

Application of principal component analysis in journal evaluation

WEN Xuebing^{1,2,a}

¹Editorial Department of Journal, Shenyang Normal University, Shenyang 110034, China

²School of Mathematics and Systems Science, Shenyang Normal University, Shenyang 110034, China

^axbw2004@163.com

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Abstract. An evaluation method on scientific and technical journals based on principal component analysis is applied to deal with the relevance between various indices of 17 mathematical core journals. In order to choose index of quantitative evaluation of domestic mathematics journals which can provide a quantitative reference for journal evaluation based on Chinese scientific and technical papers and Citations Database (TPSTCD), using the index of measurement data in 2013, by principal component analysis method, the high quality mathematics domestic journals: 17 mathematical periodicals of 2011 edition Chinese core journals are analyzed and ranked. The results show that: the result by principal component analysis agrees with that of everyone in the eye, and the principal component analysis method is suitable for domestic high quality mathematics journals, and can be extended to quantitative evaluation of all domestic mathematics journals.

0.Introduction

Academic journal is the window to show the level of technological development, and is the bridge of knowledge innovation, scientific and technological achievements, and plays important role^[1], can not be replaced in promoting social progress of science and technology.

The quantitative method of journal evaluation is many^[3-9], and principal component analysis method has certain reliability in certain professional directionis through practice.

The principal component analysis method intends to extract several indexes through the analysis of many original lobservation index information. The extracted indices are irrelevant, and can reflect the maximum indicator information, and then use several comprehensive index to characterize the individual. The principal component analysis method in mathematics essence is to reduce variable dimension, i.e., use fewer variables to instead of the original variables, and every new variable is some combination of the original variables.

According to TPSTCD^[10], we analyzes and ranks 17 mathematical periodicals of 2011 edition Chinese core journals by using principal component analysis, in order to provide quantitative reference for selecting quantitative evaluation indices, comprehensive evaluation,and improving the quality of domestic mathematics journals.

1.Select the object of study and evaluation index

Domestic well-known sci-tech periodical evaluation organization mainly has 5, respectively National Science Library of Chinese Academy of Sciences[13], The library of Peking University and other 27 units[14], Information Science and Technology Institute of China, Research Center China Academic Bibliometric Evaluation[15], Research Center for Chinese Science Evaluation of Wuhan University[16], regularly publish Chinese Science Citation Database, Guide to Chinese Core Journals, Citation Reports of Scientific Journals, Impact Factor Annual of Chinese Academic Journals, RCCSE Chinese Academic Journal Evaluation Report. And Guide to Chinese Core Journals is the most famous and get the most unit recognition. Information Science and Technology Institute of China

adopts the most comprehensive quantitative evaluation indicators, and most rapidly puts to use the latest international quantitative indicators. professional journals can generally get source support from a famous key disciplines of domestic university, and more health and more standard than comprehensive journals. Therefore, basing on TPSTCD, using the index of measurement data in 2013, by principal component analysis method, the high quality mathematics domestic journals: 17 mathematical periodicals of 2011 edition Chinese core journals are analyzed and ranked. Because Information Science and Technology Institute of China adjusts quantitative evaluation index every year according to the latest research results of intelligence assessment center, here is a list of the 2013 edition of the index to evaluate China Technology Journal Citation Report, including journal citation indexes of journals in the total citation frequency, impact factor and immediacy index, he citation rate, number of citing journals, core diffusion factor, the authority factor and cited half-life; the source volume of literature, Journal of literature measure index selection rate and AR thesis volume, the average number of citations, average number of authors, to distinguish the cloth number, distribution of the number of institutions, overseas paper ratio, ratio of funded papers, cited half-life etc.

17 mathematical Chinese core journals are as follows: 1) Acta mathematica; 2) Fuzzy Systems and Mathematics; 3) Chinese Journal of Engineering Mathematics; 4) Acta Mathematicae Applicatae Sinica; 5) Acta Mathematica Scientia; 6) Journal of Systems Science and Mathematical Sciences; 7) Journal of Mathematics; 8) Computational Mathematics; 9) Advances In Mathematics; 10) Chinese Annals of Mathematics, Ser. A; 11) Applied Mathematics Journal of Chinese Universities; 12) Journal of Mathematics; 13) Numerical Mathematics Journal of Chinese Universities; 14) Science China. Mathematics; 15) Chinese Journal of Applied Probability and Statistics; 16) Or Transactions; 17) Mathematics in Practice and Theory. In 2013 the original quantitative evaluation indexes values of Table 1, the cited half-life and citing half-life is a reverse index, must do the reverse adjustment, are presented in table 2 of TPSTCD data of 2013 years after the reverse adjustment.

Table 1 18 TPSTCD measurement indicators of 17 math core journals of 2011 version in 2013

| journal | total cited frequency | impact factor γ_2 | year index γ_3 | cited rate γ_4 | number of | diffusion factor γ_6 | authority factor γ_7 | cited half-life γ_8 | source | Literature selection | AR rate of | average number of | average number of | area | Distribution | ratio of | fund paper | citation half |
|---------|-----------------------|--------------------------|-----------------------|-----------------------|-----------|-----------------------------|-----------------------------|----------------------------|--------|----------------------|------------|-------------------|-------------------|------|--------------|----------|------------|---------------|
| 1 | 70 | 0.2 | 0.0 | 0. | 1 | 17. | 38 | 8.2 | 1 | 0.8 | 1 | 15. | 2.0 | 2 | 8 | 0. | 0. | 1 |
| | 5 | 72 | 73 | 9 | 2 | 3 | 5.4 | | 1 | 7 | 1 | 75 | 3 | 8 | 3 | 0 | 8 | 2. |
| | | | | 3 | 2 | | 6 | | 0 | | 0 | | | | | 2 | 5 | 9 |
| 2 | 29 | 0.5 | 0.0 | 0. | 1 | 35. | 27 | 8 | 3 | 0.9 | 3 | 17. | 2.7 | 1 | 3 | 0. | 0. | 1 |
| | 8 | 64 | 26 | 9 | 0 | 91 | 5.8 | | 8 | | 8 | 16 | 4 | 8 | 4 | 0 | 8 | 0. |
| | | | | | 7 | | 1 | | | | | | | | | 5 | 9 | 6 |
| 3 | 49 | 0.2 | 0.0 | 0. | 1 | 33. | 32 | 8.1 | 9 | 0.9 | 9 | 13. | 2.2 | 2 | 8 | 0. | 0. | 1 |
| | 0 | 9 | 11 | 9 | 6 | 47 | 4.7 | | 2 | 7 | 0 | 24 | 3 | 3 | 1 | 0 | 8 | 2. |
| | | | | 4 | 4 | | 2 | | | | | | | | | 2 | 8 | 1 |
| 4 | 88 | 0.5 | 0.1 | 0. | 4 | 47. | 44 | 10. | 9 | 0.8 | 9 | 22. | 2.1 | 1 | 7 | 0. | 0. | 1 |
| | 3 | 46 | 02 | 9 | 2 | 68 | 3.3 | 9 | 8 | 4 | 8 | 22 | 5 | 8 | 9 | 0 | 8 | 0 |
| | | | | 3 | 1 | | 4 | | | | | | | | | 6 | 7 | |
| 5 | 39 | 0.2 | 0.2 | 0. | 1 | 43. | 28 | 5.3 | 1 | 0.9 | 1 | 17. | 2.2 | 2 | 1 | 0. | 0. | 9. |
| | 0 | 69 | 71 | 8 | 6 | 08 | 8.4 | | 4 | 4 | 4 | 05 | 6 | 5 | 0 | 0 | 9 | 0 |
| | | | | 9 | 8 | | | | 6 | | 4 | | | | 4 | 3 | 2 | |
| 6 | 27 | 0.1 | 0.0 | 0. | 8 | 30. | 25 | 10. | 6 | 0.8 | 6 | 17. | 2.0 | 2 | 5 | 0. | 0. | 1 |
| | 2 | 36 | 32 | 9 | 3 | 51 | 8.7 | 6 | 3 | 5 | 3 | 62 | 8 | 1 | 3 | 0 | 9 | 2 |
| | | | | 4 | | | 8 | | | | | | | | | 5 | 4 | |
| 7 | 66 | 0.3 | 0.0 | 0. | 1 | 26. | 36 | 6.7 | 1 | 1 | 1 | 13. | 2.2 | 2 | 1 | 0. | 0. | 9. |
| | 0 | 48 | 5 | 7 | 7 | 97 | 2.0 | | 6 | | 5 | 97 | 5 | 5 | 0 | 0 | 8 | 7 |
| | | | | 5 | 8 | | 5 | | 1 | | 8 | | | | 9 | 1 | 4 | |

| | | | | | | | | | | | | | | | | | | |
|---|----|-----|-----|----|---|-----|-----|-----|---|-----|---|-----|-----|---|---|----|----|----|
| 8 | 51 | 0.2 | 0.0 | 0. | 1 | 32. | 33 | 6.4 | 1 | 0.9 | 1 | 12. | 2.4 | 2 | 8 | 0. | 0. | 9. |
| | 5 | 76 | 17 | 8 | 6 | 62 | 0.2 | | 1 | 7 | 1 | 89 | 3 | 6 | 1 | 0 | 8 | 9 |
| | | | | 2 | 8 | | 6 | | 6 | | 3 | | | | | 0 | 5 | |
| 9 | 29 | 0.1 | 0.0 | 0. | 1 | 35. | 26 | 8.2 | 8 | 0.9 | 8 | 18. | 2.2 | 2 | 7 | 0. | 0. | 1 |
| | 3 | 55 | 12 | 9 | 0 | 15 | 4.9 | | 5 | 4 | 1 | 27 | | 7 | 5 | 0 | 8 | 1. |
| | | | | 1 | 3 | | 5 | | | | | | | | | 1 | | 7 |
| 1 | 19 | 0.1 | 0.0 | 0. | 1 | 51. | 23 | 6.8 | 1 | 0.9 | 1 | 11. | 2.1 | 2 | 9 | 0. | 0. | 9. |
| 0 | 7 | 08 | 07 | 9 | 0 | 78 | 6.7 | | 3 | 7 | 3 | 15 | 7 | 7 | 2 | 0 | 8 | 9 |
| | | | | 1 | 2 | | 3 | | 4 | | 4 | | | | | 1 | 4 | |
| 1 | 12 | 0.1 | 0.0 | 0. | 3 | 29. | 49 | 4.4 | 8 | 1 | 8 | 9.9 | 2.6 | 3 | 4 | 0. | 0. | 8. |
| 1 | 07 | 81 | 18 | 7 | 6 | 83 | 7.1 | | 8 | | 6 | | 3 | 1 | 2 | 0 | 6 | 3 |
| | | | | 9 | 0 | | 9 | | 9 | | 9 | | | | 0 | 1 | 5 | |
| 1 | 13 | 0.1 | 0 | 0. | 7 | 54. | 21 | 8.6 | 6 | 0.9 | 6 | 13. | 2.0 | 2 | 4 | 0 | 0. | 1 |
| 2 | 5 | 12 | | 9 | 3 | 07 | 7.4 | | 1 | 4 | 0 | 25 | 8 | 1 | 9 | | 7 | 2. |
| | | | | 3 | | | 4 | | | | | | | | | | 2 | 4 |
| 1 | 20 | 0.2 | 0.0 | 0. | 1 | 57. | 23 | 7.8 | 5 | 0.9 | 5 | 11. | 2.2 | 1 | 3 | 0. | 0. | 9. |
| 3 | 3 | 36 | 36 | 9 | 1 | 64 | 6.6 | | 5 | 3 | 4 | 96 | 5 | 4 | 9 | 0 | 8 | 4 |
| | | | | 7 | 7 | | 7 | | | | | | | | | 2 | 2 | |
| 1 | 31 | 0.1 | 0.0 | 0. | 8 | 27. | 27 | 5.6 | 1 | 0.9 | 1 | 10. | 2.0 | 2 | 1 | 0. | 0. | 1 |
| 4 | 8 | 99 | 19 | 5 | 9 | 99 | 1.8 | | 5 | 8 | 5 | 6 | 5 | 5 | 0 | 0 | 7 | 2. |
| | | | | 1 | | | 3 | | 8 | | 7 | | | | 5 | 1 | 2 | 4 |
| 1 | 15 | 0.2 | 0 | 0. | 7 | 48 | 22 | 8.7 | 3 | 0.9 | 3 | 11. | 2.2 | 1 | 3 | 0. | 0. | 1 |
| 5 | 0 | 03 | | 9 | 2 | | 3.3 | | 7 | | 7 | 97 | 4 | 6 | 5 | 0 | 8 | 2. |
| | | | | 3 | | | 6 | | | | | | | | | 5 | 1 | 6 |
| 1 | 39 | 0.2 | 0.0 | 0. | 1 | 27. | 29 | 5.3 | 1 | 0.9 | 1 | 16. | 2.2 | 2 | 9 | 0. | 0. | 1 |
| 6 | 1 | 12 | 53 | 8 | 0 | 62 | 2.8 | | 1 | 5 | 1 | 71 | 4 | 5 | 3 | 0 | 8 | 1. |
| | | | | 6 | 8 | | 6 | | 3 | | 2 | | | | | 3 | 9 | 2 |
| 1 | 75 | 0.1 | 0.0 | 0. | 4 | 65. | 19 | 6.4 | 5 | 1 | 4 | 15. | 2.5 | 2 | 3 | 0. | 0. | 9. |
| 7 | | 03 | 4 | 8 | 9 | 33 | 9.0 | | 0 | | 9 | 86 | 4 | 0 | 4 | 0 | 7 | 6 |
| | | | | 8 | | | 2 | | | | | | | | | 4 | 8 | |

Table 2 18 Reverse adjust TPSTCD measurement indicators of 17 math core journals of 2011 version in 2013

| journal | total cited factor z1 | impact factor z2 | year index z3 | cited rate z4 | number of | diffusion factor z6 | authority factor z7 | cited literature | source | Literature | AR rate of | average number of | average | area | Distribution | ratio of | fund paper | citation half |
|---------|-----------------------|------------------|---------------|---------------|-----------|---------------------|---------------------|------------------|--------|------------|------------|-------------------|---------|------|--------------|----------|------------|---------------|
| 1 | 70 | 0.2 | 0.0 | 0. | 1 | 17. | 385. | 91 | 11 | 0. | 11 | 15. | 2. | 2 | 83 | 0. | 0. | 87 |
| | 5 | 72 | 73 | 93 | 2 | 3 | 46 | .8 | 0 | 87 | 0 | 75 | 03 | 8 | | 02 | 85 | .1 |
| | | | | | 2 | | | | | | | | | | | | | |
| 2 | 29 | 0.5 | 0.0 | 0. | 1 | 35. | 275. | 92 | 38 | 0. | 38 | 17. | 2. | 1 | 34 | 0. | 0. | 89 |
| | 8 | 64 | 26 | 9 | 0 | 91 | 81 | | | 9 | | 16 | 74 | 8 | | 05 | 89 | .4 |
| | | | | | 7 | | | | | | | | | | | | | |
| 3 | 49 | 0.2 | 0.0 | 0. | 1 | 33. | 324. | 91 | 92 | 0. | 90 | 13. | 2. | 2 | 81 | 0. | 0. | 87 |
| | 0 | 9 | 11 | 94 | 6 | 47 | 72 | .9 | | 97 | | 24 | 23 | 3 | | 02 | 88 | .9 |
| | | | | | 4 | | | | | | | | | | | | | |
| 4 | 88 | 0.5 | 0.1 | 0. | 4 | 47. | 443. | 89 | 98 | 0. | 98 | 22. | 2. | 1 | 79 | 0. | 0. | 90 |
| | 3 | 46 | 02 | 93 | 2 | 68 | 34 | .1 | | 84 | | 22 | 15 | 8 | | 06 | 87 | |
| | | | | | 1 | | | | | | | | | | | | | |
| 5 | 39 | 0.2 | 0.2 | 0. | 1 | 43. | 288. | 94 | 14 | 0. | 14 | 17. | 2. | 2 | 10 | 0. | 0. | 91 |
| | 0 | 69 | 71 | 89 | 6 | 08 | 4 | .7 | 6 | 94 | 4 | 05 | 26 | 5 | 4 | 03 | 92 | |

| | | | | | | | | | | | | | | | | | | |
|---|----|-----|-----|----|---|-----|------|----|----|----|----|-----|----|---|----|----|----|----|
| | | | | | | | | | | | | | | | | | | 8 |
| 6 | 27 | 0.1 | 0.0 | 0. | 8 | 30. | 258. | 89 | 63 | 0. | 63 | 17. | 2. | 2 | 53 | 0. | 0. | 88 |
| | 2 | 36 | 32 | 94 | 3 | 51 | 78 | .4 | | 85 | | 62 | 08 | 1 | | 05 | 94 | |
| 7 | 66 | 0.3 | 0.0 | 0. | 1 | 26. | 362. | 93 | 16 | 1 | 15 | 13. | 2. | 2 | 10 | 0. | 0. | 90 |
| | 0 | 48 | 5 | 75 | 7 | 97 | 05 | .3 | 1 | | 8 | 97 | 25 | 5 | 9 | 01 | 84 | .3 |
| | | | | | | | | | | | | | | | | | | 8 |
| 8 | 51 | 0.2 | 0.0 | 0. | 1 | 32. | 330. | 93 | 11 | 0. | 11 | 12. | 2. | 2 | 81 | 0 | 0. | 90 |
| | 5 | 76 | 17 | 82 | 6 | 62 | 26 | .6 | 6 | 97 | 3 | 89 | 43 | 6 | | | 85 | .1 |
| | | | | | | | | | | | | | | | | | | 8 |
| 9 | 29 | 0.1 | 0.0 | 0. | 1 | 35. | 264. | 91 | 85 | 0. | 81 | 18. | 2. | 2 | 75 | 0. | 0. | 88 |
| | 3 | 55 | 12 | 91 | 0 | 15 | 95 | .8 | | 94 | | 27 | 2 | 7 | | 01 | 8 | .3 |
| | | | | | | | | | | | | | | | | | | 3 |
| 1 | 19 | 0.1 | 0.0 | 0. | 1 | 51. | 236. | 93 | 13 | 0. | 13 | 11. | 2. | 2 | 92 | 0. | 0. | 90 |
| 0 | 7 | 08 | 07 | 91 | 0 | 78 | 73 | .2 | 4 | 97 | 4 | 15 | 17 | 7 | | 01 | 84 | .1 |
| | | | | | | | | | | | | | | | | | | 2 |
| 1 | 12 | 0.1 | 0.0 | 0. | 3 | 29. | 497. | 95 | 88 | 1 | 86 | 9.9 | 2. | 3 | 42 | 0. | 0. | 91 |
| 1 | 07 | 81 | 18 | 79 | 6 | 83 | 19 | .6 | 9 | | 9 | | 63 | 1 | 0 | 01 | 65 | .7 |
| | | | | | | | | | | | | | | | | | | 0 |
| 1 | 13 | 0.1 | 0 | 0. | 7 | 54. | 217. | 91 | 61 | 0. | 60 | 13. | 2. | 2 | 49 | 0 | 0. | 87 |
| 2 | 5 | 12 | | 93 | 3 | 07 | 44 | .4 | | 94 | | 25 | 08 | 1 | | | 72 | .6 |
| 1 | 20 | 0.2 | 0.0 | 0. | 1 | 57. | 236. | 92 | 55 | 0. | 54 | 11. | 2. | 1 | 39 | 0. | 0. | 90 |
| 3 | 3 | 36 | 36 | 97 | 1 | 64 | 67 | .2 | | 93 | | 96 | 25 | 4 | | 02 | 82 | .6 |
| | | | | | | | | | | | | | | | | | | 7 |
| 1 | 31 | 0.1 | 0.0 | 0. | 8 | 27. | 271. | 94 | 15 | 0. | 15 | 10. | 2. | 2 | 10 | 0. | 0. | 87 |
| 4 | 8 | 99 | 19 | 51 | 9 | 99 | 83 | .4 | 8 | 98 | 7 | 6 | 05 | 5 | 5 | 01 | 72 | .6 |
| 1 | 15 | 0.2 | 0 | 0. | 7 | 48 | 223. | 91 | 37 | 0. | 37 | 11. | 2. | 1 | 35 | 0. | 0. | 87 |
| 5 | 0 | 03 | | 93 | 2 | | 36 | .8 | | 9 | | 97 | 24 | 6 | | 05 | 81 | .4 |
| 1 | 39 | 0.2 | 0.0 | 0. | 1 | 27. | 292. | 94 | 11 | 0. | 11 | 16. | 2. | 2 | 93 | 0. | 0. | 88 |
| 6 | 1 | 12 | 53 | 86 | 0 | 62 | 86 | .7 | 3 | 95 | 2 | 71 | 24 | 5 | | 03 | 89 | .8 |
| | | | | | | | | | | | | | | | | | | 8 |
| 1 | 75 | 0.1 | 0.0 | 0. | 4 | 65. | 199. | 93 | 50 | 1 | 49 | 15. | 2. | 2 | 34 | 0. | 0. | 90 |
| 7 | | 03 | 4 | 88 | 9 | 33 | 02 | .6 | | | | 86 | 54 | 0 | | 04 | 78 | .4 |

2. Research method ---- principal component analysis

2.1 principle component analysis.

Set $x_i, i=1, 2, \dots, n$ from p dimension $X = (X_1, X_2, \dots, X_p)$, Our goal is to extract m indexes Y_1, Y_2, \dots, Y_m from the p indexes X_1, X_2, \dots, X_p , where m is much smaller than p . Because of these comprehensive index information is hidden in observable indicators, or each observable indicators are more or less related with some comprehensive indexes of information, therefore, the extraction process of each integrated indicators, will distribute the comprehensive index information.

From the mathematical point of view, every comprehensive indexes are regarded as a linear combination of observation in each index, then established the following mathematical model

$$\begin{cases} Y_1 = l_{11}X_1 + l_{12}X_2 + \dots + l_{1p}X_p = l_1'X, \\ Y_2 = l_{21}X_1 + l_{22}X_2 + \dots + l_{2p}X_p = l_2'X, \\ \dots\dots\dots \\ Y_m = l_{m1}X_1 + l_{m2}X_2 + \dots + l_{mp}X_p = l_m'X \end{cases}$$

Where, $l_i = (l_{i1}, l_{i2}, \dots, l_{ip})'$ is constant vector, $X = (X_1, X_2, \dots, X_p)'$ is random vector.

2.2 computation steps

1) data standardization

The quantitative evaluation index such as total cited frequency, impact factor need the same tendency treatment because of different trends, dimension and magnitude. For positive indicators, using reciprocal method, then the center sample standard. For the citing half-life, cited half-life reverse indicators, used numerical minus by 100, become positive indicators, and then normalization .

2) calculate the standardization sample matrix mean, standard deviation, covariance matrix

3) calculation of characteristic value and characteristic vector of covariance matrix

4) arrang eigenvalues from large to small, determine the M principal components

5) calculation of the first principal component of the sample value m

6) calculating the comprehensive evaluation principal component values, given the ranking.

Of course, before performing these steps, KMO and Bartlett test were finished.

3.conclusion and analysis

Take data of China Technology Journal Citation Report in 2013 as an example, and the calculation results are as follows:

Table3. The various ranking results of 17 mathematical journals

| Journal | Comprehensive principal components ranking | total cited frequency ranking | impact factor ranking |
|---|--|-------------------------------|-----------------------|
| Mathematics in Practice and Theory | 1 | 1 | 12 |
| Science China(Mathematics) | 2 | 2 | 2 |
| Acta mathematica | 3 | 4 | 3 |
| Fuzzy Systems and Mathematics | 4 | 8 | 7 |
| Chinese Journal of Engineering Mathematics | 5 | 5 | 5 |
| Acta Mathematicae Applicatae Sinica | 6 | 3 | 6 |
| Acta Mathematica Scientia | 7 | | 4 |
| Journal of Systems Science and Mathematical Sciences | 8 | 7 | 9 |
| Journal of Mathematics | 9 | 10 | 1 |
| Computational Mathematics | 10 | 14 | 16 |
| Advances In Mathematics | 11 | 9 | 11 |
| Chinese Annals of Mathematics, Ser. A | 12 | 13 | 8 |
| Applied Mathematics Journal of Chinese Universities | 13 | 11 | 13 |
| Journal of Mathematics | 14 | 17 | 17 |
| Numerical Mathematics Journal of Chinese Universities | 15 | 12 | 14 |
| Chinese Journal of Applied Probability and Statistics | 16 | 16 | 15 |
| Or Transactions | 17 | 15 | 10 |

The ranking result is close to that of total cited frequency, impact factor and subjective evaluation and illustrate the effectiveness of the proposed method.

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