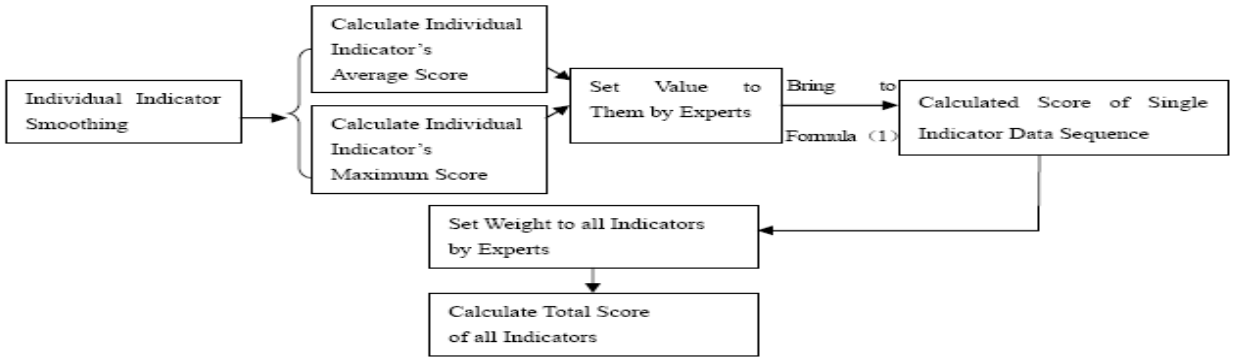

Figure 1: Multi- indicator Comprehensive Evaluation Method Flow Chart

2.1. Individual-indicator Smoothing

Here we take "Total number of papers"for example to interpret individual-indicator smoothing. Data sequence A stands for the number of papers published by researchers in an institution during a certain period of time. A = (a1, a2, ..., an). It is simple to rank the data in sequence A. However, the number just reflects the research productivity of scientists, and it can not measure the importance and influence of the work. For instance, a researcher who published 10 papers may be in a higher level than the one who published 5 papers. However, if we conclude that the

gap between them is double, then we may result in an unreasonable assessment. To avoid drastic changes in data and reduce occasional disturbances, the data is processed. Data sequence A takes the natural logarithm.

logA = (log a1, log a2, ..., logan)

2.2. Single-indicator Score Calculation

First, average the smoothed data sequence, and that is:

ElogA = (log a1 + log a2 + ... + logan) / n

Second, maximize the smoothed data sequence, and that is: maxlogA

Third, set value to the object(stands for a researcher)that gains the average score, and sigh it S0; set value to the object that gains the maximum score, and sigh it S. Using hundred mark system, we can assign S0 = 80, S = 100 (based on experts' experience). Then, the values of other objects are calculated from the following formula:

Sk = S0 + (S-S0) * (logak-ElogA) / (maxlogA-ElogA) ... ... (1)

Thus, we can get all researchers' scores of this indicator. Similarly, we can also use the same method to determine the other indicators' scores.

At last, the total score referring to indicators will be calculated by using average or the weighted average.

3、 EMPIRICAL ANALYSIS

3.1. Data Sources

We take Academy of Mathematics and Systems Science,Chinsese Academy of Scicences for example. We retrieve database SCI, and get papers which written by reseachers of "Chinese Acad * Sci *, Acad * Math * & Syst * Sci *" .

3.2. Selection of Indicators & Data Acquisition

We select 7 indicators, which contains"total number of papers", "total citation frequency", "citation frequency per article", "citation frequency per year" , "H index", "highest citation frequency of single article", and "citation frequency per year of a single article". Then, we extract the data of each rearcher.

"Total number of papers" stands for number of papers published by a seltected researcher. It is a direct reflection of scientific productivity, but it can not measure the importance and influence of the paper.

"Total citation frequency" stands for the times cited in a period of time after the paper publibushed. It is a direct reflection of the impact of the paper, and, to a large extent, it measures of the contribution to scientific development. But it is not suitable to apply this index. When the citation frequency is extremely uneven distributed. It means that If only a few papers are cited frquently, and most other papers are cited only a few times, the evaluation results would be inflated.

"Citation frequency per article" stands for the results of Total citation frequency divided by the total number of papers. This index benefits high yield people, and does not benif those low yield people.

"Citation frequency per year" characterizes the active level of seleted author.

"H index" takes citation frequency as an internal indicator, and takes "total number of papers" as a reference indicator to measure a research work. H index itself takes a balance of these two indicators. It is used to comprehensive measure both the quantity of papers and the influnce of a seleted researcher.

The value of "Highest citation frequency of single article" and "Citation frequency per year of a single article" is to highlight the importance of single papers. It will happen that a research published some a few papers, while his work is very influential and being cited a lot. So both indicators can highlight the importance of the core papers.

3.3. Data Processing and Analysis of Results

First, the author collected data published by Academy of Mathematics and Systems Science,Chinsese Academy of Scicences in database SCI-E. We get a total of 2,345 papers, 134 researchers involved. Part of the data shown in Table 1.

Table 1: The Original Data (acquisition date: June 10, 2010)

Name Code	Total number of papers	Total citation frequency	Citation frequency per article	Citation frequency per year	H index	Highest citation frequency of single article	Citation frequency per year of a single article
#1	59	331	5.61	33.1	9	73	10.43
#2	14	108	7.71	12	6	46	6.57
#3	13	35	2.69	3.89	4	13	2.17
#4	8	2	0.25	0.5	1	2	0.67
#5	23	74	3.22	8.22	5	14	2
#6	24	81	3.38	8.1	5	24	4
#7	8	2	0.25	0.29	1	1	0.33
#8	3	0	0	0	0	0	0
#9	16	67	4.19	8.38	4	25	3.12
#10	23	492	21.39	61.5	7	241	34.43
…	…	…	…	…	…	…	…
#134	14	23	1.64	2.88	3	13	3.25

We apply the multi-indicator comprehensive evaluation method, import the above data into formula (1). Some data may be zero, and will lead to incapable logarithmic operation. It is necessary to make a technical processing. So we add an 1 to all raw data. Then, it is very convenient to obtain scores of single indicator. Then, the weight is given to each indicator, the total score is calculated. Specific rates shown in Table 2, the top 20 showned in Table 3.

Total = “total number of papers” × 15% + “total citation frequency”× 10% + citation frequency per article × 15% + “citation frequency per year” × 20% + H index × 20% + “highest citation frequency of single article”× 10% + “citation frequency per year of a single article” × 10%

Table 2: Scores of Single Indicators and theTotal Scores

Name Code	Total number of papers	Total citation frequency	Citation frequency per article	Citation frequency per year	H index	Highest citation frequency of single article	Citation frequency per year of a single article	Total
#1	93.42	91.67	86.3	90	90.22	92.26	91.08	90.5
#2	82.28	87.05	88.55	85.39	86.71	89.62	87.87	86.49
#3	81.73	82.46	81.54	80.71	83.4	82.59	81.09	81.92
#4	78.18	72.17	72.7	75.06	74.38	73.63	76.1	74.71
#5	86.06	85.51	82.63	83.74	85.19	82.99	80.66	84
#6	86.39	85.87	82.94	83.68	85.19	85.95	84.64	84.81
#7	78.18	72.17	72.7	74.34	74.38	71.28	74.33	74.15
#8	71.66	67.62	70.88	73.12	67.56	67.25	72.1	70.21
#9	83.29	85.1	84.32	83.82	83.4	86.18	83.13	84.02
#10	86.06	93.31	96.26	92.89	88.02	99.15	99.9	92.76
…	…	…	…	…	…	…	…	…
#134	82.28	80.78	78.8	79.6	81.2	82.59	83.38	80.99

It can be seen from Table 3, if all indicators ranks forward, then the total ranking would be forward. If only individual indicators rank high, then the would be more rearward generally. According to this table, we can analyze relative position of a researcher among all researchers. It also helps to adjust research goals, such as researchers could consider more difficult and influencing work if they have published many papers and have been cited a lot.

Table 3: Indicators of the Top 20

Rank	Total	Total number of papers	Total citation frequency	Citation frequency per article	Citation frequency per year	H index	Highest citation frequency of single article	Citation frequency per year of a single article
1	#63	#87	#63	#63	#63	#63	#63	#63
2	#10	#63	#10	#10	#10	#87	#10	#10
3	#1	#1	#87	#25	#87	#1	#1	#1
4	#87	#123	#1	#2	#1	#15	#2	#123
5	#123	#111	#15	#15	#111	#123	#118	#88
6	#15	#116	#123	#32	#15	#66	#87	#87
7	#111	#66	#66	#1	#123	#116	#111	#111
8	#66	#131	#116	#49	#66	#10	#99	#2
9	#118	#15	#111	#27	#116	#111	#95	#119
10	#2	#99	#118	#29	#119	#128	#123	#99
11	#84	#122	#84	#118	#118	#118	#88	#72
12	#88	#106	#131	#38	#84	#84	#66	#118
13	#116	#128	#2	#95	#131	#131	#84	#84
14	#99	#118	#99	#84	#88	#2	#15	#122
15	#131	#88	#106	#41	#95	#99	#122	#93

16	#95	#84	#88	#36	#2	#113	#131	#66
17	#122	#110	#95	#20	#99	#106	#106	#95
18	#106	#47	#128	#66	#106	#88	#9	#6
19	#119	#6	#122	#9	#38	#95	#6	#55
20	#6	#10	#6	#88	#41	#122	#27	#94

In addition, we select the top 20 researchers whose total score rank forward. Then, indicators except H index (because of tied rankings) are reordered to determine the relative ranking among the 20 people. Results showns in the following radar chart (Figure 2). In the radar chart, a ray on behalf of a scientific researcher, point on the ray on behalf of the ranking of each indicator.The more close to the center point, the more forward the researcher is ranked.

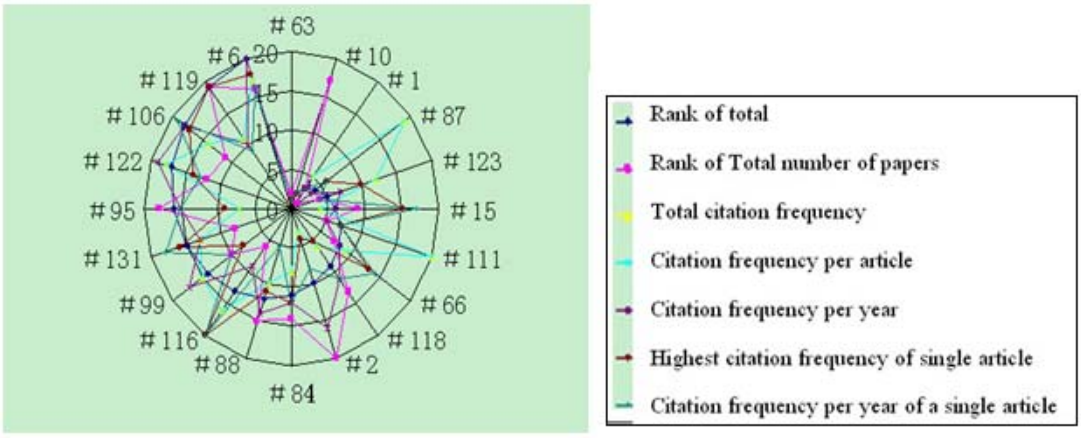

Figure 2: Ranking of all Indicators

From figure 2, we can see that if all indicators of a researcher are close to the center, then the total ranking is also close to the center. These researchers are generally the core members of the team. However, most researchers's indicators are not evenly distributed. There are indicators close to the center of the target, but ones in the off-center position. From figure 2, all researchers's ranking of different indicators can be seen clearly. We can analyze the reasons have led to the ranking. Meanwhile, this method helps to find the potential researchers. As shown in the figure, researchers who are cited a lot and published a few are more likely to be short-lived potential researchers. Conversely, some researchers' total score ranked forward, but may be found because of the large quantity of published papers. According to the Multi-indicator comprehensive evaluation method and the ranking chart, you can find potential researchers, prolific researchers, and influential scientists. The method is helpful for project management, research work evaluation, discovery of potential researchers and so on.

4、 Conclusion

In this paper, the multiple indicator comprehensive evaluation method is proposed. According to it, scientific research is ranked. The results have a strong objectivity as well as desirability to some extent, which reflect the actual effects and contributions of a specific research.

Data we used mainly come from SCI-E database. We can also collect data from other sources, and select specific indicators that could meet the need. Then, we can import the data into formula(1), give weights to indicators ,and obtain the final score of a specific researcher. In our paper, the indicator weights are based on subjective experience, which may lead to inaccurate results. Peer review and expert evaluation are also needed to objectively measure science research.

Acknowledgment

Professor Zhou Ningli proposes valuable advisory opinions. In this paper, we express our sincere thanks!

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