Chapter 2
Measuring the Impact of Articles, Journals and Nations

Abstract The rise of metrics that measure scientific production and impact is increasingly important. The system of determining 'impact' of a journal was created 50 years ago and the now ubiquitous 'impact factor' dominates much scientific publishing. The impact factor is used for judging journal importance although criticisms of this metric abound. Indices that count the number of scientific articles produced around the world indicate that the U.S. is no longer in first position, outplaced by Europe, and China has growing visibility in science article production.

Keywords Impact factor • Bibliometrics • Ranking • Web of Science • Metrics • Global standing • Rating scientists • Status • Google scholar • ISI • Citations • International journals

"Impact" is defined by the *Oxford English Dictionary* as "a marked effect or influence", and most scientists would hope that their work will have a marked effect or influence on their field. In science, having "impact" has become quantifiable through the "impact factor". The system of determining the impact of a journal was created in 1961 by Eugene Garfield, founder of the Institute for Scientific Information (ISI). The ISI is now incorporated into Thomson-Reuters' Web of Knowledge which includes the hugely important Science Citation Index (SCI) and Social Science Citation Index (SSCI). The impact factor, which Thomson-Reuters calculates, has become ubiquitous.

The formula for calculating a journal's impact factor is simple: (See Box 2.1)

Box 2.1 Calculation of Impact Factor

Number of citations to articles in a journal in one year (e.g. 2012)	÷	Number of articles published in that journal in the previous 2 years (e.g. 2010 and 2011)	=	IMPACT FACTOR

The reasoning behind this formula is simple: a journal publishes articles that are cited by others; therefore, the journal has a measurable impact on the field (Garfield 2006). The higher the impact factor, the greater the impact. Impact factors are recalculated every year.

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Criticisms of the impact factor are numerous (See Box 2.1). Fundamentally, some argue that "citations are a shallow measure of research quality or impact" (Lillis and Curry 2010, p. 15).

Box 2.2 Criticisms of the Impact Factor

- A recent paper argues that the current metrics "undermine, rather than foster and reward, scholarship that matters" (Adler and Harzing 2009, p. 3).
- The two-year basis for counting citations may disadvantage journals or disciplines with longer publishing timelines, so that an accurate reflection of the number of citations an article would accrue is not seen within two years.
- Journals that publish many more articles, and disciplines that have many more journals, can obtain higher impact factors. Consequently, big journals in big disciplines are advantaged over smaller and highly specialized journals, and this may not be a true reflection of the importance of a journal.
- Young researchers who are trying to build a tenure and promotion file may avoid the more specialized journals with lower impact factors even though the work "would be better appreciated, published more quickly, and perhaps have more impact if they were published in specialized journals… This [practice] ultimately slows the diffusion of ideas into the research literature and stifles academic dialogue" (Segalla 2008, cited in Adler and Harzing 2009, p. 75).
- Journal policies sometimes encourage authors to cite other articles published by that same journal which can interfere with an objective indication of impact.
- Impact factors are used for purposes that were not intended. For example, impact factors are sometimes used for evaluating individuals (for the purpose of hiring, tenure and grant entitlement) and academic departments and institutions.

Nonetheless, the impact factor is now well entrenched in the world of scientific publishing. The impact factor is stated on the individual journal webpages of the world's four major journal publishers (Elsevier, Springer, Taylor and Francis and Wiley-Blackwell have well over 1000 journals each) (Ware and Mabe 2009). The impact factor is calculated for the 16,000+ journals included in the Web of Knowledge, comprised of the Science Citation Index Expanded, Social Sciences Citation Index Expanded, Conference Proceedings Citation Index, and Arts and

Table 2.1 Share of world articles and world citations by country/region

Country/region	Share of world articles (%)		Share of world citations (%)	
	1998	2008	1998	2008
World	100.0	100.0	100.0	100.0
United States	34.0	28.9	46.9	38.3
European Union-27	34.6	33.1	32.4	33.2
Japan	8.5	7.8	6.8	6.3
Asia-8	3.6	6.8	1.5	4.6
China	1.6	5.9	1.5	4.6

Humanities Citation Index (Thomson Reuters 2011). The field of bibliometrics, which has grown up around measuring impact, is central to the ranking of journals. For scientists to achieve maximum impact in the bibliometric system that is prevalent today, they are best to publish in the journals that are indexed in Thomson Reuters' Web of Knowledge.

A journal's impact factor is dependent upon being included in a prestigious citation index. The Web of Knowledge indexes 16,183 journals—a large number. Yet those journals constitute only 24 % of the "academic/scholarly" journals published in all languages that are included in Ulrich's Periodicals Directory (Lillis and Curry 2010, p. 17). Thus three-quarters of the scholarly journals published around the world are not counted in key international rankings of institutions and nations.

Certain types of journals are more likely to be included in the Web of Knowledge indexes. The index is "heavily biased" toward journals published in English from English-speaking countries (Lillis and Curry 2010, p. 18). Only 11.6 % of the journals that are included in the Web of Knowledge publish in a language that is not English (Brunner-Ried and Salazar-Muñiz 2012). The Web of Knowledge includes more minor U.S. journals than minor European journals, and relatively few non-English journals are included. In other words, a vast amount of scholarly publishing does not get included and therefore does not get counted.

Nonetheless the metrics determined by Web of Knowledge are used as the most authoritative and often the sole indicator of science knowledge production. Organizations that rank research publication output, such as the Organization for Economic Cooperation and Development (OECD) and the World Bank, rely almost exclusively on the journal, research article and citation data produced by the Thomson Reuters sources.

The statistics of production and attendant rankings reveal trends in world science, particularly when we take into account the limited number of journals counted in the Web of Knowledge. As shown in Table 2.1, the United States is now surpassed by the European Union in the share of world articles produced. However, papers published by American scientists continue to be cited in greater numbers than those by Europeans. Although China still ranks below Japan and the Asia-8, which includes India, it has produced a four-fold growth of papers to over 110,000 in the decade 1998–2008 (Pérez-Llantada 2010, p. 26).

Table 2.2 Publications and citations of 36 Latin American scholars reported in Web of Science and Google Scholar, selected from data in Brunner-Ried and Salazar-Muñiz 2012

Countries	Web of Science		Google Scholar	
	Number of journals	Number of citations	Number of journals	Number of citations
Argentina	9	29	715	6,202
Brazil	14	41	2,197	35,013
Spain	4	4	638	11,079
Mexico	11	43	1,264	12,796
United States	50	397	730	11,525

The research captured in the international indexes is also used to rank universities worldwide. Highly visible listings created by the *Times Higher Education* journal and the Shanghai Jiao Tong University determine university rankings by a mix of criteria, including the amount of research funds obtained, professor-student ratios, and number of degrees conferred. Significant weight in the determination is placed on "quality of staff" (i.e. number of highly cited researchers in a discipline) and research output as counted in publications and citations.

Citation counts are valuable in determining the importance of published work; these counts are used as a measure of the "quality" of the work. The importance of counting citations is based on the premise that the more frequently subsequent scholars refer to a paper, the higher the quality of that paper is. Much as the Web of Knowledge disproportionately favors journals published in English, also the citation counts that Web of Knowledge generates favor English-language citations.

The citation count differs when the Google Scholar citation search engine is used rather than Web of Knowledge. Google Scholar is used in many parts of the world as a search engine since access is free with internet connection. For example, the impact of 36 well-established Latin American scholars who have each been publishing for more than 30 years was compared in the two databases, Google Scholar and Web of Science (Table 2.2) (Brunner-Ried and Salazar-Muñiz 2012). A group of Argentinian academics, for example, received 29 citations in Web of Science and 6202 citations in Google Scholar. The immense difference can be due to the large number of Spanish-language journals included in Google Scholar and the fact that there are few in the Web of Knowledge. The large citation counts captured in Google Scholar seem to indicate that the impact of Latin American academics throughout the region is significantly more substantial than the Web of Science metrics indicate. In short, the picture of the impact of a scholar's work is altered when different citation searches are conducted.

The emphasis on publication metrics has created new demands and incentives for scientists in many parts of the world (Qiu 2010; Englander and Uzuner-Smith 2013). In China, scientists are awarded cash prizes, housing benefits or other perks for their publications in high profile journals. Failure to publish at least one paper per year can cause practicing doctors at a major surgical hospital in China to lose their medical privileges (Yongyan Li, personal communication, March, 2013). Systems of

merit pay in Mexico and Turkey are linked directly to publishing research papers (Galaz-Fontes and Gil-Antón 2013; Englander and Uzuner-Smith 2013).

The pressure to "rack up publications" seems to encourage dubious research practices such as plagiarism, fabrication and falsification of data (Qiu 2010, p. 142). There is a concomitant rise in the number of retractions of published work, although these retractions were papers that all passed the peer review process. There is now a growth industry of "predatory publishers" which charge large sums of money to publish an author's work, provide no peer review and little or no database indexing (Rollin Kent, personal communication, May 26, 2013). Scientists may seek out the journals published by such publishers, either unwittingly or deliberately to get their work published. One biochemist expressed concern that "counting the number of publications, rather than assessing the quality of research, becomes the norm of evaluation" (Qiu 2010, p. 143). Thus individuals, institutions and nations all emphasize producing a high number of publications.

In sum, metrics have become central in determining value within science today. The emphasis on metrics of the number of articles and the citations they accrue is highly visible in institutional, national and international rankings. The metrics that underlie the rankings are calculated using indexes such as those created by the Web of Knowledge. There, journals gain visibility, since they are the journals that are included in the databases and thus are the journals that are identified when a scientist conducts a search for papers. The journals that are included provide the papers that are more likely to be consulted. Subsequently, those papers are more likely to be cited, raising the likelihood of obtaining or maintaining a high impact factor for the journal. The metrics very heavily favor publications in English, and publishing in English is more likely to produce citations in subsequent English-language articles. The desire on the part of nations, institutions and scientists to rank highly in the measures of research output and impact can give scientists much reason to be cognizant of the impact factors of the journals in which they seek to publish (Englander and Uzuner-Smith 2013).

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