

# Are Elite Journals Declining?

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Previous research indicates that during the past 20 years, the highest-quality work has been published in an increasingly diverse and larger group of journals. In this article, we examine whether this diversification has also affected the handful of elite journals that are traditionally considered to be the best. We examine citation patterns during the past 40 years of seven long-standing traditionally elite journals and six journals that have been increasing in importance during the past 20 years. To be among the top 5% or 1% cited papers, papers now need about twice as many citations as they did 40 years ago. Since the late 1980s and early 1990s, elite journals have been publishing a decreasing proportion of these top-cited papers. This also applies to the two journals that are typically considered as the top venues and often used as bibliometric indicators of “excellence”: *Science* and *Nature*. On the other hand, several new and established journals are publishing an increasing proportion of the most-cited papers. These changes bring new challenges and opportunities for all parties. Journals can enact policies to increase or maintain their relative position in the journal hierarchy. Researchers now have the option to publish in more diverse venues knowing that their work can still reach the same audiences. Finally, evaluators and administrators need to know that although there will always be a certain prestige associated with publishing in “elite” journals, journal hierarchies are in constant flux.

## Introduction

Since at least the middle of the 19th century, scientific ideas and discoveries have been disseminated and discussed primarily via papers in journals (Harmon & Gross, 2007; Meadows, 1974). Until recently, these papers consisted, literally, of paper, bound within issues and volumes, physically delivered on a regular basis to subscribing individuals and institutions. Since the 1990s, through the effects of the Internet, this age-old system has begun to be supplanted by the electronic dissemination of digital “papers.” In this new digital age, access to scientific papers has been radically transformed by web repositories of preprints (such as ArXiv), institutional and personal repositories of accepted and published papers, electronic access of print journals, online-only journals, and open access journals.

Russell and Rousseau (2002) noted that the Internet shifts the emphasis away from the journal toward the individual article and suggested that this trend could decrease the importance of the impact factor (IF). More specifically, given that in the digital age scientists have access to each paper individually without having to view an entire issue or volume of a journal, we predicted that the relationship between the IF and papers’ citations would be weakening (Lozano, Larivière, & Gingras, 2012). We tested that hypothesis using a data set of more than 29 million papers and 800 million citations, and we showed that from 1902 to 1990 the strength of the relationship between IFs and paper citations had increased, but as predicted, the variance of papers’ citation rates around their

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respective journals' IF has been steadily increasing since 1991. Furthermore, until 1990, the proportion of top (i.e., most cited) papers published in the top (i.e., highest IF) journals had been increasing. However, since 1991 the pattern has reversed and we observe a decline in the proportion of top-cited papers in journals with the highest IF. Hence, the most important literature is now being published in increasingly diverse sources (Lozano et al., 2012).

However, the effect we documented at the macro level might not apply to the handful of "elite" journals that promote themselves as, and are perceived to be, the most important. Despite the changes in the publishing industry during the past two decades, this small group of elite journals could have kept publishing a stable or even increasingly larger proportion of the most-cited papers. Here we compare citation rates in the 20 years before and after 1990, arbitrarily taken to be the time about which papers began to be disseminated digitally. Using the proportion of most-cited papers by individual journals (Bornmann, Leydesdorff, & Mutz, 2013; Waltman et al., 2012; Waltman & Schreiber, 2012), we examine whether the patterns we found on a macro scale also occur in a selected number of elite journals, which are then compared with several journals that are becoming increasingly important.

## Materials and Methods

We used Thomson Reuters' Web of Science (including all standard citation indexes: Science Citation Index, Social Sciences Citation Index [SSCI], and Arts and Humanities Citation Index [AHCI]) from 1970 to 2010 (1970–2012 for citations received), with a total of more than 27.8 million papers and 784 million citations.<sup>1</sup> This database is based on Thomson Reuters' source data transformed into a Structured Query Language (SQL) relational database designed for bibliometric analyses. To have consistent measures over time, we used a fixed citation window of 2 years following publication, to which we added citations received during publication year. We also compiled the data using a 5-year citation window following publication year, and the results were nearly identical. However, a 5-year citation window would eliminate the last 6 years of data, so only the 2-year citation data and analysis are presented. We used two citation thresholds: the top 5% most-cited papers and the top 1% most cited. In both cases, citations received included self-citations. Given that the proportion of self-citations decreases with higher numbers of citations, self-citations are not a factor when one looks at the top-cited papers (Glänzel, Debackere, Thijs, & Schubert, 2006). The documents included were articles, notes, and reviews, and editorials were excluded, as is typically the case in bibliometric analyses (Moed, 2005). The citations they received could come from any type of document.

<sup>1</sup>Although references made by SSCI and AHCI journals are included, no journal from these two databases met the criteria to be considered an elite journal.

The calculation proceeded in the following three steps: (a) We calculated the number of citations each paper received, (b) we ranked the papers and selected the 1% and 5% top-cited papers for each year, and (c) we calculated the proportion of these papers published in each of the selected journals. If that proportion declines for a given journal it means that its share of top-cited papers is decreasing and vice versa. It is important to distinguish this indicator, which tells us which journals obtain the larger part of top-cited papers every year, from another indicator based on the proportion of citations that accrue over the years to papers published in those journals in a given year. Although the latter indicator has been used to measure a form of concentration of citation over time (Barabási, Song, & Wang, 2012), it is not a valid measure because it is affected by the half-life of citations received by papers. It is obvious that highly cited papers published in high-impact journals will see their share of citations within the specific journals in which they were published accrue in the years following their publication. What we need to measure is whether the proportion of papers coming from elite journals and cited in the top 1% or 5% most-cited papers is changing over the years.

We conducted this analysis for two groups of journals, which shall be referred to as "elite" journals and "emerging" journals. "Elite" journals were chosen from the most prestigious journals, which also had the highest IFs in 2011 (among the top 1%). Additionally, these journals publish a high number of papers annually, have been in existence for several decades, and are not review journals. This group includes three general journals (*Nature*, *Science*, and *Proceedings of the National Academy of Science [PNAS]*) and four medical/biomedical journals (*Cell*, *Lancet*, *New England Journal of Medicine [NEJM]*, and the *Journal of the American Medical Association [JAMA]*). *PNAS* has a slightly lower IF than the other journals but was nonetheless included because of its reputation and the fact that in the 1980s it published the highest proportion of highly cited papers. On the other hand, "emerging" journals were chosen from those that had the highest growth in their proportion of top-cited papers during the past 40 years. This group included one general journal (*PLoS One*), three journals from material sciences/nanotechnology (*Nano Letters*, *Advanced Materials*, and *Nature Materials*), one from medicine (*Journal of Clinical Oncology*), and one from chemistry (*Chemical Reviews*). Of these, *PLoS One*, *Nature Materials*, and *Nano Letters* are relatively recent, created in this century, and the other three are older. *Chemical Reviews* was established in 1925, and the *Journal of Clinical Oncology* and *Advanced Materials* began publishing in the 1980s.

Figure 1 presents the change of the percentage of all papers included in the top 1% and top 5% most cited (Figure 1A) and the change of the citation threshold (Figure 1B). The citation threshold for including papers in either the 1% or 5% category is an integer, but several papers can have this number of citations, so the percentage of papers included is always slightly above 1% or 5%.

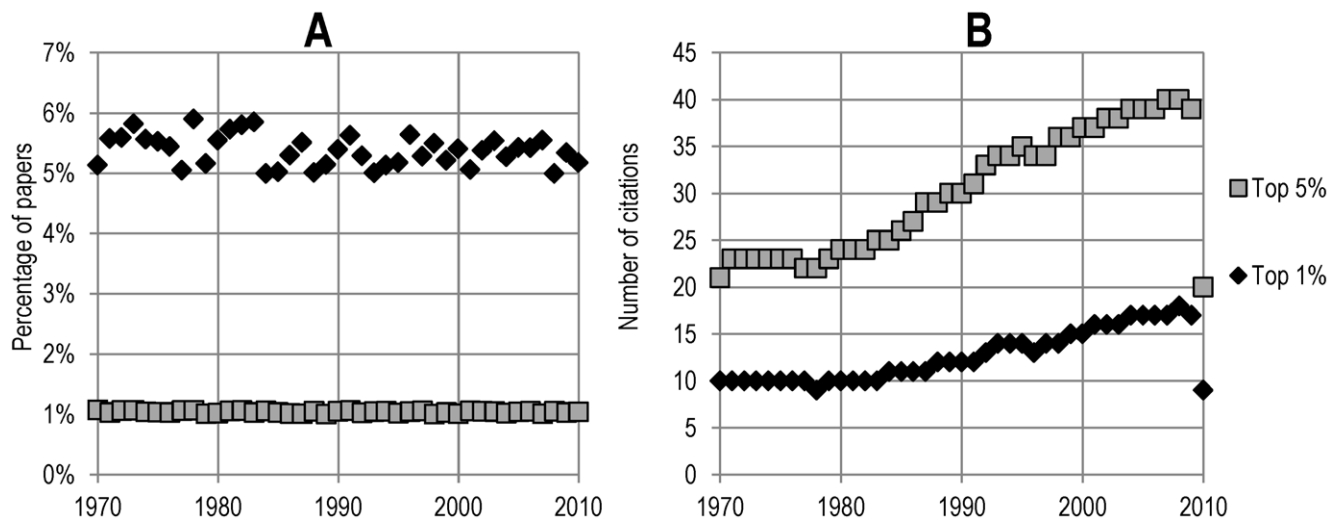


FIG. 1. (A) Proportion of papers in the top 5% and 1% most-cited papers. (B) Citation threshold for inclusion in the top 5% and 1% most-cited papers, 1970–2010.

Citations are more spread out at the top tail of the citation distribution, so for the top 1% of papers the number of papers included is actually closer to the actual 1% of papers. The number of citations needed to be included among the top-cited papers has increased steadily (Figure 1B). To be included among the top 5% or 1% most-cited papers, in 2010 papers needed about twice as many citations as 30 or 40 years earlier.

## Results

All seven elite journals are now publishing a smaller proportion of top-cited papers than they did 20 to 25 years ago (Figure 2). In all cases, these elite journals have been publishing a larger proportion of the top 1% most-cited papers than of the top 5% most-cited papers. The proportion of highly cited papers in the three general journals (*Science*, *Nature*, and *PNAS*) and *Cell* had been increasing until around 1990 and decreased thereafter. In the mid-1980s, *PNAS* was publishing almost 9% of the top 1% most-cited papers, and more than 4% of the top 5% most-cited papers. By 2010, these percentages had dropped considerably to about 2.7% and 2.2%, respectively. Similarly, at their peak in the late 1980s and early 1990s, *Nature* and *Science* published, respectively, about 7% and 6% of the top 1% most-cited papers. These percentages are now about 4% and 3%, respectively. A similar trend occurs for the top 5% most-cited papers, except that the increase in the first 20 years was evident only for *PNAS* and *Cell*. Among the biomedical journals, *The Lancet* and *NEJM* follow a slightly different pattern when one considers the top 1% most-cited papers. *NEJM*'s share has steadily decreased since the 1980s, and that of the *Lancet* has been relatively stable. However, both journals decreased their proportion of the top 5% most-cited papers throughout the period, from about 1% in the 1970s to

about 0.5% in 2010. Finally, *JAMA* increased its share of the top 5% most cited until the second half of the 1990s and of the top 1% cited papers until the early 2000s, and slowly lost ground afterward.

Emerging journals were selected because they have been increasing their share of highly cited papers (Figure 3). Of the three newer journals, *PLoS One*, an open access interdisciplinary journal founded in 2006, currently accounts for 0.6% of the top 1% most-cited papers and 0.8% of the top 5% most-cited papers. Similarly, *Nature Materials* and *Nano Letters* currently each have more than 0.5% and 1% of the top 1% most-cited papers, respectively. The three older journals, *Chemical Reviews*, *Advanced Materials*, and the *Journal of Clinical Oncology*, have managed to increase their proportion of top-cited papers since the early 1980s.

The total number of papers published has been increasing during the past several decades, and in most cases the number of papers published yearly by individual journals has also been increasing. To assess whether these patterns were simply due to increases in the number of papers published by each journal relative to the total number of papers published, we computed a yearly normalized top 1% index for each journal. The normalized top index is a measure of the number of top papers (1%, 5%, etc., here we use the 1% threshold) published in a journal in a given year relative to what would be expected if the top papers were randomly distributed throughout all journals. More specifically, for a given year it is the relative number of top papers in a given journal (top papers / total papers) divided by the proportion of top papers published in all journals. A coefficient of 1 would indicate that the number of top papers published by a journal is what would be expected by chance. A coefficient of 10 indicates that a journal published 10 times as many top papers as would be expected by mere chance. For example, if 1 million papers are published in a given year, 10,000

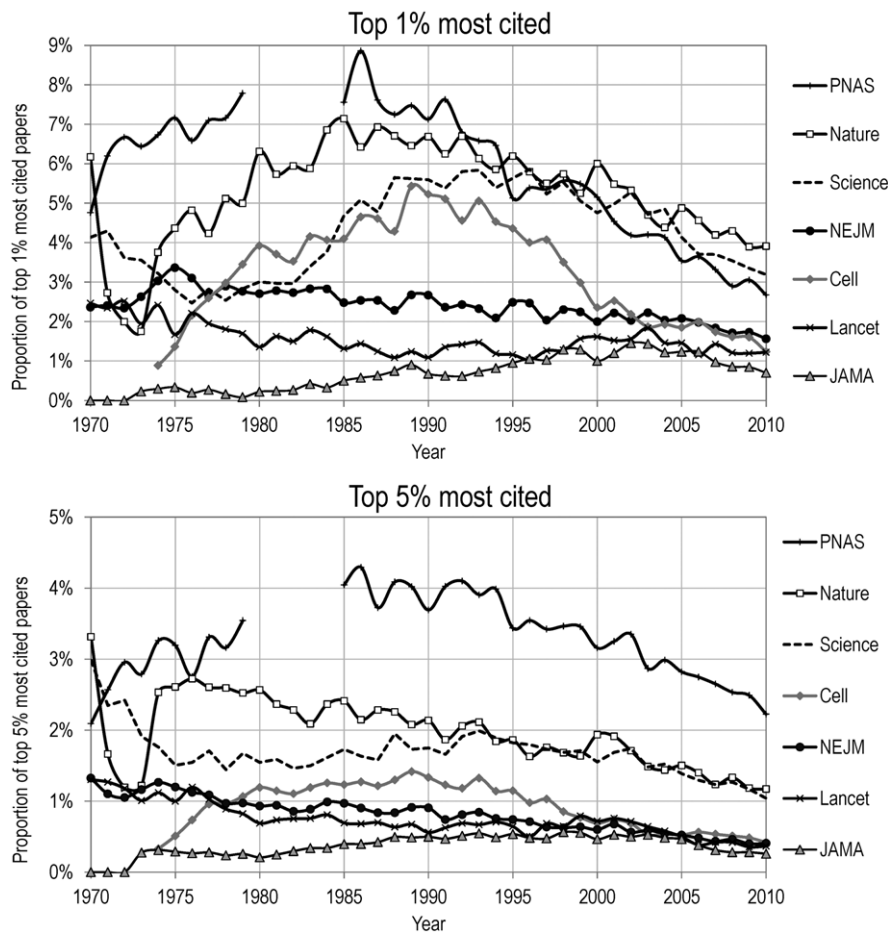


FIG. 2. Proportion of top 1% and 5% most-cited papers in elite journals, 1970–2010. *PNAS* data were not available from 1980 to 1984.

would be in the top 1%, and if a given journal publishes 500 papers that year, and 25 are among these 10,000, then its normalized top 1% index would be 5.

Elite journals publish far more top papers than would be expected by chance, but different patterns occur (Figure 4A). In the first 20 years, *Cell* went from about 30 to 70, and today it is down to about 50. From 1970 to 1990, *JAMA* and *Lancet* were in the single digits and low teens, respectively, and then increased sharply to the 40 to 50 range. *PNAS* held steady at the low 20s until about 1990 and since then has been slowly decreasing to about 10. Finally, in the past 20 years, *Nature*, *Science*, and *NEJM* have been slowly increasing, but still more or less within the same range, from about 40 to about 50. Interestingly, *Nature* and *Science* had their sharpest increases in the 1970s and 1980s from 10 to about 40. These patterns do not necessarily differ along subject lines.

Emerging journals are also publishing a higher proportion of top 1% most-cited papers than expected by chance given the number of papers they publish (Figure 4B). *Chemical Reviews* and *Nature Materials* are now in the 40 to 50 range. Oddly, from 1970 to 1990 *Chemical Reviews* was highly variable. *Journal of Clinical Oncology*, *Advanced*

*Materials*, and *Nano Letters* are now in the high teens. For *PLoS One*, this ratio has remained in the low single digits, and was only at 1.09 in 2010, which shows that its increase in the proportion of top-cited papers (Figure 3B) is mostly due to the high number of papers it publishes.

## Discussion and Conclusion

Previously, in a large-scale analysis, we documented that the proportion of the most-cited papers published in the highest IF journals had been steadily decreasing since the advent of the digital age (Lozano et al., 2012). Here we tested whether this pattern was also true for the handful of elite journals that are generally considered the most important. Our preliminary analysis indicated that the definition of “highly cited” has changed. More papers are published now and these papers have longer references lists, so papers receive more citations and fewer papers go completely uncited (Wallace, Larivière, & Gingras, 2009). Consequently, to be among the top *n*th percentile, papers now need about twice as many citations as they did 30 to 40 years ago. The effect of this inflation is such that citations have devalued by about half in a time span that is within the range of

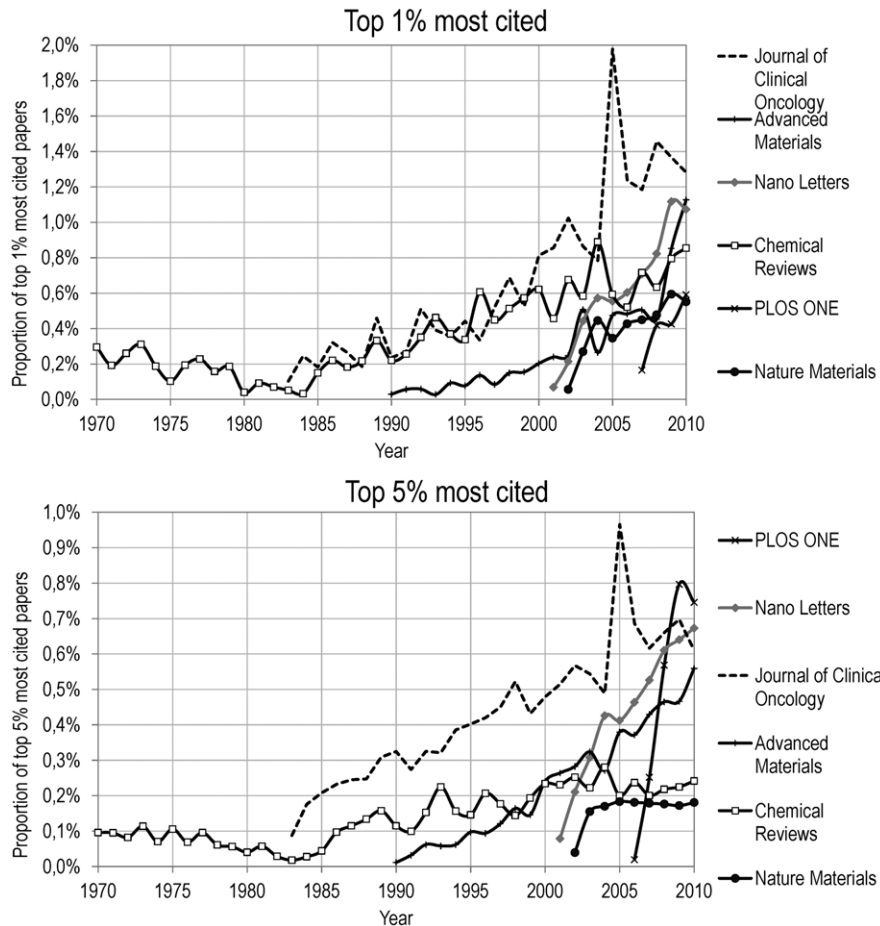


FIG. 3. Proportion of top 1% and 5% most-cited papers for emerging journals, 1970–2010.

a scientific career, which might affect the interpretation of career-long citation-based impact measures for individual researchers.

Since the late 1980s and early 1990s, several new and some long-established journals have been becoming more important, whereas traditional elite journals, including *Science* and *Nature*, are publishing a decreasing proportion of the top-cited papers. However, even though their share of the most-cited articles is declining, elite journals still “punch above their weight” and publish a larger proportion of top-cited papers than we might expect from their total number of papers. This relative decline of elite journals among all journals is in fact consistent with the general trend toward the deconcentration of research activities. At the level of countries as well as within countries, the production of papers is more diversified geographically and thus less concentrated in a few top countries or cities (Grossetti et al., 2012). In terms of citations received, the distribution is less concentrated now than in the past, as more papers receive their share of citations (Larivière, Gingras, & Archambault, 2009).

The relative decline of elite journals was caused by the Internet via several interrelated effects. First, the digital age made papers more independent of their respective journals.

The digital age has transformed the manner in which scientists find papers. We used to search for papers on the bookshelves of the library, but now we do so via the Internet, often at our library’s website. Furthermore, papers are now directly accessible independently and one does not have to even look at the corresponding issue or volume of the journal. Hence, whether papers get cited or ignored is increasingly independent of the journal in which they appear.

Second, the digital age also facilitated the creation of new journals. Several high-quality journals were triggered by the creation of new fields (e.g., *Nano Letters*, *Advanced Materials*), but often new journals appeared simply because digital journals are easier and cheaper to produce and distribute than print-based journals. As new journals were created, journals that were already in the system were likely to lose market share, and those journals more likely to be negatively affected were those having the highest proportion of top papers. A similar phenomenon occurred for the share of papers at the level of countries. When China increased its share of the world’s research papers during the 1990s and 2000s, the share of the most important countries declined, as was the case for the United States and Japan (Leydesdorff &

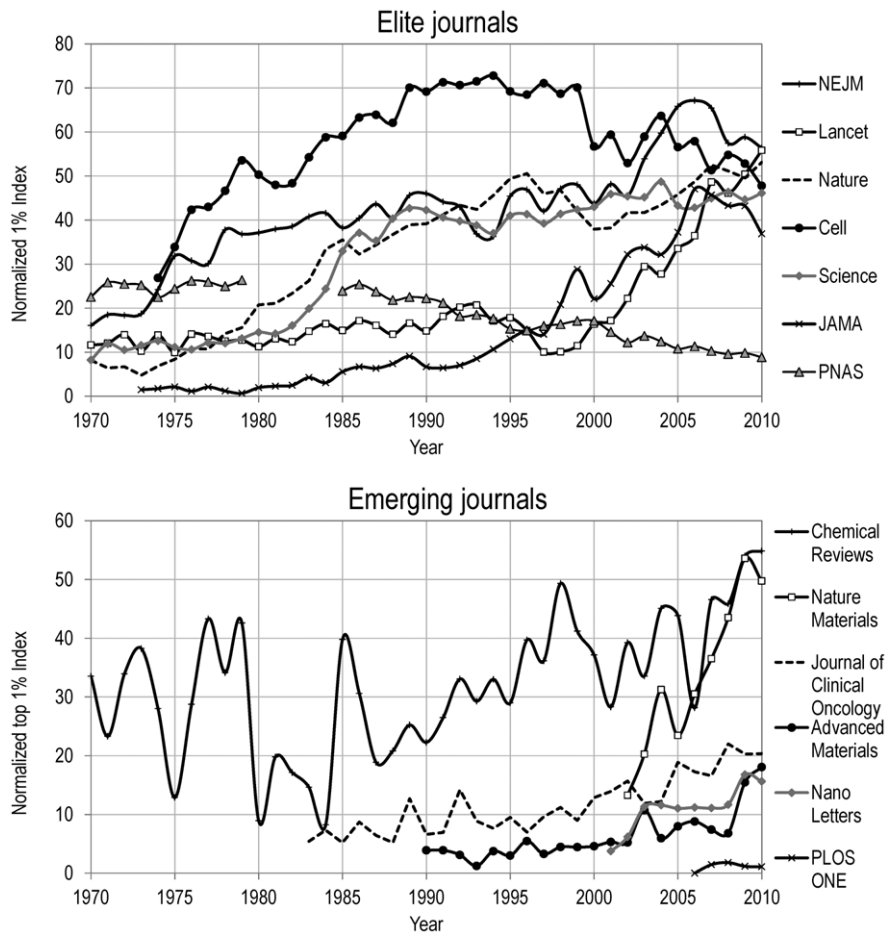


FIG. 4. Normalized 1% index for elite and emerging journals, 1970–2010.

Wagner, 2009; Zhou & Leydesdorff, 2006). Dozens of new publishers and hundreds of new journals have appeared in the past 20 years. Inevitably, elite journals had to lose some of the top papers to these new competitors.

Third, the creation of some of these new journals was motivated by ideals of “free access to all” that took advantage of the ease with which information can be disseminated in the digital age (e.g., *PLoS One*). Papers that are freely accessible have a greater probability of being cited (Gagouri et al., 2010). Researchers now access papers from a greater variety of journals, not just the so-called premier journals in a given field or elite journals in general. Technically, a paper could now be in any journal, and it would still be found by Internet searches, downloaded if available, and cited if deemed relevant.

Although elite journals were generally declining, the different patterns do not fall neatly along subject lines, general versus biomedical. Similarly, the patterns in emerging journals do not depend on the field of study, or the journal’s age or novelty. Among emerging journals, *PLoS One*, the only one examined here that is completely “open,” had a high proportion of highly cited papers but only because it publishes a high number of papers. Hence, on average, its papers

are not necessarily better, but they can be found and read by anyone, free of charge. This complexity during the past 20 years indicates that the digital age has affected each journal differently, depending on the effectiveness of their editorial, advertising, and marketing policies.

Elite journals have been aware of the threat of new journals and have tried to counter their effect. For example, Nature Publishing Group, a private company, started to create specialized journals in the 1990s (*Nature Genetics*, *Nature Neuroscience*, *Nature Medicine*, etc.) and review journals in the 2000s (*Nature Reviews Cancer*, *Nature Reviews Immunology*, etc.) instead of just expanding their flagship journal. They now publish 37 other journals with the name “Nature.” These new journals capitalized on the symbolic capital of the original journal, *Nature*, and rapidly attracted high-impact papers. One potential explanation for choosing this route, a phenomenon that economists call *versioning*, is that the publisher can charge new subscription and advertising fees for the new journals, whereas it might be difficult to make consumers and advertisers accept large price increases for the flagship journal even when accompanied by proportional increases in the size of the journal. These new journals spread and diluted the impact of the flagship journal across all of the

publisher's journals. Combining all of Nature Publishing Group journals, however, the proportion of the top 5% papers increased from 3% in 1970 to 5% in 2000, and has remained stable since then. On the other hand, the journal *Science* is published by the American Association for the Advancement of Science (AAAS), a nonprofit organization that publishes only three peer-reviewed journals.

With these new journals, elite and otherwise, researchers now have increasingly more venues where they can submit their papers and generate the visibility that before was only possible when publishing in the most widely distributed journals, the "elite" journals. Given the high rejection rates of elite journals, around 93% for *Science*, for example, researchers might prefer to save time and submit their papers to other journals that ultimately will reach the same audience faster and potentially obtain as many citations. In the digital age, it is relatively easy to determine the actual citation rate of individual papers or authors, so the value of a journal's reputation is now less important. Nevertheless, researchers might still prefer to publish in elite journals. Whether justifiable or not, journal reputation still has some value to the papers therein, through a Matthew effect (Larivière & Gingras, 2010), particularly when the research is viewed and evaluated by nonexperts.

Finally, advancement, recruitment, and grant-evaluation committees, administrators, and other evaluators should heed these results. The quality of papers and competence of researchers should be evaluated independently of the journal in which the work appeared for two reasons. First, traditional "elite" journals still have the highest citation impact, but other journals are also publishing an increasingly higher proportion of top-cited papers. Second, even if this journal hierarchy were valid, the hierarchy is not fixed. In fact, even if journal reputations are loosely based on a journal's tendency to publish high-quality work, reputations have an intrinsic inertia and there is always a time lag between a journal's actual value and its reputation. Although there will always be a hierarchy of journal prestige, the hierarchy is dynamic. Many other, more suitable criteria can be used to assess researchers, but if journal quality must be used, equity demands that evaluators become attentive to changes in the scientific publishing landscape.

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