SCIENCE POLICY

Changing Incentives to Publish

National incentive policies relate to increases in research article submissions and publications in *Science*.

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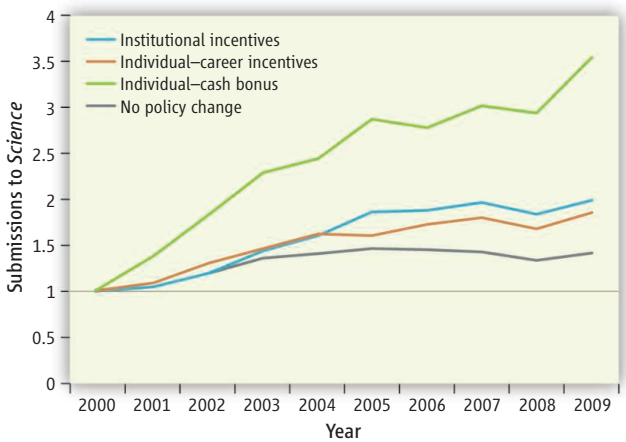
Many national governments have implemented policies providing incentives for researchers to publish, especially in highly ranked international journals. Although still the top publishing nation, the United States has seen its share of publications decline from 34.2% in 1995 to 27.6% in 2007 as the number of articles published by U.S. scientists and engineers has plateaued and that of other countries has grown (*1*, *2*). Hicks (*3*) argues that the two events are not unrelated: The decline in the relative performance of the United States relates to increased international competition engendered by newly adopted incentives that have crowded out some work by U.S. authors.

We investigate how changes in incentives to publish implemented at the country level relate to the number of submissions and publications and the acceptance rates to the journal *Science* for 27 OECD (Organization for Economic Cooperation and Development) countries and 3 OECD-monitored countries (China, Russia, and Singapore) for the period 2000–09. We further differentiate by type of incentive. Our analysis shows that the introduction of incentives by a country is associated with an increase in submissions by the country; the relation is particularly strong between cash bonuses and submissions. We find some indication that publications relate to career-based incentives.

Incentives

Incentives for faculty to publish have a long history in the United States and Canada. Promotion and tenure, as well as compensation, depend to a considerable extent on a faculty member's publication record (*4*). An active labor market exists for highly productive faculty, who often increase their salaries by receiving offers from alternative institutions. In many other countries, incentives for faculty to publish in international journals have been less strong with regard to salary and promotion. Funding for research often did not emphasize publications in international journals. Departments often received funds based on enrollment numbers and number of personnel.



Trend in number of submitted papers to *Science*. Thirty countries by type of incentive relative to number submitted by country in 2000 [see (*13*) and SOM for details].

Incentives to publish in international journals began to be more widespread in the 1980s. In some countries, incentives apply only to science and engineering; in other countries, they apply to a wider range of disciplines. The UK took the lead with adoption of the Research Assessment Exercise (RAE) in 1986, which allocates national funds to departments on the basis of past performance and peer review. A number of factors are included in the rankings, but publications constitute the core for science and engineering (*5*, *6*).

The UK reform provided an example for governments worldwide. Australia and New Zealand drew on the RAE to put in place policy reforms for funding academic institutions whereby better-performing institutions receive more funding than lower-performing ones and, thus, have more resources to compete in the job market for scientists. Norway, Belgium, Denmark, and Italy started similar policies during the past decade for allocating a share of the budget [table S1, supporting online material (SOM)].

Other countries focus on incentives directed at individuals rather than institutions. Germany and Spain made reforms in the mechanisms that regulate access to university careers, promotion, and salary, linking them more tightly to international publications. In Spain, a national agency was put in place to assess the performance of young recruits and to decide tenure and promotions. In Germany, reforms were made that allow universities to link salaries to research performance (table S1, SOM).

Some countries have introduced a system of cash bonuses to individuals for each article published in a top international scientific journal. Turkey introduced in 2008 a national agency that collects publication data and, for each article, pays a cash bonus equivalent to ~7.5% of the average faculty salary (*7*, *8*). The Chinese Academy of Sciences adopted a bonus policy in 2001. Rewards vary by institute but represent a large amount of cash compared with the standard salary of the researchers. Bonuses are particularly high for publications in journals such as *Science* and *Nature* (*9*). The Korean government inaugurated a similar policy in 2006 whereby 3 million won (roughly U.S. $2800) is paid to the first and corresponding authors on papers in key journals such as *Science*, *Nature*, and *Cell* (*10*).

Data and Models

We studied the journal *Science* because of its high impact factor and international and interdisciplinary scope. Moreover, the annual number of published articles has remained fairly constant at ~800. During the 10-year study period, first authors from 144 different countries submitted 110,870 original research articles; 7.3% of these submissions were accepted for publication, with first authors from 53 different countries (*11*, *12*).

We analyzed funding and reward policies for 30 countries, which collectively represent 95% of all articles submitted and 99% of all articles published in *Science* during the period (see chart and table). Eleven of the 30 countries have introduced reforms and policies related to incentives to publish in international journals in the past 10 years. Incentives are subdivided into three categories: policies

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that link institutional funding to publication performance, policies that link promotion and salary to publication performance, and policies that provide cash bonuses to individual authors in recognition of publication performance [see (*13*) for countries and policy types and SOM analysis for details].

Submissions to *Science* were differentiated by type of country incentive as shown in the chart. Submissions have grown from countries that have implemented incentives relative to countries that have not. Growth is greatest for countries implementing cash bonuses. (See SOM for trends in publications.)

To analyze impacts of incentives, we estimate two versions (specifications A and B) for each of three models. The dependent variable in model 1 is submissions by country; in model 2, it is publications; and in model 3, it is the acceptance rate. In specification A, all incentive programs are grouped together. In specification B, incentives are differentiated according to whether they link institutional funding to faculty performance or whether they provide rewards to individual researchers either in terms of career advancement or cash bonuses. In order to account for variation in research inputs, we control for each country's expenditures on research in higher education. Year and country fixed effects are included in all models to capture aggregated dynamics unrelated to country-specific incentives. Full results are presented in the SOM, including additional specifications used as robustness checks.

Our results suggest that the implementation of incentives is associated with an ~22% increase in submissions, all else equal (see the table). When we differentiate between incentives, we find effects of all three to be positive and significant. Cash bonuses are associated with the largest percentage increase in submissions (46%). The effect is statistically significantly larger than the estimated effect for either institutional incentives or career incentives. We find evidence that incentives are also positively correlated with the number of articles published. However, it is career incentives that matter; neither institution-based incentives nor cash incentives to individuals show statistically significant association with publications. The results also suggest that acceptance rates are negatively correlated to cash bonuses. They are not significantly related to other kinds of incentives.

We check the robustness of the estimations, including as further controls the national composition of the editorial board of *Science* and the extent of international collaboration, measured as the percent of publications by a country with one or more international coauthors. The submission and publication results are robust to the inclusion of these variables (see SOM); the acceptance rate results are not.

Conclusions

Our research suggests that government-initiated incentives to publish are associated with increases in submissions and publications at the country level. Career incentives are positively correlated not only with submissions but also with publications, which suggests that they encourage faculty to submit their best work to *Science*. Institutional incentives are correlated with submissions but not with publications. Cash incentives appear to encourage submission of research regardless of quality, as suggested by correlation with lower acceptance rates.

Our research provides some support for the competition hypothesis concerning why U.S. publications have plateaued. Incentives increased competition from countries with latent capacity by altering the amount and apparent quality of the work that is submitted for scientific review and eventually published. Other possible explanations include the considerable amount of time required to administer grants (*14*) and the aging of the U.S. research community (*15*).

The research has limitations. We cannot test for causality, and the incentive schemes may have been accompanied by other changes not controlled for in our models. Our work invites further research with data from additional journals and for a longer time period. Data at the individual level would permit examination of whether the same individuals submit more articles in response to incentives or whether incentives encourage more individuals to submit. It would also allow investigation of the degree to which incentives act to attract and retain productive researchers.

Dependent variable	Model 1 Submissions	Model 2 Publications	Model 3 Acceptance rate
Specification A			
Incentive (undifferentiated)	21.89**	27.12**	–0.122
Specification B			
Institutional incentives	24.23**	20.92	–0.076
Individual incentives: cash bonus	46.08**	–1.98	–0.389*
Individual incentives: career advancement	11.73**	34.44**	0.102

***Science* submissions, publications, and acceptance rates related to incentive policies.** Data for 30 countries, 2000–09. Models 1 and 2 are estimated by using a fixed-effect Poisson model; effects are reported as percent increase or decrease in submissions or publications. Model 3 is estimated by using a fixed-effect ordinary least squares model; coefficients are reported. *$P < 0.05$; **$P < 0.01$. [See (*13*) and SOM for details.]

References and Notes

1. National Science Foundation (NSF), *Changing U.S. Output of Scientific Articles: 1988–2003* (NSF07-320, NSF, Arlington, VA, 2007).
2. For the period 1995 to 2007, see appendix Table 5-25, in (*16*).
3. D. Hicks, in *Science and the University*, P. Stephan and R. Ehrenberg, Eds. (Univ. of Wisconsin Press, Madison, WI, 2007), pp. 223–242.
4. P. Stephan, S. Levin, *Int. J. Technol. Manag.* **22**, 676 (2001).
5. RAE2008, Research Assessment Exercise, www.rae.ac.uk/Results/intro.aspx.
6. Quality profile will provide fuller and fairer assessment of research, press release 11 February 2004; www.rae.ac.uk/news/2004/fairer.htm.
7. Turkish Academic Network and Information Center, www.ulakbim.gov.tr/cabim/ubyt/.
8. Research Directorate-General, European Commission (EC), *Remuneration of Researchers in the Public and Private Sector* (EC, Brussels, 2007).
9. Y. Ding, *Science* **291**, 1477 (2001).
10. I. Fuyuno, D. Cyranoski, *Nature* **441**, 792 (2006).
11. Data were provided by *Science*. To ensure confidentiality, *Science* did not include article title, author name, author institutions, or other identifying information.
12. *Science* publishes three kinds of original research papers: Reports, Research Articles, and Brevia. Here we use the term "article" to refer to the three.
13. Eleven countries where policies were introduced, and year of introduction, during the period 2000–09 (see table S1 for details): institutional incentives—New Zealand (2002), Australia, Belgium, Norway (2006), Denmark (2008), Italy (2009); individual career incentives—Spain (2001), Germany (2004); individual cash bonuses—China (2001), Korea (2006), Turkey (2008). The other 19 countries are Austria, Canada, Finland, France, Greece, Hungary, Iceland, Ireland, Israel, Japan, Netherlands, Poland, Portugal, Russia, Singapore, Sweden, Switzerland, UK, and USA.
14. S. Kean, *Chron. High. Educ.* **52**, A23; http://chronicle.com/article/Scientists-Spend-Nearly-Half/23697/ (2006).
15. J. Mervis, *Science* **317**, 582 (2007).
16. NSF, *Science and Engineering Indicators* (NSF, Arlington, VA, 2010).

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Supporting Online Material

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