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Positive correlation between quality and quantity in academic journals

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ABSTRACT

This study reports a positive correlation between impact factor and article number in scholarly journals. High impact journals publish more articles. Quality and quantity are positively correlated. This is a common trend in different disciplines as revealed by empirical data. The correlation is obscure in a direct plot of article number versus impact factor. A plot of accumulated article number versus normalized rank of impact factor clearly demonstrates the correlation. The reasons behind this correlation are discussed.

1. Introduction

The trade-off between quality and quantity in scholarly work has long been discussed. Cole and Cole (1967) studied the scientific output of university physicists and found that quality and quantity tend to be positively correlated. They argued that, in the case of an inconsistency, quality is more important than quantity. Smith and Fiedler (1970) studied the scholarly performance of university departments and showed that the relationship between quality and quantity is less clear. Their study indicated that citation count is the least biased measure of scholar work. Later on, Katz (1999) studied the publishing and citing activities as a self-similar social process. A positive correlation between quality and quantity was demonstrated in various science communities. Recently, many studies focused on evaluating the academic performance of individuals or groups. The results were mixed with regards to the correlation between quality and quantity. A positive correlation had been reported in the study of 500 largest universities worldwide (van Raan, 2013), top 100 European universities (van Raan, 2008a) and Italian universities (Abramo, Cicero, & D'Angelo, 2014; Abramo, D'Angelo, & Di Costa, 2010b). On the contrary, a negative correlation had been reported in the study of Australian academics (Harzing, 2005), UK scientists (Moed, 2008), Iranian institutes (Hayati & Ebrahimy, 2009), and US physicians (Tchetchik, Grinstein, Manes, Shapira, & Durst, 2015). The discrepancy indicates that the correlation can be influenced significantly by research policy and funding guidelines. A biased evaluation might reward quantity rather than quality (Butler, 2002; King, 2004).

Evaluating the quality of a research work has not been a simple task. With an emphasis on peer review, the number of citations is basically a good indicator to measure the impact of a published article. In practice, impact factor of the journal publishing the article is frequently used as a simple indicator to the long-term citation count. The advantage of impact factor is the simplicity. However, some caution has been raised against the use of impact factor to measure the quality (Editorial, 2005; Seglen, 1997). Citations reflect not only the quality of the research work, but also the practice of the field and the popularity of the topic. Citation analysis cannot be justified to compare different disciplines. Besides, there are large fluctuations

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between the citations to a particular article and the average citations per article in that journal. An article published in a low impact-factor journal might receive more citations than an article published in a high impact-factor journal. In contrast, more recent studies showed that the impact factor of the journal can still be a preferable proxy of an article's quality. The long-term citations of a published article can be predicted more accurately by impact factor of the journal than by early citations of the article (Abramo, D'Angelo, & Di Costa, 2010a; Levitt & Thelwall, 2008). More complicated relations among impact factor, early citation, and long-term citation had been investigated (Stegehuis, Litvak, & Waltman, 2015; Stern, 2014). Alternative indicators of quality had also been proposed (Frey & Rost, 2010; Sidiropoulos, Katsaros, & Manolopoulos, 2015; van Raan, 2008b). Compared to the ambiguity in measuring the quality, counting the number of articles published by a scholar seems to be a simple task. Nowadays, various kinds of collaborations among researchers are essential and encouraged. The issue of co-authorship becomes more and more complicated. A clear-cut definition of quantity is difficult due to the overlap in different scholars' publications. Measuring the quantity can be as ambiguous as measuring the quality.

It is interesting to note that the ambiguity disappears when the issue is addressed from the perspective of publishers. An article can be co-authored by a number of scholars; each published article belongs only to one journal. The impact factor was originally created to help classify the journals, not the articles. Compared to the citation count of an article, the impact factor of a journal is relatively stable over the years. To our knowledge, there is no systematic study on the correlation between impact factor and article number of the scholarly publishers. It is a reasonable opinion that quality and quantity are negatively correlated. The simple assumption is that rare things are precious. On the other hand, it is also plausible to argue that quality and quantity are not correlated. Since the total citations have already been normalized by the number of articles, the impact factor should be independent of the article number. In this work, empirical data are collected to reveal a positive correlation between quality and quantity in the professional journals, i.e., high impact journals publish more papers. A new plot is proposed to give a clear demonstration of this positive correlation. Data analysis and results are presented in Section 2, followed by the discussions in Section 3.

2. Analysis and results

Data are collected from the 2011 Journal Citation Reports (JCR) published by Thomson Reuters. The database includes more than ten thousand scholarly journals, which are divided into more than two hundred subject categories. To avoid comparing journals from different research fields, data are compiled from the same subject category. To have sufficient statistics, the subject categories consisting of less than one hundred journals are excluded from consideration. To include a variety of quality, both the high impact-factor subject categories and the low impact-factor subject categories are covered. This work selects 24 subject categories from science (SCI) and social science (SSCI). The SCI subject categories include: *Cell Biology* (3.263), *Immunology* (2.992), *Biochemistry & Molecular Biology* (2.857), *Neurosciences* (2.748), *Oncology* (2.534), *Genetics & Heredity* (2.524), *Statistics & Probability* (0.863), *Veterinary Sciences* (0.812), *Engineering, Mechanical* (0.743), *Mathematics, Applied* (0.724), *Engineering, Civil* (0.681), and *Mathematics* (0.561). The SSCI subject categories include: *Psychology, Clinical* (1.386), *Psychiatry* (1.354), *Public, Environmental & Occupational Health* (1.278), *Management* (1.183), *Business* (1.135), *Psychology, Multidisciplinary* (0.955), *Sociology* (0.784), *Economics* (0.778), *Law* (0.759), *Education & Educational Research* (0.708), *Political Science* (0.613), and *Linguistics* (0.487). The number in parentheses is the median impact factor in each subject category. All citable articles are included. The mean and standard deviation for both impact factor (F) and article number (N) are listed in Table 1. The data show that the mean and the standard deviation are in the same order of magnitude, i.e., $\langle F \rangle \sim \Delta F$ and $\langle N \rangle \sim \Delta N$, which imply large fluctuations in both the impact factor and the article number within a subject category.

A typical result is shown in Fig. 1 for the SCI subject category *Cell Biology*, which consists of 181 journals. The vertical axis is the article number published in each journal; the horizontal axis is the rank of impact factor for each journal. The plot is shown in a semi-logarithmic scale. The average number of articles is 129, which is shown as the dotted line. The data points fluctuate wildly. Yet it can still be discerned that more data points lie above the average for the lower ranks and below the average for the higher ranks. To show the trend more clearly, these journals are divided into quarters. The bold-grey line shows the average number of articles in each quarter. It is evident that the publication quantity decreases as the impact-factor rank increases. Furthermore, the solid line shows the result when these journals are divided into deciles. The trend is not monotonic. But it shows clearly that high impact-factor journals publish more articles. Fig. 2 shows a similar result for the SSCI subject category *Psychology, Clinical*, which consists of 110 journals. The same trend is confirmed.

Figs. 1 and 2 plot the article number N_i versus the impact-factor rank i, where the index i runs through all the M journals within the subject category, i.e., $i = 1, 2, 3, \ldots, M$. This work proposes a new plot to clearly demonstrate the correlation between the article number and the rank of impact factor. The same data in Figs. 1 and 2 are re-plotted in Figs. 3 and 4, respectively. The vertical axis y is the accumulated article number; the horizontal axis x is the normalized rank of impact factor, as following

$$y_i = \frac{\sum_{j=1}^{i} N_j}{\sum_{j=1}^{M} N_j} \quad \text{and} \quad x_i = \frac{i}{M}, \tag{1}$$

where $x_i, y_i \in (0, 1]$. This cumulative curve is also known as the Lorentz curve in the study of inequality of the frequency distribution. By definition, the curve $y(x)$ is monotonically increasing and has two fixed end-points at $(x, y) = (0, 0)$ and $(1, 1)$. If the article number is independent of the impact factor, the result will be a straight line $y = x$ as shown by the dotted line. If