Open Access and Global Participation in Science

James A. Evans[1]* and Jacob Reimer[2]

The issue of open access (OA), free and unrestricted online access to scientific publications, has stirred debate among scientists, policymakers, and editors in recent years. Most previous research claimed that OA articles are cited about 100% more (*1*), although these studies have been limited to a single journal or lacked analysis of commercial electronic availability or changes over time (*2*–*4*). In contrast, recent experiments suggested that OA may have no effect on journal citations or even a negative impact (*5*–*7*). We used more extensive citation data than those of previous studies to show the influence of OA on research attention and highlight its greatest impact: developing world participation in global science.

Citation data were from Thomson Scientific's Science, Social Science, and Humanities Citation Indexes (CI), including articles and associated citations from the 8253 most highly cited journals going back to 1945. We linked this with online availability of journals by means of Information Today, Incorporated's Fulltext Sources Online. Merged, this data set comprises 26,002,796 articles whose journals came online by 2006, 88% of which are published in English. For CI articles, 77% showed author institutions, which we coded and linked to World Bank and United Nations Educational, Scientific, and Cultural Organization data on per capita gross national income (GNI) (*8*).

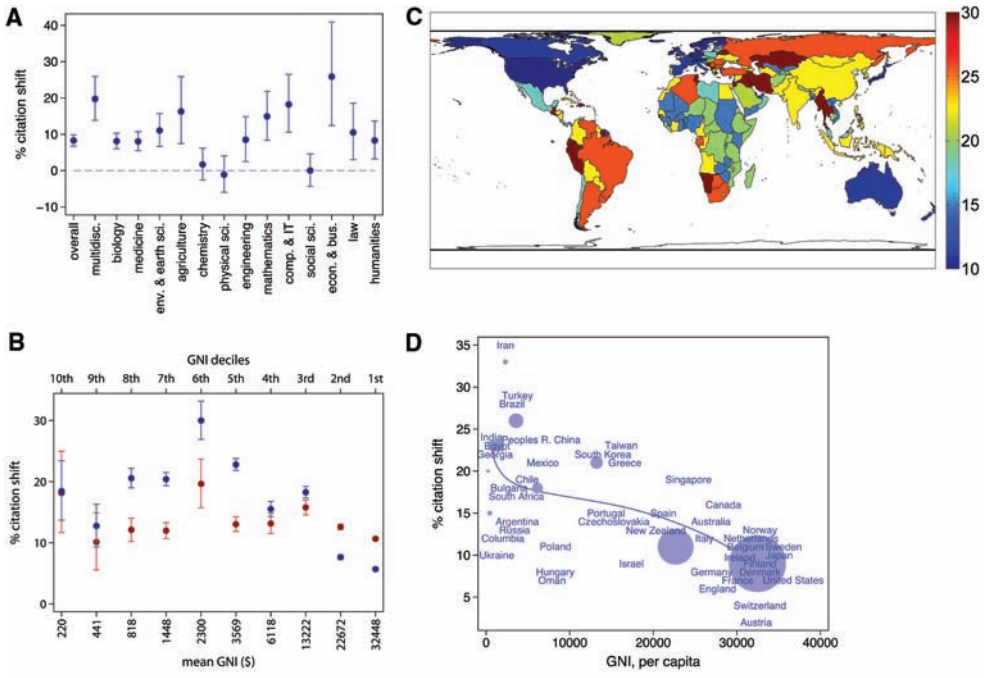

Fig. 1. (**A**) Percentage increase in citations for subfields after free online availability, 1998–2005. Online availability is measured in the previous year. Error bars indicate 95% confidence intervals. (**B**) Percentage increase in citations after free (blue) and commercial (red) online access for GNI country deciles of the richest country hosting a citing author. (**C**) Global projection of percentage increase in citations for GNI country deciles of the poorest country hosting a citing author after free online availability. (**D**) Percentage increase in citations after free online access for the poorest individual countries and GNI deciles (blue circles, sized proportional to the total number of citations they generate). The downward sloping line is a prediction of the OA citation shift for GNI deciles based on estimation of a fractional polynomial of GNI. All countries represented in deciles, but only 44 individually because some have very few citations in the CI.

Within the natural sciences, OA influence was strongest for multidisciplinary journals (Fig. 1A). In three areas, OA confers no additional attention, including physics, where preprint and publication databases already provide nearly complete access, and the social sciences, where personal preprint archiving and lengthy review times are common. Across subfields, the impact of commercial online availability was positive, statistically significant, and on average 40% larger than the OA effect, suggesting that most researchers rely on institutional subscriptions.

We tested the influence of OA on dissemination of science to poor countries by first calculating the per capita GNI for the poorest country hosting an author on every paper that cites an article in our data set (*9*). Although commercial availability had double the effect of OA for countries in the top two deciles, OA had greater influence in all lower deciles (Fig. 1B). Online OA had the greatest effect in the developing Southern Hemisphere rather than the wealthy Northern and Western (Fig. 1C). The influence of OA was more than twice as strong in the developing world but was less apparent in the very poorest countries where electronic access is limited (Fig. 1D).

Lastly, we regressed average per capita GNI for the poorest countries hosting citing papers on Internet availability the prior year. OA had a strong, negative effect even while controlling for commercial access. After the average journal volume became OA, the average per capita GNI of the poorest countries hosting scientists that cited it dropped by $804 ± 26 (SEM). After adding the effect of commercial availability, the GNI lowered by $1705 ± 42 (SEM), equivalent to extending access from scientists in Russia to those in Western Sahara.

The influence of OA is more modest than many have proposed, at ~8% for recently published research, but our work provides clear support for its ability to widen the global circle of those who can participate in science and benefit from it.

References and Notes

1. M. J. Kurtz *et al.*, *Inform. Process. Manag.* **41**, 1395 (2005).
2. E. A. Henneken *et al.*, http://arxiv.org/abs/cs/0604061 (2006).
3. S. Lawrence, *Nature* **411**, 521 (2001).
4. G. Eysenbach, *PLoS Biol.* **4**, e157 (2006).
5. P. M. Davis, M. J. Fromerth, *Scientometrics* **71**, 203 (2007).
6. E. R. Maher, *J. Med. Genet.* **42**, 97 (2005).
7. P. Davis *et al.*, *Br. Med. J.* **337**, a568 (2008).
8. GNI is used instead of gross domestic product (GDP) because it more precisely captures average, realized income. We first used fixed effects Poisson regression models with robust standard errors to compare citations to journal volumes in periods when their articles were not available electronically to periods in which they were, commercially and for free. To control for the number of citations that would have been received without a change in online access, we used a log-normal curve fit to the empirical distribution of citations (*10*). All models control for the online commercial availability of research and are estimated for those articles published in years 1998–2005, after published research began to become available online and the influence of online access on subsequent citations became consistently positive (*9*, *11*). Exponentiated Poisson coefficients represent incidence ratios: the ratio of citations in years with OA to those in years without. Reduced by one and multiplied by 100, these become percentage shifts in citation after free availability.
9. Materials and methods are available as supporting material on *Science* Online.
10. M. J. Stringer, M. Sales-Pardo, L. A. N. Amaral, *PLoS One* **3**, e1683 (2008).
11. J. A. Evans, *Science* **321**, 395 (2008).

12. Supported by NSF grant 0242971. We thank Thomson Reuters, Incorporated, for use of its SCI data.

Supporting Online Material

www.sciencemag.org/cgi/content/full/323/5917/1025/DC1
Materials and Methods
Fig. S1
References

21 December 2007; accepted 12 December 2008
10.1126/science.1154562

[1]Department of Sociology, University of Chicago, Chicago, IL 60637, USA. [2]Department of Neurobiology, University of Chicago, Chicago, IL 60637, USA.

*To whom correspondence should be addressed. E-mail: jevans@uchicago.edu