Measuring the Competitive Pressure of Academic Journals and the Competitive Intensity within Subjects

Ma Zheng[1], Pan Yuntao[2], Wu Yishan[2], Yu Zhenglu[2] and Su Cheng[2]

[1] *mazheng@istic.ac.cn*
Institute of Scientific and Technical Information of China (ISTIC), 15 Fuxing Rd. 100038 Beijing (China); and Nanjing University, School of information Management, 22 Hankou Rd. 210093 Nanjing (China)

[2] *panyt@istic.ac.cn, wuyishan@istic.ac.cn, luluyu@istic.ac.cn, sucheng@istic.ac.cn*
Institute of Scientific and Technical Information of China (ISTIC), 15 Fuxing Rd. 100038 Beijing (China)

Abstract
A journal's impact and similarity with rivals is closely related to its competitive intensity. A subject area can be considered as an ecological system of journals, and can then be measured using the competitive intensity concept from plant systems. Based on Journal Citation Reports data from 1997, 2000, 2005, 2010, and 2013, we calculated the mutual citation, cosine similarity, and competitive relationship matrices for mycology journals. We derived the mutual citation network for mycology according to Journal Citation Reports data from 2013. We calculated each journal's competitive pressure, and the competitive intensity for the subject. We found that competitive pressures are very variable among journals. Differences between a journal's absolute and relative influence are related to the competitive pressure. A more powerful journal has lower competitive pressure. New journals have more competitive pressure. If there are no other influences, the competition intensity of a subject will continue to increase. Furthermore, we found that if a subject has more journals, its competitive intensity decreases.

Conference Topic
Journals, databases, electronic publications

Introduction
Scientific and technical (S&T) journals have an important role in science and knowledge dissemination. Journals that are focussed on the same subject are at competition with each other. We must build a favourable competitive environment to realize the optimal allocation of limited resources. At the same time, the "survival of the fittest" mechanism boosts the development of S&T journals.
To build a sustainable environment and competition mechanism, we must analyse and measure the present environment of S&T journals, especially in terms of competition. Many researchers have investigated the competitive environment of S&T journals.

Reaching a consensus on the relationship between the journal environment and competition

Scholars began to study the competitive relationship of journals in the 1920s. Competition is mainly related to the resources of subeditors, editors, and authors. Studies found that competitive power is related to a journals' impact factor (IF) (Campanario 1996). Zhu (1999) discussed the relationship between an S&T journal's quality and competitive spirit. A few years later, scholars proposed that competition is a basic attribute of science and noted the differences between different journals' abilities to secure resources. Powerful journals typically attract more attention, which results in a Matthew effect on the journal's development. Scholars have attempted to measure competition between journals using quantitative indexes (Manfred & Scharnhorst, 2001). Researchers have generally accepted that S&T journals develop within a competitive environment. They have explored definitions of the competition between S&T journals (Cai, 2003), how to increase a journal's core competitive strength (Chen 2005), and how to take advantage of market competition (Gao, 2004). Recently, Leydesdorff, Wagner and Bornmann (2014) focused on competition between highly cited journals dependent on the proportions of most-frequently cited publications in the European Union, China, and the United States, which are represented differently because they use different databases.

Determining the competitive relationship between journals using quantitative methods

Leydesdorff noted that Pearson correlations could be used as similarity measures for citation patterns based on bi-connected graphs (Leydesdorff, 2004). He then used principal component analysis and factor analysis to design indicators for the position of the cited journals in the dimensions of the database (Leydesdorff, 2006). Yang analysed the relationship between a journal's value chain and competitive edge using value chain theory (Yang, 2006). As a whole, these ideas and methods for quantitatively measuring a journal's competitive relationship have not been generally accepted, and are not fully developed.

Applying research ideas from ecological competition

Recently, ideas related to competition and competitive intensity in ecology have been applied to research related to S&T journals. Scholars such as Tao, Daoping and Gaoming (2007) have attempted to consider the survival and development of S&T journals from an ecological perspective. Xinyan (2008) researched the concentration ratio of an S&T journal's market share and its competition. She also analysed the index model of competitive intensity in ecology, and applied it to measure a journal's competitive intensity (CI). This was a meaningful exploration, but did not result in a proper index for measuring a journal's distance in terms of the ecological system of S&T journals (Xinyan, 2008).

The competitive environment of S&T journals has been extensively analysed. Progress has been made in terms of the quantitative analysis. Although the CI concept from ecology is useful, we do not know how to define and measure the "distance" between journals. The institute of Scientific and Technical Information of China has measured journal similarity using the mutual citation matrix and cosine similarity method since 2011 (ISTIC, 2011). This provides a measurement of the distance between journals.

In this study, we considered a journal's absolute impact value and similarity as parameters based on the *Journal Citation Reports*. We measured the competitive pressures of mycology journals and the CI for the entire subject using scientometrics and the CI.

Methodology

In this study, we used the concept of CI from the field of ecological research to define the "competitive pressure" among S&T journals. The following design scheme illustrates how we calculate the relevant values.

Main factors that influence the competitive relationship between S&T journals

In a relatively closed ecological environment, the CI mainly depends on the differences between plant diameters and the distance between plants. In this closed environment, the competitive relationships between plants can indicate the strength of the overall competition within the ecological environment.

If we consider journals that focus on one subject, we are investigating a relatively closed ecological environment. Then, all the individual journals can be viewed as separate plants. As shown in Figure 1, the respective "diameters" (D_i and D_j) of journals i and j, and the "distance" (L_{ij}) between them are the major factors of the competitive relationship.

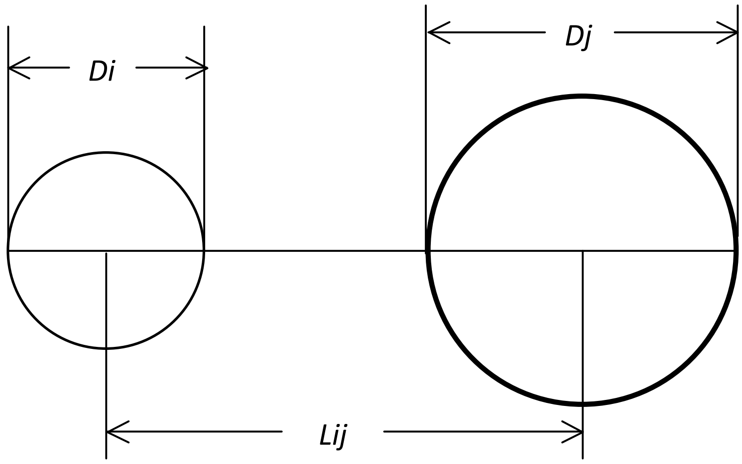

Figure 1. Main factors influencing the competitive relationship between S&T journals.

The number of total citations can be used as an alternative indicator to reflect the influence of the journal

The absolute influence of the journal can be seen as the plant thickness (diameter). Typically, a thicker plant is more capable of competing for resources and fighting rivals. Similarly, more influential journals are generally stronger in terms of their access to excellent manuscripts, funding, and attention. Journals with weaker influences are under more pressure from competitors.

The absolute influence of journals can be quantified using three main indicators: total citations (TC), IF, and the number of published papers.

Among these indicators, the IF is more likely to fluctuate. The number of papers is more vulnerable to subjective factors and can sometimes change dramatically. For example, a change to the journal's publishing cycle from bimonthly to monthly will lead to a sudden increase in the number of papers, and an accordingly sharp drop in the IF (because of a doubled denominator). Compared with the IF and paper number, the total citation indicator is relatively more stable and objective. It visually reflects the influence of journals, is less effected by other factors, and has a distinct advantage in terms of long term monitoring.

Additionally, the IF depends on the average number of citations of paper in a journal, so the total citation is equal to the IF multiplied by the number of papers. From this point of view, the total citation is monotonic in the mathematical sense.

Considering the above discussion, the total citation can be used as an alternative indicator of the influence of a journal. Therefore, in this study, we use the total citation as the diameter (D_i) of journal *i*. That is,

$$D_i = TC_i, \tag{1}$$

where TC_i is the total citation of journal *i.*

The similarity of two journals can be compared using the "distance" between them

It is widely accepted within the ecological community that competition is most intense when the same species live in the same environment (Clements, 1905). The similarity between two journals is also an important factor in their competitive relationship. In other words, a greater similarity between two journals leads to more intense competition. The similarity between two journals can be compared using the "distance" between them (L_{ij}).

Zheng, Na & Guozhen (2012) calculated a citation matrix for a sample of Chinese journals, which is classified into 61 subjects. They calculated the similarities for each journal in a specific subject area, and then constructed the similarity matrix for the journals. We used the same definition, and calculated the distance between periodicals using

$$\mathrm{Lij} = \frac{1}{Sij} - 1, \quad (2)$$

where S_{ij} is the cosine similarity indicator between *i* and *j*. S_{ij} is in the range of [0,1], and l_{ij} is in the range of [0,∞]. A S_{ij} value that is closer to 1 means that journals *i* and *j* are more similar. Accordingly, the distance L_{ij} is closer to zero. Conversely, if S_{ij} is closer to zero, *i* and *j* are less similar and the distance L_{ij} is closer to infinity.

Calculating the competition pressure between S&T journals

We used Hegyi's quantitative measurement for plant competition in ecology (Hegyi, 1974). Suppose that there are *n* journals for a subject, the target journal is called *i* and is set as the "basic journal", and the other is called *j* and considered a "rival journal". Then, *CRij* is the competitive pressure on journal *i* from rival *j*. It is calculated using

$$\mathrm{CRij} = \frac{Dj}{Di \cdot Lij}. \quad (3)$$

We can assume that the competitive pressure on *i* from *j* is inversely proportional to the absolute influence of *i*, is directly proportional to the absolute influence of the rival, and is inversely proportional to the distance between the journals. This assumption is consistent with an intuitive understanding of the competitive relationship.

Combining Equations (1), (2), and (3), we get

$$\mathrm{CRij} = \frac{TCj}{TCi \cdot \left(\frac{1}{Sij} - 1\right)}, \quad (4)$$

where TC_i and TC_j represent the TC for *i* and *j*, and S_{ij} is the cosine similarity between periodicals.

CR_{ij} and CR_{ji} represent the competitive relationship between *i* and *j*. The cosine similarity S_{ij} measures the angular distance between a journal and its rival, so S_{ij} and S_{ji} are equal. However, CR_{ij} and CR_{ji} are not equal if TC_i is not equal to TC_j. Equation (4) implies that C_{ij} and C_{ji} have a mutually reciprocal relationship.

We can conclude from the definition that the basic journal is under less competitive pressure if it has a higher total citation value than its competitor, and vice versa. The more similar the journals are, the greater the competitive pressure. A journal does not compete with itself, so CR_{ii} is zero.

Calculating the competitive pressure on basic journal i

Suppose that, within its discipline, basic journal *i* has *n-1* rival journals. Then, CI_i is the total competitive pressure on journal *i* from all of its rivals,

$$\mathrm{CIi} = \Sigma_{n}^{j=1} CRij. \quad (5)$$

Overall competitive strength for a specific subject

The number of competing journals depends on the subject classification. To compare disciplines, we define the overall competitive strength as CIS. It is the average competitive pressure for all journals, i.e.,

$$\mathrm{CIS} = \frac{1}{n}\Sigma_{n}^{i=1} CIi. \quad (6)$$

Analysis and Results

We calculated the mutual citation, similarity, competitive relationship, and competitive pressure matrices for the journals, and the CI for mycology using Journal Citation Reports (*JCR*) data from 1997, 2000, 2005, 2010, and 2003.

The inter-citation matrices for the target subject, and the similarity and competitive relationships

We used journals focussed on mycology to demonstrate how to calculate and analyse inter-citations within the target subject, and the similarities and competitive relationships between journals.

There are 23 journals indexed in the *JCR 2013* for mycology (*n=23*). The inter-citation matrix (*C*) was constructed by calculating the inter-citations of each pair of journals. We used the cosine similarity method to transform the inter-citation matrix to the similarity matrix, *R*. The cosine similarity is calculated using

$$\text{Cosine}(x,y) = \frac{\sum_{i=1}^{n} x_i y_i}{\sqrt{\sum_{i=1}^{n} x_i^2}\sqrt{\sum_{i=1}^{n} y_i^2}}. \quad (7)$$

We transformed *R* into a net document and used Pajek to produce Figure 2, which shows the mutual citation network for mycology according to *JCR 2013*. Each node represents a journal, and a node's area represents the journal's TC. The location of the journal and the thickness of the link represent its similarity with its rivals.

From another perspective, we considered the whole subject area as an ecological space. Then, the 23 journals are independent plants. Figure 2 can be regarded as an ecological system with 23 plants, as viewed from above. The differences between the plant diameters and distances between plants determine the CI and the state of the journals.

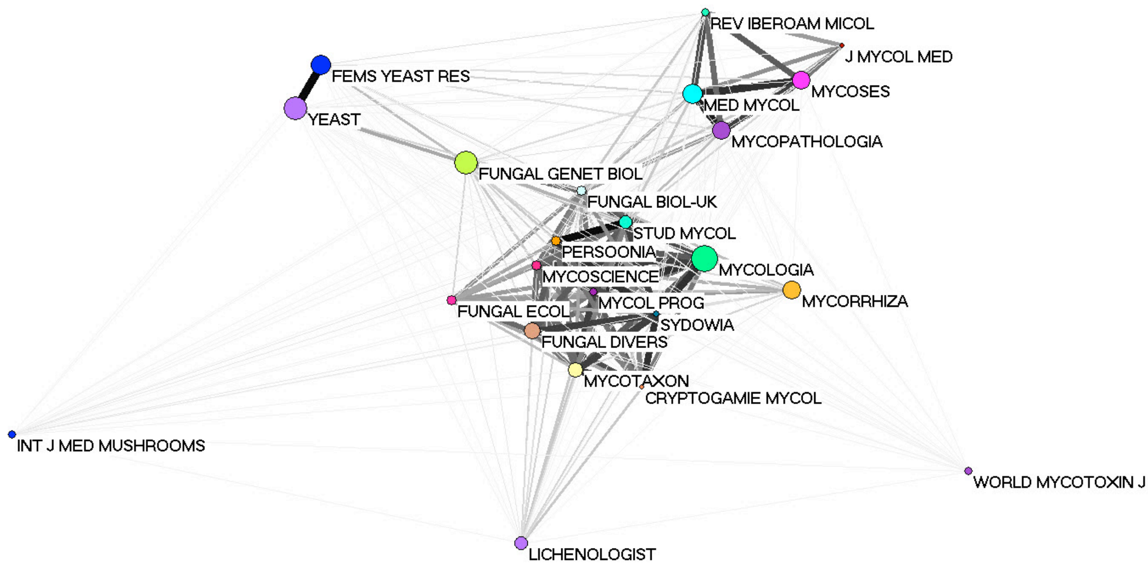

Figure 2. Mutual citation network of journal focussed on mycology, according to *JCR 2013*.

We applied Equation (4) to construct the competitive pressure matrix (*CR*) for the 23 journals, by considering each journal's TC and the cosine similarities between each journal pair.

Competitive pressure for a journal (CI)

Equation (5) shows that the CI of a journal is a combination of the competitive pressure from all of each rivals. We measured the competitive pressure of the all journals using competitive relationship matrices for mycology at five time points.

Table 1 shows that there were large differences in the competitive pressures of the rival journals. The maximum was 408.198 and the minimum was 0.022. In *JCR 2013,* two journals had competitive pressures over 100, 15 were between 10 and 100, and six were under 10.

Table 1. Competitive intensity (CI) for mycology journals.

Title	*1997*	*2000*	*2005*	*2010*	*2013*
CRYPTOGAMIE MYCOL	79.15	278.326	37.227	90.551	140.329
EXP MYCOL	13.81				
FEMS YEAST RES				17.673	32.585
FUNGAL BIOL-UK				81.125	48.575
FUNGAL DIVERS			28.170	8.875	14.402
FUNGAL ECOL				16.954	23.032
FUNGAL GENET BIOL	4.394	14.820	2.985	1.929	3.222
INT J MED MUSHROOMS				0.341	2.175
J MED VET MYCOL	13.572				
J MYCOL MED	42.521	18.324	31.853	17.819	41.412
LICHENOLOGIST			3.753	3.057	3.249
MED MYCOL		28.391	5.748	7.315	18.067
MIKOL FITOPATOL	3.280	1.854	2.389		
MYCOL PROG				189.149	98.921
MYCOL RES	3.751	6.649	11.217	11.919	
MYCOLOGIA	4.663	7.341	12.558	5.09	6.046
MYCOPATHOLOGIA	11.130	4.616	5.069	6.109	17.724
MYCORRHIZA	4.993	8.529	4.174	2.036	2.292
MYCOSCIENCE				30.886	53.764
MYCOSES	10.392	3.991	3.422	12.211	18.333
MYCOTAXON	16.890	20.216	18.220	15.182	16.865
PERSOONIA	94.223	84.520	408.198		92.237
REV IBEROAM MICOL				31.666	35.185
STUD MYCOL	139.528	69.935	51.901	31.591	36.342
SYDOWIA			116.148	298.986	230.812
WORLD MYCOTOXIN J					0.095
YEAST	0.031	0.022	0.318	5.028	15.638

Table 2 shows the competitive intensities compared with the IF and TC, for mycology journals in 2013. The rankings based on the IF and TC is different from the CI rankings. Some journals are ranked in the top 10 in terms of TC and IF but have low CIs, and some are ranked in the bottom five in terms of TC and IF but have higher CI*s*. Therefore, a more powerful journal has lower competitive pressure. We have only listed the results based on the 2013 data, but they were similar for 1997, 2000, 2005, and 2010. The difference between a journals' absolute and relative influence is related to its competitive pressure.

There are certainly some exceptions. Journals that are extremely similar have a significant influence on the competitive pressure. For example, some journals have TCs that are greater than one thousand and are very similar to other journals with the same mass influence, so they also have high competitive pressures. However, some journals are focused on narrow fields and have distinctive characteristics, and therefore do not have much competition because there are not many similar journals, although their TC may be high.

Table 2. Competitive intensity (CI) compared with impact factor (IF) and total citations (TC), for mycology journals in 2013.

Title	*CI 2013*	*rank*	*IF 2013*	*rank*	*TC 2013*	*rank*
CRYPTOGAMIE MYCOL	140.329	2	1.153	18	254	22
FEMS YEAST RES	32.585	10	2.436	7	2935	5
FUNGAL BIOL-UK	48.575	6	2.139	10	790	14
FUNGAL DIVERS	14.402	17	6.938	2	2120	9
FUNGAL ECOL	23.032	11	2.992	5	701	15
FUNGAL GENET BIOL	3.222	20	3.262	4	4298	2
INT J MED MUSHROOMS	2.175	22	1.123	19	554	19
J MYCOL MED	41.412	7	0.4	22	247	23
LICHENOLOGIST	3.249	19	1.613	14	1285	12
MED MYCOL	18.067	13	2.261	9	3132	4
MYCOL PROG	98.921	3	1.543	16	623	18
MYCOLOGIA	6.046	18	2.128	11	5754	1
MYCOPATHOLOGIA	17.724	14	1.545	15	2913	6
MYCORRHIZA	2.292	21	2.985	6	2650	7
MYCOSCIENCE	53.764	5	1.288	17	926	13
MYCOSES	18.333	12	1.805	12	2451	8
MYCOTAXON	16.865	15	0.643	21	1959	10
PERSOONIA	92.237	4	4.225	3	669	16
REV IBEROAM MICOL	35.185	9	0.971	20	649	17
STUD MYCOL	36.342	8	9.296	1	1461	11
SYDOWIA	230.812	1	0.213	23	355	21
WORLD MYCOTOXIN J	0.095	23	2.38	8	454	20
YEAST	15.638	16	1.742	13	4268	3

Figure 3 shows the difference between the CI rankings for a set of journals between 1997 and 2000, and a second set of journals between 2005 and 2013. For the first set, the CI rankings for most of the 14 journals decreased from 1997 to 2013, and only four were in the top ten. This typically means that the competitive pressures of traditional journals (with a longer publishing history) were declining. At the same time, most of the second set started in a high competitive pressure situation, and approximately half of them remained in the top ten of the CI ranking. This means these new journals had to face more challenges.

Competitive intensity for a subject

Equation (6) shows that the CI for a subject is the average competitive pressure of all the journals. We calculated the CIs for mycology in 1997, 2000, 2005, 2010, and 2013.

Table 3 shows that the competitive intensity for a subject (CIS) increased from 1997 to 2005, but the number of journals only increased from 15 to 17. We can see that the CIS decreased between 2005 and 2010 because the number of journals increased from 17 to 23 (by approximately 35%). By analysing the relationship between the subject's scale and CIS, we can see that more journals correspond to low CIs. From 2010 to 2013, the number of journals was stable at 23 so the CIS increased. In the absence of any other influences, the CIS will continue to increase.

By analysing the competitive pressure on each journal and the CIS, we can determine the state of the competitive environment using a quantitative method, and compare the competitive relationships of different journals and subjects. Through a comparative analysis, we can research reasons for any differences and provide S&T publications with scientific data and tools. Additionally, the data can be used to monitor the S&T journals environment at a macro level, and help decision makers with regard to administration.

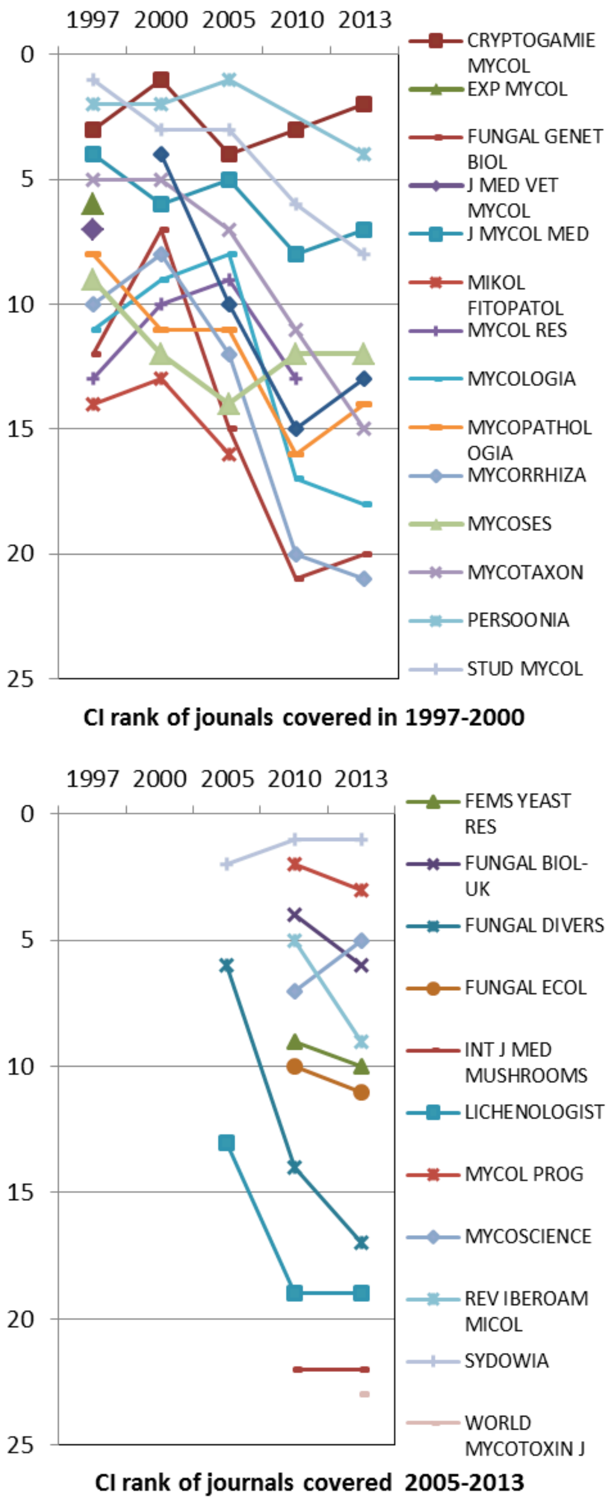

Figure 3. Relationship between competitive intensity (CI) and time.

Table 3. Competition intensity (CI) and number of journals for mycology

	1997	*2000*	*2005*	*2010*	*2013*
number of journal	15	14	17	23	23
CIS	29.489	39.110	43.726	38.500	41.361

Conclusions

There is vast difference in the CIs between subjects and competition pressures between journals.

We have measured journals' competition pressures and the CIS using quantitative methods. The differences between journals' competitive environments may be caused by many related factors. Different journal attributes are related to competitive pressure. For example, the competitive environment and resources vary among multidisciplinary, ordinary professional, and specialized professional journals. Fundamental research or academic journals and engineering or application journals have different competitive features. Chinese journals are obviously different to English language journals. So the factors that influence competitive pressure and intensity, measurements of these related factors, and mechanisms that influence journals' competitive environments must be studied further.

The competitive pressure from a powerful rival may be equal to the pressure from several weakly similar journals.

The ecological concept of CI is a combination of all kinds of competitive pressure. So the competitive pressure on a journal is a combination of the competitive pressure from all of its rivals. The competitive pressure from a powerful rival may be equal to the pressure from several weakly similar journals. The combination of competitive pressure for each journal may be different, which can lead to a high competitive pressure and number of rivals. It can be used as reference when analysing a target journal's competition.

A journal's homogeneity is important when developing S&T journals. Using our quantitative method, we found that homogeneity is obvious in some fields, especially journals that lack "personality". Such journals have higher competitive pressures. The homogeneity of a journal increases its competitive pressure, and the homogeneity of a subject hinders a favourable competitive environment. There is typically fierce competition between two journals that are very similar. Abnormal cooperative relationships exist between some journals, who adopt inter-citation journal group models. These very similar journals pursue high IFs and cited rates. The academic misconduct phenomenon is one problem that results from a journal's homogeneity.

More study is required for multidisciplinary or interdisciplinary journals.

In our method, each journal only belongs to one subject. However, developments in science and technology have led to fusions and evolutions in subject areas. Most articles belong to more than one subject area. At the same time, some journals are multidisciplinary, so it can be difficult to define their subject. We measured a journal's competitive pressure in terms of only one subject. Future research is required to determine how to measure and compare competitive pressure and similarities for multidisciplinary or interdisciplinary subjects.

A favourable competitive environment is only possible at the proper scale

The scale of the subject (number of journals) is related to its competitive pressure and intensity. A favourable competitive environment is only possible at the proper scale. If there are too many or too few journals the CI decreases. In S&T journal administration, the distribution and trends of the CIs can be used as a reference to promote the development of favourable and sustainable environments.

The research findings in this study can be used as a reference for a new journal when choosing a subject and field.

In management science, there are "red ocean" and "blue ocean" strategies when facing competitive environments. The red ocean strategy directly reacts to competition, whereas the blue ocean strategy avoids direct competition and exploits new markets (Chan & Mauborgne, 2005). When facing competition from rivals, S&T journals must choose an optimal path based on the current environment and future positioning. Journals with relative advantages tend to use red ocean strategies, proactively consolidating and extending their advantages. Relatively weak journals use blue ocean strategies, seeking paths that reduce homogeneity problems and competitive pressures. The findings of this study can be used as a reference for a new journal when choosing a subject and field. In a fiercely competitive fields, it is difficult to successfully launch a new journal without obvious diversity.

Acknowledgments

This research was supported by National Key Technology Support Program of China. (Project Number: 2015BAH25F01)

References

Bonitz, M. & Scharnhorst, A. (2001). Competition in Science and the Matthew Core Journals. *Scientometrics*, 51, 37-54.

Cai, Y. (2003). On Market Competitiveness of Sci-tech Journals. *Chinese Journal of Scientific and Technical Periodicals*. 14, 345-348

Campanario, J.M. (1996). The Competition for Journal Space among Referees, Editors, and Other Authors and Its Influence on Journals' Impact Factors. *Journal of the American Society for Information Science*, 47,184-192

Clements, F.E. (1905). *Research Methods in Ecology*. Lincoln Nebraska: University Publishing Company.

Chen, X. (2005). On sets of core competitiveness of scientific and technical journal. *Media*. 2005, 9, 55

Gao, J. (2004). Market competitive game of sci-tech periodicals. *Acta Editologica*, 16, 319-320.

Hegyi, F. (1974). A simulation model for managing jack-pine stands. In *Growth models for tree and stand simulation*. J. Fries (Ed.). Stockholm: Royal College of Forestry.

Institute of Scientific and Technical Informaiton of China. (2011). *Chinese S&T Journal Citation Reports 2011*. Beijing: Scientific and Technical Documention Press.

Kim, W.C. & Mauborgne, R. (2005). *Blue Ocean Strategy*. Beijing: The Commercial Press.

Leydesdorff, L., Wagner, C.S., & Bornmann, L. (2014). The European Union, China, and the United States in the top-1% and top-10% layers of most-frequently cited publications: Competition and collaborations. *Journal of Informetrics*, 8, 606-617

Leydesdorff, L. (2006). Can Scientific Journals be Classified in terms of Aggregated Journal-Journal Citation Relations using the Journal Citation Reports? *Journal of the American Society for Information Science and Technology*, 57, 601-613.

Leydesdorff, L. (2004). Clusters and Maps of Science Journals Based on Bi-connected Graphs in the Journal Citation Reports. *Journal of Documentation*, 60, 317-427.

Tao, Y., Daoping, W. & Gaoming. Z. (2007). Think deeply in ecology of sci-tech periodicals' survival and development. *Acta Editologica.*, 19, 3-5.

Xinyan, L. (2008). Study on Competition Intensity in Scientific and Technical Journals Publishing Industry. (Unpublished Master's Dissertation) Institute of Scientific and Technical Information of China.

Zheng, M., Na, W. & Guozhen, Z. (2012). The Analysis of Mutual Citation Network on Patterns of Chinese S&T Core Journal Groups. *Studies in Science of Science*. 2012, 30, 983-991.

Zhu, J., & Mei, H. (1999). Relation between competitiveness and quality for S&T journal. *Science Technology and Publication*, 5, 27-29