Royal Society, Tuesday March 29, 2011: 'Knowledge, Networks and Nations'

NF speech (15 minutes): Knowledge, Networks and Nations: the role of science information

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0. Good morning. I'm delighted to have the opportunity to talk about the role of science information in the context of *Knowledge, Networks and Nations*. Elsevier is one of two thousand science information companies and is part of Reed Elsevier that is headquartered just a few hundred metres from here.

1. As one of the world's leading science information companies we are fortunate to have a unique vantage point on the world of scientific and medical research. We publish and disseminate thousands of books and peer reviewed journals in print and electronic formats every year, and we manage terabytes of data in doing so. The science journals industry alone receives three million article submissions globally, each one seeking to advance science in its sub-field. We co-ordinate their peer review via relationships with 300,000 expert reviewers. We accept, edit, produce, disseminate and preserve around 1.5 million articles via electronic and print journals to a worldwide audience of 30 million researchers and practitioners. They download over 2 billion articles a year. We then record the citations that are made to those articles at the rate of 80,000 per day, or 30 million per year.

   By managing the inputs, interactions and outputs of the global forum in which scientists report, debate and advance research, we get to see much of what is going on in that forum.

   While we are fortunate to have a unique vantage point, it has limitations. Our view is weighted towards basic rather than applied research, and to academic rather than commercial outputs such as patents, licenses and spin-offs. While publications and citations are widely recognised measures of output and impact, they are proxy not absolute indicators. Publication impact is certainly not the same as societal impact even though the two are often associated.

   We were delighted when the Royal Society invited us to collaborate on the report that it has released today, and that it saw us as the partner of choice to provide not only data, but also analysis, insight and interpretative expertise. We are of course also keen to understand the dynamics shaping the research landscape that we serve.

   It's impossible to do justice to the findings of the Royal Society's report in this brief speech, so I have chosen to focus on a handful of findings that underpin the report's five key recommendations, and to suggest ways in which science information companies like Elsevier may be able to help address them.

2. First, our analysis with the Royal Society found a clear link between funding inputs and research outputs, as is shown by this chart which shows R&D spend inputs vs. published outputs by country.

3. As R&D spending rates by country change over time, they drive shifts in the share of research outputs. As a result, we are seeing challenges to established science leaders like the US and the UK who are spending at a slower rate than others, and the emergence of new global research hubs and leaders like China, South Korea and Brazil who are stepping up their rates of spending due to explicit government policies to support R&D.

   For example, in 2006 China had a 4% share of global R&D spending and an 11% share of published articles. Because it continues to increase R&D spending by over 20% per year towards a goal of a 2.5% share of GDP by 2020 (in an economy whose GDP is growing at 15% per year) it is expected that China will become the world's leading publisher of scientific articles (ahead of the USA) within the next decade, possibly as early as 2013.

   Published articles are of course just one form of scientific output - others include patents, licenses and spin-offs, as well as scientifically trained workers. The dramatic shifts in share that we are seeing in published articles are a proxy for shifts in these other forms of research output.

4. The link between inputs and outputs underpins the report's leading recommendation that *support for international science should be maintained and strengthened*, and its supporting recommendations that national governments need to maintain investment in their science base, that international activities and collaboration should be embedded in national science and innovation strategies, and that commitments to

multinational research efforts and infrastructures should not be seen as an easy target for cuts during a period of economic turbulence.

5. What might science information companies do to support this recommendation? One thing we can do is to identify national research strengths to help focus and co-ordinate R&D investments within and between nations.

   For example, here are four maps of national research strengths for the world's four most prolific countries in terms of articles published: the US, China, the UK, and Germany. Each map shows its country's distinctive research strengths and is based on articles published in 18,000 journals globally. Each bubble represents an area of research in which its county's researchers are especially prolific or highly cited. The larger the bubble, the more articles there are in that area of research. Bubbles on the edge of the circle fit neatly into traditional subject classifications such as Maths, Physics, Chemistry, Biology and Engineering. However, bubbles close to the centre are more inter-disciplinary in nature.

   For example, since we're in London today, the UK map shows that there are about 400 areas of research in which the UK is distinctively strong by international standards. The UK's strengths span a broad range of disciplines, from specializations in Social Sciences such as public policy and education, in Health Sciences such as mental health care and treatment of schizophrenia to asthma control, in Earth Sciences such as climate change research, and in Physical Sciences such as cutting-edge areas of theoretical physics like quantum dots. The UK shares many strengths with the other three nations shown here, and is remarkably similar in profile to Germany suggesting opportunities for collaboration and co-ordination.

6. This brings us onto the second of the report's recommendations which focuses on a key theme of the report: collaboration. Overall, the percentage of journal articles that were co-authored by researchers residing in separate countries has increased from 26% in 1996 to 36% in 2008.

7. The general trend of international collaboration is good news because international collaboration is associated with higher publication impact. Articles that have four co-authors residing in separate countries are cited around three times more than articles with no international co-authors.

   As a result, international collaboration is emerging as a strategy for smaller research nations and institutions to sustain excellence in the face of bigger R&D spenders. For example, Mexico has improved its publication impact by collaborating with Germany and Italy. Australia is collaborating with Spain and China, and has benefitted from the strength of those countries in medicine and genetics/genomics respectively[1].

   The report also finds, however, that collaboration between developing countries is still minimal. For example, it cites a recent study showing that from 2004-2008, while 77% of African biomedical research papers are produced with international partners, just 5% were the result of collaborations with another African country[2].

8. These findings drive the second key recommendation that *Internationally collaborative science should be encouraged, supported and facilitated*, and its supporting recommendations that research funders should provide greater support for international research collaboration, that national border agencies should minimise barriers to the flow of talented people, and that national research policies should be flexible and adaptive.

9. What might science information companies do to support this recommendation? One thing we can do is to help map existing networks of collaboration based on co-authorship analysis, to nurture existing opportunities and to identify opportunities for new ones.

   For example, this map shows collaboration among Brazil, Russia, India and China (the so-called 'BRIC countries') and the G7 (Canada, France, Germany, Italy, Japan, UK and USA) based on co-authored articles. The closer the nodes are together, the higher the volume of co-authored articles. Not surprisingly, the US accounts for the largest number of co-authored articles reflecting the size of its research base. Its collaborating partners reflect geographic proximity such as Canada, and geopolitical proximity such as the UK.

[1] *Knowledge, Networks and Nations – Global scientific collaboration in the twenty-first century*, The Royal Society, March 2011, p51-52

[2] DevelopingANDI: A Novel Approach to Health Product R&D in Africa, PLoS Medicine 7, 6 June 2010. Cited in *Knowledge, Networks and Nations – Global scientific collaboration in the twenty-first century*, The Royal Society, March 2011, p46

However, relative to their research strength, ties with China, Japan, India and Brazil are comparatively weak. Note, that collaboration between BRIC countries is also weak, suggesting opportunities for the future.

10. A second way in which science information companies might help is to help map "brain circulation" to ensure effective policies to attract and retain top science talent. As science becomes more collaborative scientists are moving from nation to nation to develop their careers, to expand their networks, to pursue funding opportunities and to work with the best faculty and equipment. For example, this map illustrates a new capability that we are developing. It is based on researchers' profiles that are derived from authors' institutional affiliations. It shows that of over 250,000 authors once affiliated with UK institutions, almost half are now working outside the UK, most commonly in the US, Germany, and France.

    But of course, brain circulation works in both directions. For example, we also analyzed the publications of over 100 of today's UK university vice chancellors and found that 88% were previously affiliated with non-UK institutions.

11. Around one third of the Royal Society report is dedicated to case studies of "global challenges" such as climate change, global health, food security, biodiversity, water security, population and energy security.

12. These studies led to the third recommendation that *National and international strategies are required to address global challenges*, and its associated recommendations that funders of global challenge programmes should devise ways to better co-ordinate their efforts, share good practice, minimise duplication and maximise impact; that national research funding should be adaptive and responsive to global challenges; and that in devising responses to global challenges, governments worldwide need to rely on robust evidence-based policy-making.

13. What might science information companies do to support this recommendation? First, we can continue stewarding the existing peer review publishing system: science journals create the norms and rules that determine the ethics and integrity of science in society, and as such are crucial in building public trust in science. Without peer reviewed journals, there would be a cacophony of claims and voices with no means of judging quality or authenticity. Peer reviewed journals shape an ethics of knowledge, which is critical to the effective use of that knowledge in public affairs.

    Second, we can help amplify the outputs of objective scientific research to inform government policy. For example, the UCL/*Lancet* commission brought together 29 researchers across 13 UCL departments to examine the Health Effects of Climate Change. Since being published, it has been in the top 1% of most downloaded of Elsevier articles. Its findings were discussed at a meeting of commonwealth health ministers and were mentioned at the World Health Assembly.

    The Lancet has extended this model, publishing a joint commission on the future of health and development with the London School of Hygiene and Tropical Medicine to coincide with the UN Summit held in New York. It is developing a second commission with UCL on Healthy Cities, and it will soon launch a commission with Harvard University on the future of health professional education.

    We stand ready to engage in further similar collaborations to connect evidence-based science to government policy to address global challenges nationally and internationally.

14. The report found that the development of communications infrastructure clearly has a significant role on the development of international science research capability building. These findings underpin the fourth key recommendation that *International capability building is crucial to ensure that the impacts of scientific research are shared globally* and not just concentrated among a wealthy few.

15. How might science information companies help here?

    The efficient flow of quality information is an essential resource to build capabilities because the efficient circulation of quality information helps drive the efficiency of research, as numerous studies have shown. Through participating in programmes such as the World Health Organisation's Research4Life which provides developing countries with free or low cost access to academic and professional peer-reviewed content online, we can dramatically improve access to countries that otherwise would not have the resources to.

Currently eligible libraries and their users benefit from online access to over 8,100 peer-reviewed international scientific journals, books, and databases, and Elsevier happens to be its single biggest contributor of articles. Countries participating in Research4Life have seen a dramatic and associated - though not necessarily causal - increase in usage and in articles published since the program began in 2002.

16. Finally, while current data such as publications and citations can be mined creatively to inform questions such as collaboration networks, interdisciplinary research, brain circulation and global challenges, there is a limit to their utility, and they tell only part of the story. The report therefore recommends that ***Better indicators are required in order to properly evaluate global science***.

17. So how might we help? Through projects such as our collaboration in 2010 with Imperial College London, and our joint follow up this year with Imperial, UCL, Oxford, Cambridge, Bristol, Queen's University Belfast and Leeds, we are developing new metrics and tools to help institutions maximise the impact of their research investments. With these institutions we have now identified around 50 metrics that these institutions agree would help them manage and benchmark their research activities more effectively. We are now working to source the data for these metrics in consistent and scalable ways, and will involve other stakeholders such as funding bodies that have also expressed strong interest in being involved as we do so.

18. In summary, science information companies are embedded in science research communities and are well positioned to help address the significant challenges that we face.

    Quality information helps increase the impact of scientific research which in turn drives the impact of science on society.

    Through collaborations such as we have with the Royal Society on its *Knowledge, Networks and Nations* report, we aim to help scientists and policy-makers to protect and strengthen science in society.

    There is much that we are doing, but there is much more that we can do. We want to collaborate further with researchers, universities, societies, and governments to help you maximise your returns on research investments.

    Through closer collaboration we aim to help address the complex, global and interdisciplinary challenges of our time to advance science and improve health for the betterment of society.

    Thank you.