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Research Performance Assessment Based on T-Indicator

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ABSTRACT

A novel indicator named after Tianjin University (TJU)-T-indicator-was investigated as an effective supplement of established Article Assessment System of Tianjin University, aiming to correct differences among fields. Based on normalized citation counts, T-indicator could give the order of research performance of researchers or groups in different disciplines. Weighted citation analysis was also introduced in this method to judge the contribution of researchers to their research outcomes. A given example was used to thoroughly discuss this evaluation method, via the application of derivative indices, including T_{year}, $T_{average}$, T_{total} and weighted-T_{total}.

Keywords: Research Performance Assessment; TJ-Indicator; Normalization; Citation Counts

1. Introduction

Research performance assessment (RPA) plays important roles in universities and research institutions, especially in the process of recruitment, academic promotion, offering tenure, granting, etc. The general indices of RPA include publications, patents, awards, and grants. It is hard to evaluate the quality level of patents, awards, and grants among different institutions and countries as there is no same standard. However, journal publication, mostly published after peer reviews, is a good and unique index for internal and external comparison. Nowadays, journal publication has been widely used officially or subconsciously in the process of RPA.

An article assessment system has been successfully established based on both Tianjin University and nine key Chinese Universities' academic disciplinary benchmarks [1]. With this scientific benchmarking system, the quality of a researcher's papers could be easily located in a percentile scale in corresponding field and within certain groups. Several factors, including total number of papers, order of authors, impact factor of journals, citation count, h-index [2], e-index [3], a-index [4], m-quotient [2], as well as weighted citation analysis [5], were also utilized for both quantity and quality analysis.

This article assessment system has played a significant role as an important part of RPA in Tianjin University. However, with unique advantages in comparing researchers or groups in a same field, it is hard to tell their RPA in different fields. To improve this article assessment system, citation counts were normalized for correcting differences among fields. Breaking the boundary of disciplines, this modified citation-based article assessment system could easily give the order of research performance of researchers or groups even in different disciplines.

2. Methods

The average number of citation count of all TJU publications from Scopus citation database are obtained for each discipline and for each year from the year of 2001 to the year of 2009, based on the accumulation of citations from the year of publication to the current year (Equation (1)).

$$AC_{y_j} = \frac{1}{n_j}\sum_{i=1}^{n_j} C_{i,j} \tag{1}$$

where $C_{i,j}$ are the citations received by the i^{th} paper in the year j, and n_j is number of papers published in the year j. On the left hand of Equation (1), AC_j represents the average number of citations received in the period from year j to 2009 by papers published in the year j.

To obtain the total T-indicator (T_{total}), annual T-indicator (T_{year}) are required to be calculated firstly: the sum of a researcher or group's actual number of citations of all publications is divided by the above average number for each year in the same discipline (Equation (2)).

$$TJ_{y_j} = \frac{1}{m_j}\frac{\sum_{i=1}^{m_j} C_{i,j}}{AC_{y_j}} \tag{2}$$

where m_j is the number of papers published by an individual researcher or a group of researchers in the year j, and TJ_{y_j} is the ratio of the average citations received

for an individual researcher or a group of researchers in the year *j*, over the average number of citations received in the year *j* of the whole university, both in the same discipline.

The average number of T_{year} is the T-indicator (Equation (3)), and the standard deviation (SD) is also calculated to show the stability of research performance (Equation (4)).

$$TJ_{\text{total}} = \frac{1}{(y_2 - y_1)} \sum_{j=y_1}^{y_2} TJ_{y_j} \quad (3)$$

$$SD_{TJ} = \sqrt{\frac{\sum_{j=y_1}^{y_2} \left(TJ_{y_j} - TJ_{\text{total}}\right)^2}{(y_2 - y_1) - 1}} \quad (4)$$

where y_1 is the first year of the period in which the research performance of an individual researcher or a group of researchers are required to be analyzed, and y_2 is last year of this period required to be analyzed.

3. Results and Discussion

Table of *Mean of Citation Count of all TJU Publications* is prepared (**Table 1**) for 25 disciplines from the year of 2001 to the year of 2009. Total number of TJU publications over 9 years and of each year, as well as the annual mean citation count were all included for every category in this table. For example, in category of "Agricultural and Biological", total number of TJU publication is 388; the number of publications in the year of 2001 and the mean citation count is 11 and 14.18, respectively.

The following example is taken to discuss the application of T-indicator. Tianjin University announced the competition for a 3-level award funding for research performance, and there are 8 candidates entered the last round. In the process of research publication assessment, as shown in **Table 2**, all of them are excellent in their research fields, and some of them have similar number of publications (Candidate 3 and Candidate 5), total citation count (Candidate 3 and Candidate 8), and average citation count (Candidate 1 and Candidate 5) as well. Furthermore, considering the property of citation frequency in different research areas, it is very hard to simply compare them via the common indices, including citation count, h-index, e-index, etc., as mentioned above. However, T-indicator, based on normalized citation count, could be conveniently used here to give the order of research performance as a helpful reference to the award

Table 1. The mean of citation count of all TJU publications. The data were collected from Scopus citation database at 10/08/2010. (The table is too big to present entirely here; for details please refer to the Appendix).

Subject	Total Pub.	2001		2002		2003	
		No.	Mean	No.	Mean	No.	Mean
Agricultural and Biological Sciences	32	11	14.2	5	13	16	7.94
Arts and Humanities	0	0	0	0	0	0	0
Biochemistry, Genetics and Molecular Biology	219	36	14.6	50	19.28	133	9.92
Business, Management and Accounting	6	0	0	2	15.5	4	0.25
Chemical Engineering	460	126	5.32	162	7.72	172	6.73

Table 2. Publication details of 8 candidates for the award funding for research performance. The data were collected from Scopus citation database at 20/09/2010.

No.	College	Total pub.	Total citation count	Average citation count
1	College of Science	197	994	5.05
2	College of Science	134	401	2.99
3	College of Science	157	2619	16.68
4	College of Precision Instrument and Opto-electronics Engineering	176	1098	6.24
5	College of Precision Instrument and Opto-electronics Engineering	152	813	5.35
6	College of Material Science and Engineering	105	493	4.7
7	College of Chemical Engineering and Technology	67	735	10.97
8	College of Environment Science and Technology	125	2677	21.42

funding committee.

In Scopus citation database, collected journals are categorized into 25 disciplines; however, due to the relativity among certain fields, publications of some journals are subjected to 2 or even more disciplines. In such case, the average of T-indicators of different disciplines could be used instead, due to the normalized native of T-indicator. For example, Candidate 1 has published 197 articles, which are categorized to "Physics & Astronomy" (140) as well as "Material Science" (102). Apparently some of the publications are classified to both disciplines by Scopus.

As shown in **Table 3**, in Discipline 1—the category of "Physics & Astronomy", averages of citation count of different year were calculated firstly (Row 3), which were then divided by the corresponding average number of citation count of all TJU publications for each year in **Table 1**, and the quotients obtained (Row 4) were T_{year}-indicator. T_{total} (1.53) and SD (0.91) were then subsequently calculated. The same method was also been used to calculate the T_{total} (0.83) and SD (0.97) of publications in Discipline 2 of "Material Science". Finally $T_{average\text{-}year}$ and T_{total} (1.18) were achieved by simply computing the mean value of them in different subjects. SDs indicated the consistency of research performance of Candidate 1 in the same discipline.

As shown in **Figure 1**, $T_{average\text{-}year}$ could also show an individual annual research performance. For Candidate 1, his $T_{average\text{-}year}$ hit the peak (2.83) in the year of 2002, and reached the bottom (0.22) in the year of 2008, presenting a decreasing research performance. However, the $T_{average\text{-}year}$ of Candidate 2 has gradually climbed up since the year of 2001, and a sudden jump to the maximum of 7.14 appeared in the Year of 2009, demonstrating an increasing research performance. A conclusion could be drawn that both Candidate 1 and 2 are very excellent in their own research field as their $Ts_{average\text{-}year}$ are almost over 1, and Candidate 2 showed higher potential in research.

When comparing the research performance among more scholars in different disciplines, T_{total} displays unique advantages. As shown in **Table 4**, T_{total} of each candidate was calculated, and from these data, Candidate 8 showed the best research performance with the highest T_{total} of 5.47, followed by Candidate 5 and Candidate 4, with 3.19 and 2.69, respectively, and the poorest performance in this group is Candidate 6, showing the lowest T_{total} of 1.06.

For further analysis when considering candidates' contributions to publications, weighted T-indicator is introduced based on weighted citation analysis. The use of weighted citation analysis has been thoroughly discussed elsewhere (Zhang 2009b, Zhang 2010), which is a

Table 3. TJ-indicator and SD of publication of Candidate 1. The data were collected from Scopus citation database at 20/09/2010.

Candidate 1									
Discipline 1: Physics & Astronomy									
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
No. of Publication	5	9	10	13	10	15	14	9	6
No. of cit. count	46	124	101	78	45	51	24	2	2
Aver. of cit. count	9.2	13.78	10.1	6	4.5	3.4	1.71	0.22	0.33
TJ_{year}-indicator	2.4	3.03	2.38	1.39	1.47	1.26	0.87	0.18	0.76
TJ-indicator = d1.53						Standard Deviation = 0.91			
Discipline 2: Material Science									
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
No. of Publication	2	6	7	9	5	9	8	4	7
No. of cit. count	0	111	24	72	47	51	11	2	2
Aver. of cit. count	0	18.5	3.43	8	9.4	5.67	1.38	0.5	0.29
TJ_{year}-indicator	0	2.64	0.4	1.57	2.4	1.31	0.4	0.26	0.46
TJ-indicator = 0.83						Standard Deviation = 0.97			
$TJ_{average}$	1.2	2.83	1.39	1.48	1.93	1.29	0.63	0.22	0.61
TJ_{total} = 1.18									

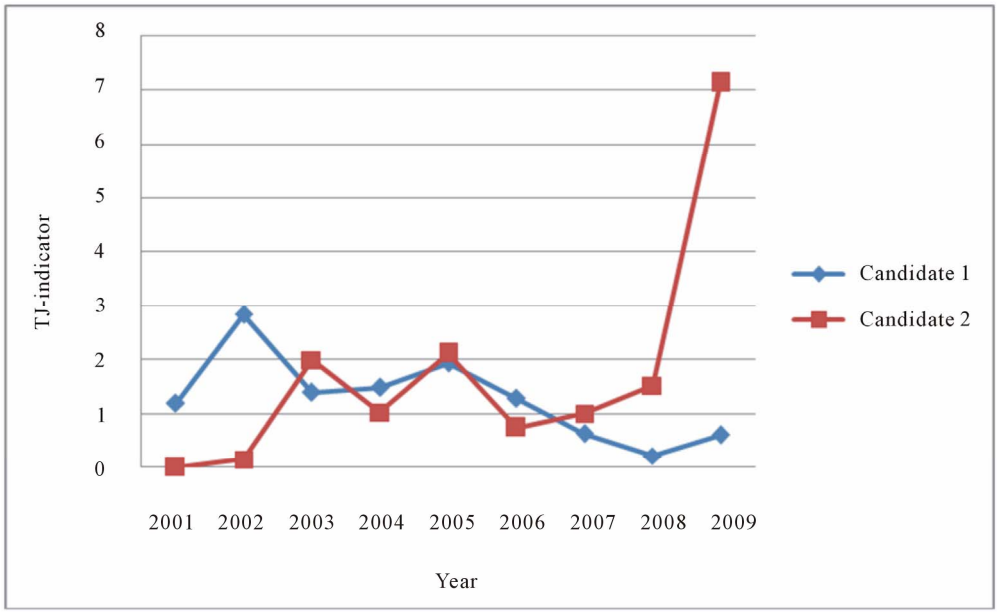

Figure 1. TJ-indicator vs. year of Candidate 1 and Candidate 2. (The data were collected from Scopus citation database at 20/09/2010).

Table 4. TJ-indicator and SD of publication of 8 candidates. The data were collected from Scopus citation database at 20/09/2010.

No.	Discipline 1			Discipline 2			Average
	Field	TJ_1	SD_1	Field	TJ_2	SD_2	TJ_{total}
1	Physics & Astronomy	1.53	0.9	Materials Science	0.83	1	1.18
2	Engineering	2.1	2.8	Physics & Astronomy	1.09	1.7	1.6
3	Biochemistry, Genetics and Molecular Biology	1.86	1.1	Engineering	1.13	1.7	1.5
4	Physics & Astronomy	5.23	4.5	Engineering	0.16	0.2	2.69
5	Engineering	3.1	1.5	Physics & Astronomy	3.28	1.4	3.19
6	Materials Science	1.68	0.4	Physics & Astronomy	0.44	0.7	1.06
7	Materials Science	2.57	1.5	Chemistry	0.53	0.7	1.55
8	Chemistry	7.79	9.6	Materials Science	3.15	5.4	5.47

quantitative scheme to describe the contribution of co-authors via weight coefficient. Basically weight coefficients for the first and corresponding authors are 1 for both, and the correspondence of the second, third, and the other authors are decreased sequentially. Weighted T-indicators of each candidate were obtained in **Table 5**. The weighted T-indicators were very similar to the normal T-indicators of both Candidates 3 (1.50 and 1.44, respectively) and Candidate 4 (2.69 and 2.11, respectively), showing their high research contributions to all publications; however, the big difference of these two indicators of Candidate 2 (1.60 and 0.77, respectively) and Candidate 7 (1.55 and 0.91, respectively) demonstrated their un-ideal contribution to all publications. Consequently, the order of research performance of these candidates based on weighted T-indicator could be listed as Candidate 8, Candidate 4, Candidate 5, Candidate 3, Candidate 1, Candidate 7, Candidate 2 and Candidate 6, without the consideration of differences among disciplines.

As described above, the research performance of these 8 candidates was quantitatively analyzed via this assessment method, which could give helpful reference to the award funding committee but still need the comprehensive qualitative evaluation via peer reviews, to get a final reasonable evaluation result of research performance of

Table 5. Weighted TJ-indicator of publication of 8 candidates. The data were collected from Scopus citation database at 20/09/2010.

No.	Discipline 1		Discipline 2		Average
	Field	Weighted-TJ_1	Field	Weighted-TJ_2	W-TJ_{total}
1	Physics & Astronomy	1.07	Materials Science	0.84	0.95
2	Engineering	1.07	Physics & Astronomy	0.48	0.77
3	Biochemistry, Genetics and Molecular Biology	1.78	Engineering	1.1	1.44
4	Physics & Astronomy	4.17	Engineering	0.06	2.11
5	Engineering	2.93	Physics & Astronomy	1.12	2.02
6	Materials Science	0.71	Physics & Astronomy	0.67	0.69
7	Materials Science	1.32	Chemistry	0.51	0.91
8	Chemistry	6.19	Materials Science	2.29	4.24

these candidates.

4. Conclusion

This new article assessment method, via the application of T-indicators, was established successfully for correcting differences among disciplines. An example was given to describe this whole assessment procedure which could not only give the research performance curve with year of candidate each, but also could provide the order of their research performance. Last but not least, because of the increasing citation times with time, the Table of the Mean of Citation Count of all TJU Publications is required to be updated at least twice annually.

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Appendix

Subject	Total Publication	2001		2002		2003		2004		2005		2006		2007		2008		2009		2010	
		No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
Agricultural and Biological Sciences	388	11	14.18	5	13	16	7.94	27	7.7	55	3.55	50	262	69	3.29	72	2.75	52	0.69	31	0.1
Arts and Humanities	8	0	0	0	0	0	0	1	14	1	0	0	0	3	1.3	0	0	2	0	1	0
Biochemistry, Genetics and Molecular Biology	1594	36	14.56	50	19.28	133	9.92	124	7.97	232	4.46	308	3.13	248	3.35	159	2.43	206	1.24	98	0.19
Business, Management and Accounting	274	0	0	2	15.5	4	0.25	2	0.5	17	0.47	22	0.5	54	0.59	30	0.1	113	0.04	30	0
Chemical Engineering	3147	126	5.32	162	7.72	172	6.73	285	6.17	500	3.32	476	3.39	459	2.6	432	1.85	347	0.67	188	0.1
Chemistry	2577	91	5.71	95	6.27	159	6.23	212	6.2	287	5.45	306	5.63	310	3.43	394	2.44	476	0.91	247	0.07
Computer Science	2552	42	4.67	37	6.78	126	3.71	121	3.15	155	2.51	215	1.29	364	0.98	574	0.47	807	0.13	111	0.04
Decision Sciences	199	4	14	0	0	1	4	2	34	6	7.83	15	3.73	14	1.93	49	0.29	104	0.08	4	0.25
Earth and Planetary Sciences	772	28	1.79	34	0.79	45	1.49	50	2.72	110	1.66	127	1.28	126	1.05	105	0.5	121	0.13	26	0
Economics, Econometrics and Finance	15	0	0	1	1	0	0	0	0	0	0	2	2.5	2	4	1	0	5	0	4	0
Energy	1316	39	3.51	58	2.34	74	183	123	3.33	147	2.37	153	2.36	150	2.37	174	2.07	288	0.54	110	0.09
Engineering	11176	318	2.65	429	3.39	580	2.96	1203	2.09	1492	1.88	1698	1.33	1534	1.11	1676	0.69	1608	0.31	638	0.03
Environmental Science	589	12	3.25	21	9	22	5.55	31	6.13	56	6.41	82	3.82	95	3.99	78	2.28	134	0.66	58	0.03
Health Professions	34	0	0	1	67	1	27	3	11.67	0	0	2	14.5	3	5	3	5	21	0.05	0	0
Immunology And Microbiology	154	14	20.93	13	10.08	12	15.5	15	8.07	13	10.08	18	6.72	19	7	11	4.18	19	2.89	20	0.2
Materials Science	3985	102	7.73	156	7.02	172	8.5	292	5.08	471	3.92	537	4.32	536	3.44	589	1.93	811	0.62	319	0.06
Mathematics	1057	20	3.6	19	4.74	20	1.55	43	3.3	59	3.8	94	1.86	176	1.07	174	0.95	356	0.19	96	0.03
Medicine	478	3	5.67	7	11.86	11	5.73	26	3	23	1.96	47	3.81	84	2.04	83	1	141	0.38	53	0.04
Neuroscience	21	1	13	1	2	0	0	1	23	0	0	4	8.75	2	3	2	1.5	4	1.25	6	0.33
Nursing	5	0	0	0	0	0	0	0	0	0	0	1	5	0	0	1	3	1	3	2	0.5
Pharmacology, Toxicology, Pharmaceutics	271	3	3.67	7	32.14	10	7.4	15	103	31	148	26	2.5	42	1.45	52	1.58	58	0.48	27	0.07
Physics and Astronomy	3958	117	3.84	166	4.55	228	4.24	317	4.31	575	3.07	593	2.69	548	1.97	610	1.26	773	0.44	31	0.38
Psychology	4	1	44	1	38	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0
Social Sciences	214	0	0	0	0	1	2	3	21.67	6	0.67	11	1.82	51	1	63	0.56	71	0.35	8	0
Veterinary	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

