ACADEMIC RESEARCH: A HIGH-COST, LOW-BENEFITS BUSINESS

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Less than two years after thousands of directors of French public research agencies were about to resign from their administrative duties as a protest against the reduction of research budgets (see for instance Nature, No 428, p 105), it may be timely to look at how well publicly-funded research is doing. Indeed, even in highly visible areas such as medical sciences, a number of drifts and malpractices are progressively turning public research into a costly and biased activity. One of the reasons lies in the pressure put on researchers to publish their work in scientific journals. This used to be an essential means of communication, but today publishing is much more a matter of career than one of disseminating scientific knowledge. Also, research in general tends to set its objectives independently from society's needs. This situation has given rise to a number of absurdities which undermine the usefulness of the scientific work itself. On the basis of simple facts and data, this study therefore attempts to demonstrate that modern science conducts research activities that exhibit flawed methods and poor deliverables.
This paper is a critical insider's look at the world of academic research. It has been written by one researcher and one lecturer of the School of Computing Science at the University of Newcastle upon Tyne. It is obviously difficult for us to speak with a total guarantee of accuracy about other disciplines. However, the various sources of information used in this study tend to demonstrate that drifts pervade many, if not all domains. The paper highlights a number of drifts within the world of research, the description of which will hopefully increase the awareness of the public and of the scientific community. In the end, the authors wish that the contents, however controversial, trigger a reflection on what science should and should not do, to the benefit of whom, and at what cost.

1. The absurdity of scientific publications

Writing articles and having them published is the main assessment criterion for research laboratories and researchers. This is an incentive for more and more papers to be written in an uncontrolled inflation. Unsurprisingly, some critical consequences become unavoidable. Cheats and tricks, excessive volume of material to read, poor quality of the research, and poor societal usefulness have become common in the world of modern science.

1.1 Cheats and tricks

There are a number of malpractices that authors can adopt to increase the chances of having their articles published.

- The same work is published in slightly different versions in several journals, conferences and book chapters. This artificially increases the number of one's publications and, sadly, is widely tolerated;
- Some senior academics publish other people's work under their own name. Alternatively, for political reasons, they add colleagues' names in the authors list, even if these people did not contribute to the work;
- In experimental disciplines, hypotheses are sometimes made after the results are obtained in order to increase the impression of cohesion of the work;
- The references in the bibliography of an article sometimes include works that authors quote for exhaustivity but did not necessarily read (see Simkin & Roychowduhry, 2003);
- Research results might even be selected if not falsified (see Abbott, 1999; Beasley *et al.*, 2002).

Although undesirable, these malpractices are encouraged by the importance given by research assessment authorities and funding bodies (Garfield, 1982) to the number of publications achieved by laboratories and individual researchers.

1.2 Too many publications

Andrew Odlyzko (1995), a researcher in Mathematics, asserts that in 1870, there were 840 articles published in his discipline. In 1995, the annual number had increased to 50,000. Certainly, this increase has to be compared with the growing number of mathematicians over the years. But since reading has remained an individual task, the volume of literature is simply unworkable. There are too many journals and publishers (Delamothe & Smith, 1999) and researchers are now virtually incapable of absorbing the volume of information produced by their discipline.
The consequence is that many papers are never read, thereby failing their primary objective: dissemination. Malcolm (1996) highlighted the excessive number of publications and the impossibility of being fully aware of the advances of the work done in one's research field. He quoted the number *five* as the estimated average readership for a scientific article. Wagner and Walker (2005), based on an analysis of citations per article, found similar numbers in the field of Zoology. If correct, these would be awfully low numbers. Given that some papers are well-known across a scientific discipline and attract hundreds of readers, the average number five implies that a large number of articles remain simply unread. If this line of reasoning is valid, it constitutes a solid argument for the claim that the mechanism of scientific knowledge dissemination is flawed.

The growth rate of the number of publications is hard to assess over all disciplines. However, the number of periodicals available from publishers can give a view of the tremendous quantity of paper produced. Let us consider some examples. Elsevier, the biggest science publisher in the world, produces yearly more than 2000 journals in hundreds of domains[1]. Several hundreds of other journals are available from Taylor & Francis[2] and another 500 from Springer[3]. Together, these 3 publishers alone produce the equivalent of 1,200,000 pages per year[4]. It takes 120 metres of shelving to store this amount of paper. This number is for periodicals only. It does not take into account the multiplication of copies around the world due to multiple institutions subscribing to the same

[1] The full list appears at http://www.elsevier.com/wps/find/journal_browse.cws_home
[2] The periodicals, sorted by topic, appear at http://www.tandf.co.uk/journals/alphalist.asp
[3] Visit Springer at http://www.springerlink.com/
[4] The breakdown is as follows. 3000 periodicals x 8 issues x 50 pages. The 8 issues numbers comes from the fact that not all journals produce 12 issues a year.

periodical. This number includes neither books nor proceedings produced by the many conferences happening all around the world.
Conferences are a particular case. Not only do they add to the amount of paper produced but they also have problems in terms of attendance and organisation. Let us consider two worldwide computing associations, both with a very strong reputation: the IEEE[5] Computer Society and the ACM[6]. The IEEE Computer Society provides a list of conferences of potential interest for its members. The list consists of 15 conferences per month for the first 6 months of 2005. The ACM provides roughly as many events, with little overlap with the IEEE Computer Society[7]. The situation is so absurd that the conferences' deadlines for paper submission are harder and harder for authors to meet and for organisers to maintain. Though this applies to Computing Science it is probably also the case for other disciplines.

1.3 Poor quality of the research

In a sense, it is perhaps lucky that research papers have so few readers (see section 1.2), as this serves to hide the low standards of communication that have become accepted because of the pressure to publish. Some papers say very little that is not known already or are so poorly written that it is extremely difficult to understand them. But even more worrying problems occur: quality is at risk. In medical sciences for instance, research can happen to be "*seriously flawed through the use of inappropriate designs, unrepresentative samples, small samples, incorrect methods of analysis and faulty interpretation*" (Altman, 1994). The same sort of defects can be found in the field of computer interfaces (Gray & Salzman, 1998) and probably in the vast majority of disciplines. How can these faulty pieces of research find their way to publication? One cause is due to peer-reviewers not always having all the required skills to properly evaluate the work done. Another explanation has to do with the fact that authors repeatedly try to have their paper published until a journal or conference is found whose standards of publication match the contents of the paper.

1.4 Poor societal usefulness

Publications are the main criterion used to assess the achievements of researchers. Therefore, the primary objective of researchers is to have their work published. With such an approach, the potential usefulness of research results is often totally absent from the motivation for the research. In practice, many scientific articles turn out to be just a description of a fact or problem with little interest given to potential ways to exploit or solve it. Characterising or quantifying a phenomenon is a necessary step but researchers only consider the exploitation or solution stage in a minority of cases. In other words, researchers seldom ask themselves the question of what can concretely be done with their research. More worryingly, the benefit to society is not an assessment criterion used during the review of laboratories' and researchers' achievements. Theoretical articles are therefore highly attractive to many researchers who then have the option of bypassing data gathering and analysis, and enjoy a shortened publication cycle. In the end, as Malcolm (op. cit.) puts it, many research publications rehash the same long-established facts, with little added value.

Having one's work published often takes precedence over making this work useful to society. A different working model would consist in promoting needs-driven research. In other words, let us work in priority on problems we know we have or will have. This does not mean that theoretical

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[5] Institute of Electrical and Electronics Engineers. Visit the IEEE at http://www.ieee.org
[6] Association for Computing Machinery. Visit the ACM at http://acm.org
[7] Pointers to the conference calendars of the IEEE Computer Society and the ACM appear in the references section.

research must be abandoned. An example of its importance is the invention of the electric bulb. The latter was not created by making candles work better but by the exploitation of fundamental discoveries in the domain of electricity. We therefore do need efforts in the so-called "blue sky" research. However, this term can encompass virtually anything. Thus the scientific community needs to address the issue of what is a fundamentally important research objective and what is not. For instance, a potential working model could be driven by concrete problems to solve and a definition of the theoretical scientific progress required, as opposed to carrying out unguided theoretical work and then just hoping it will be of some use some day. So the question is not one of leaving theoretical research. Instead, it is one of adjusting the balance between applied and theoretical objectives. Failing to do so will result a) in theoretical research to remain the cheap-and-easy way to publish, b) in the amount of exploitable research to remain awfully low, and c) in industry lacking interest in academic research.

We now have to state that researchers are not fully responsible for this state of affairs. In the UK, large funding authorities such as the EPSRC[8] as well as the governmental Research Assessment Exercise[9] do not put enough emphasis on the applicability of the research. Instead, the intrinsic quality of the work, the scientific challenge and the novelty of the results are the main evaluation criteria. Scientifically speaking, these certainly are valuable metrics. However, a strong incentive to ensure technology and knowledge transfer is missing, although being fully compatible with, if not complementary to modern science.

In section 1.2 we concentrated on such issues as the volume of papers produced per year to show that the current scientific working model produces too much. An aspect of this inflation of publications that we have not addressed yet is one of finances. In the next section, we will see that too many publications is not only an absurd state of affairs, it is also an expensive one.

2. The pervasiveness of slavery: Scientific journals

On average, publishers charge several hundreds of pounds for 12 or fewer issues of a journal on which they do very little work. Altogether, University libraries subscribe to hundreds of these journals. Hidden behind the scene lies a marvel of modern slavery.
In order to get published, authors need to spend a lot of time in polishing, proof-reading and formatting their papers, not to mention the months or years needed to carry out the scientific work. Publishers do not pay for that. Moreover, articles need peer-reviewing before they are published. Once more, this is done and coordinated free of charge by other researchers acting as reviewers. Lastly, authors have to transfer their copyright to the publisher, thereby giving up on their own liberty to share their work freely within their community. Publishers do not pay for this copyright either. In some areas (i.e. Economics), the situation is even worse. Researchers have to pay a submission fee ($50 to $100) or purchase an association membership to have their work published. In areas such as Finance, the submission fee can go as high as $1000, for as many times as there are revision cycles needed.

The final picture is that:

- private publishers of scientific journals make their business rely on the efforts and time of publicly-subsidised workers;

[8] Engineering and Physical Sciences Research Council. Visit EPSRC at http://www.epsrc.org/
[9] Visit the RAE web site at http://www.rae.ac.uk

- public funding bodies and research assessment authorities collaborate in this exploitation through their choice of evaluation criteria (as described in section 1.4);
- developing countries, the general public as well as small companies, who do not have enough resources to invest in expensive subscriptions, are *de facto* totally unable to have direct access to most of the scientific knowledge[10];
- University libraries buy articles from private publishers that their own researchers have produced with public funds.

In 2003, David Adam (*The Guardian*) interviewed Jan Wilkinson, head librarian at the University of Leeds. She highlighted the absurdity of the current system. According to her, "we need to get academics to recognize the craziness of what they have been doing. They do all this work and then they just hand it over for free, and then the publishers sell it back to us at these rip-off prices". Some figures support this claim. For instance, it is not uncommon for a UK University with a population of between 15,000 and 20,000 students[11] to spend £1.5M of its library budget on periodicals. For instance, Dr Tom Graham, University Librarian at the University of Newcastle upon Tyne, quotes £1.8M as the periodicals budget for 2004-2005. If we look more closely at 2003 figures, the average cost of these periodicals was about £630 for a British title and about $1883 for an American title. And prices go up year after year. For 2004, the journal prices rise was expected to be in the range of 8%. As another example, an American library journal published the evolution of its subscription fees, for the combined disciplines of Mathematics and Computing Science. Between 2000 and 2004, the average fee has jumped from $881 to $1171, which is a 33% increase. Some increases are even higher.

Under the current publishing model, subscriptions to paper periodicals (or their electronic counterpart) are needed. However, it has to be stressed that this publishing model is not the only one that is available. It has simply survived over centuries and, due to conservatism, is the one that the scientific community prefers. But alternatives exist, though they would surely take time to establish, as well as needing a huge change in practices. In the meantime, some numbers might help characterise the criticality of the situation. According to HESA[12] figures, the average number of students for a British higher education institution is about 13,500[13]. Let us then assume, as a derivation from the numbers in the previous paragraph, that £1M is an acceptable estimation of a higher education institution's library budget for periodicals. HESA lists 180 of these institutions in the UK. We can then estimate that each year, in the UK, around £180M of public money is given away to private publishers.

3. Towards new publishing models?

The previous sections have pointed out that the current publishing model might hamper dissemination, partly because of the incurred cost and the poor visibility of research papers. Several initiatives exist (even among private publishers) that attempt to provide an answer to one or both of these problems.

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[10] A free electronic portal to medical research has been set up for developing countries to allow them to access published medical research (see for instance the Health HIN InterNetwork at http://www.healthinternetwork.org/)

[11] There are 22 such institutions in the UK, out of a total of 180.

[12] Higher Education Statistics Agency. Visit HESA at http://www.hesa.ac.uk

[13] A full breakdown is available online from the Higher Education Statistics Agency at http://www.hesa.ac.uk/holisdocs/pubinfo/student/institution0203.htm

First, the House of Commons (2004) published a report that recommends working on guidelines for a new publishing model as well as the creation of public repositories in academic institutions. These are intended to store the papers that were published within a given institution and make them accessible free of charge to its members, if not the general public. Years before this initiative, the main private science publishers (see example names in section 1.2) started to run electronic libraries to supply electronic versions of the papers they published. The scale of this initiative has widely expanded today. Some of these papers can even be bought individually, thereby providing (charged but cheap) access to single pieces of research.

The open access model is another possible way ahead, although the picture is not as clear-cut as it seems. First, open access journals are not free. They have to attract funds to sustain their activity, possibly by charging the institutions from which papers are coming from. Other problems have to do with version control and integrity of documents but the major hurdle to expansion of open access is reputation. Private publishers are usually respected in comparison to open access journals which are generally perceived as a public, uncontrolled forum (Schroter, Tite & Smith, 2005). But given that quality control in scientific publications essentially depends on authors and reviewers, and not on the medium on which the research is disseminated, the move to open access at a very large scale is technically feasible and scientifically sound. At least two well-known open access repositories exist that are accessible by the general public. These are BioMed Central[14] and the Public Library of Science[15]. Both demonstrate, yet with different working models, that open access can be a sustainable enterprise.

4. A bird's eye view

To sum up, the pressure to publish scientific research causes a number of drifts:

- Scientists adopt malpractices to increase their number of publications or the chances they have to get their work published;
- There are too many publications, causing the amount of scientific literature to stand beyond what one can reasonably read;
- The quality of research decreases;
- The relevance of research to society's needs is not taken into account by researchers.

On top of these shortcomings, the research articles are then published in expensive privately-owned journals that publicly-funded research laboratories buy and few people read. In other words, a portion of the taxpayers' money is invested in piling up paper on shelves with microscopic benefits for our society and huge profits for private publishers.

5. What should be done?

Although what follows would require in-depth changes in research, some simple and common-sense suggestions can help in solving the above mentioned flaws:

- *The main assessment criterion for research should not be publications alone.* Today, an important assessment criterion for a given publication is its impact factor, defined essentially by the number of times this publication has been quoted by other authors. Not all disciplines adopt this rating technique but the majority of them still ground their assessment on some purely

[14] http://www.biomedcentral.com/

[15] http://www.publiclibraryofscience.org/

academic metrics, in one form or another. Instead, a fairer assessment could be that of the *influence* of a paper, as defined by such criteria as creating changes in a research field and practices, setting agendas, being followed, etc. (Abbasi, 2005).

- *Open access and conventional publications should be rated.* This should be done according to a similar set of criteria, so that open access journals get recognised by assessment authorities and therefore appeal to more researchers.
- *We do not need private publishers.* The quality of a scientific article relies on the authors who wrote it, the reviewers who reviewed the work and the scientific committee of the journal. None of these factors is paper-dependent. Moreover, none of the above people is paid by the journals they do work for or to which they send articles. From this standpoint, conservatism is the main hurdle standing in the way of electronic scientific journals.

6. Conclusion

This paper represents the views of two researchers of the world of public research. What we have described is not restricted to the UK. To say the least, all of the so-called developed countries are subject to the same forces we have described.

It might be hard to accept, but a lot of the resources allocated to public research are simply wasted. There are too many causes, combined in too complex a mesh of long-lasting practices for one more paper to change the face of the scientific world. However, some factors have been identified that, if taken into account, could improve the situation.

One might then want to ask: Why do we need to change things? Isn't *better* the enemy of *good*? Isn't it the case that changing our working model will provoke uncontrolled side-effects? Yes, it is a possibility. But we are also facing a certainty: a larger and larger chunk of the scientific work is not done for the benefit of society but for the promotion of researchers' careers. Scientific progress could be achieved far quicker, with less resources and to the benefit of more people if we accepted the idea that the scientific model we are currently running needs to be recast. With such potential benefits and after the countless years of wasted resources, it might be worthwhile taking the risk of change.

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