

## Reflections on Research Performance Measures and the Rise of Asia

DAVID A. PENDLEBURY

David A. Pendlebury is a citation analyst at Thomson Reuters. E-mail: david.pendlebury@thomsonreuters.com.

The English poet William Blake wrote of “seeing the Universe in a grain of sand.” That is how I think of the footnote, relegated to the bottom of a page or the end of a text. In this particle of acknowledgment—often overlooked—we can find “the Universe,” or at least a path that leads to “the Universe.”

Citations in the journal literature represent the pathways of communication among researchers. Taken together, they represent a complex network of the exchange of knowledge, as complex as any set of communication connections, whether of telephone calls, links on the World Wide Web, or even neurons and synapses in the brain.

### CITATIONS: WHAT DO THEY REPRESENT?

I have spent the last three decades analyzing and contemplating citations. What do they represent? What do they reveal? Observers express many different opinions. Some say the citations are primarily rhetorical and serve to support an argument. Others say they are mostly shaped by social relationships. But I subscribe to the view that they are, when taken in quantity, reliable indicators—and symbols—of influential ideas.

In the sciences, a professional and even moral imperative exists to cite what is relevant to one's work. This is “giving credit where credit is due.” The sociologist of science, Robert K. Merton, spoke of citations as “repayments of intellectual debts.” I think that is the most accurate understanding of what citations represent and reveal.

### CITATION DATABASES: INFORMATION RETRIEVAL AND ANALYSIS

Thanks to the invention of citation indexes for scientific journals by Eugene Garfield in the early 1960s, we have citation databases. Thomson Reuters Web of Science database is primarily designed for information retrieval. Citation indexing gives researchers a powerful way to navigate and explore the literature because it relies on the expert judgments and connections made by scientists themselves—not indexers. Such a rich collection of data, now covering the year 1900 to the present and including some 50 million journal articles and three-quarters of a billion citation connections, invites quantitative analysis. And that is citation analysis, one aspect of bibliometrics.

### QUANTITATIVE ASSESSMENT AND PEER REVIEW

The most-cited papers and researcher can be identified. One can identify the most influential institutions, nations, and journals. Likewise, the dynamics of research productivity and indicators of influence or impact can be monitored and explored.

Citation analysis, when pursued in concert with traditional peer review, can contribute to a more thorough understanding of research performance—of nations, institutions, research groups, and even individual scientists. Such analysis aids decision making, whether by funders or those with responsibility for promotion. It can also increase fairness in a system of evaluation, since peer review can at times be unfair, owing to biases that even the reviewers may not recognize.

### THE RISE OF ASIA

In October and November 2009, I traveled throughout Asia to deliver lectures about citation analysis and the research performance of Asian nations. I met with government and university officials, leading scientists, and journalists.

*Japan still strong.* In Japan, I listened to concerns about Japan's declining world share of articles in the journals indexed by Thomson Reuters—from nearly 10 percent in 2000 to 7 percent by 2008. Policymakers expressed worry that Japan's scientific standing in the world is falling. However, I showed that in terms of impact, or citations per paper, Japan's performance is the highest it has been in three decades. This illustrates the difference between output and impact. It also illustrates how scientific research has undergone a huge transformation in the last 30 years: globalization.

*I have spent the last three decades analyzing and contemplating citations. What do they represent? What do they reveal?*

In the early 1980s, the United States was the publication leader in science, with some 40 percent of all articles indexed by Thomson Reuters. By 2008, that number had fallen to 29 percent. Europe saw its world share climb from 33 percent in 1981 to 36 percent in 2008, but even Europe has lost world share since 2000 when it claimed 39 percent. Meanwhile, Asia, as a region, has increased its world share, from 13 percent in the early 1980s to nearly 30 percent today. The calculation of world share is a zero-sum game: if some nations produce papers at a faster rate than others, their share will increase while the latter will decline.

*Singapore emphasizes quality.* The government of Singapore seeks to create a dynamic knowledge-based economy. Singapore's investment in research and development is now a remarkable 2.6 percent of the gross domestic product. That is about the same as the United States. Singapore's goal for 2010 is a 3 percent investment in R&D. Though a small producer, with only a .7 percent world share in the Thomson Reuters

database, Singapore accounts for 1.1 percent of the world's highly cited papers. This reflects a policy of focusing on and supporting world-class scientists, many of whom have been recruited to Singapore from the United States, the United Kingdom, and elsewhere. Areas of particular strength for Singapore are materials science, engineering, and computer science. Singapore represents an intriguing experiment in emphasizing quality over quantity, and it is already producing good results.

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*India boosts output.* In India, I discussed the proper use of publication and citation data for evaluation with faculty members at the Guru Gobind Singh Indraprastha University. The professors were eager for advice on best practices since it was clear to all that quantitative assessment would increasingly affect decisions about funding and promotion. In many nations—and not limited to Asia—rather crude measures and rewards have sometimes been implemented to improve research productivity. It is imperative that any system of quantitative performance indicators be transparent to all, understandable, and fair. For their own sake, scientists need to educate themselves concerning world standards in research assessment, if for no other reason than to guard themselves against uninformed or bad practices by university or government administrators.

Our national indicators for India have shown a spike in output since 2000, from 2.2 percent of the world's journal literature to 3.4 percent recently. During the last decade, citation impact has also increased in tandem with increased output, which is often not the case (frequently we find that a large increase in output causes citations-per-paper scores to decline). India's research impact stands at some 44 percent below the world average, but it is improving. The strongest areas for Indian science are, as they have been traditionally, the physical and agricultural sciences.

*China's remarkable rise.* As impressive as the growth of Indian science is, China takes the prize for its astonishing increased output over the last few decades. In the early 1980s, journal articles indexed by Thomson Reuters that carried a Chinese author address were only .4 percent of the world's output. That number is now 10 percent, up from 5 percent only seven years ago. Today, China is second, behind the United States, in its production of research articles published in internationally influential journals in the sciences and social sciences. Like India, the influence of Chinese research is below the world average—about 38 percent below the world average,

but this statistic began to increase in the late 1990s. China also, like India, places an emphasis on the physical sciences: materials science, chemistry, physics, mathematics, and engineering. These fields, along with agricultural sciences and plant and animal sciences, exhibit relatively high impact. Another phenomenon, discernible in the last few years, is an increasing number of hot papers from China. Hot papers are defined as those published in the last two years that rank in the top .1 percent by citations, taking into account their date of publication and field. China now produces more hot papers than Italy, the Netherlands, Japan, Switzerland, Australia, Spain, or Sweden. China is rapidly becoming a world power in research. ■

## Assessing Four Budget-Balancing Strategies in Higher Education

ARTHUR M. HAUPTMAN

*Arthur M. Hauptman is a public policy consultant specializing in higher education finance issues. E-mail: art.hauptman@yahoo.com.*

Countries around the world that run educational systems and institutions at all levels face serious challenges in responding to cutbacks in government funding. Thus, it is worth considering whether the options open to public higher education in addressing these challenges correspond with those available to public school systems.

### PUBLIC SCHOOL AND HIGHER EDUCATION SYSTEMS

For school systems, government is typically the principal source of revenues for almost all of their budgets. Moreover, new students often are seen as a drain on resources as any growth in students typically is not matched by more public funds. This crisis is especially true during recessions when governments have trouble meeting the many demands on their resources. This explains why public school systems must increase class sizes, cut programs and/or reduce staffing in response to government cutbacks in funding. Public higher education systems and institutions share this characteristic with public school systems.

Yet, in two other critical respects, the economics of public higher education are strikingly different from the pressures that engulf public school systems. One issue is that public higher education has a major revenue source that public school systems do not—tuition fees. This means that increas-