Journals and scientific productivity
a case study in immunology and microbiology

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The Publishing Research Consortium (PRC) is a group representing publishers and societies supporting global research into scholarly communication, with the aim to provide unbiased data and objective analysis. Our objective is to support work that is scientific and pro-scholarship. Overall, we aim to promote an understanding of the role of publishing and its impact on research and teaching.

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Executive overview

1. The biggest single productivity issue facing biomedical researchers is funding: not just a lack of adequate resources but an increasingly short-term, ‘stop-go’ funding culture that makes forward planning and staff retention very difficult (pp. 10-12).

2. Other major issues impacting upon their productivity are problems in recruiting suitably qualified research staff, a lack of seed corn funding to help get risky new ideas off the ground, a lack of autonomy in terms of the research that they would like to do but which does not fit in with funders’ priorities, and too much time spent in filling forms and other non-productive bureaucratic tasks (pp. 10-12).

3. In comparison, researchers do not consider that problems in accessing the journal literature are a significant barrier to their work: this aspect is ranked in 12th place (of 16) (pp. 11-12).

4. The key predictors of research productivity in this study are grant-getting skills and knowledge, motivation, professional networking, gender, research type and good access to the literature (pp. 13-14). There is evidence of a significant gender gap in article productivity, irrespective of age, women researchers seem to be being held back, for whatever reason. This is an important policy issue.

5. Biomedical scientists place a high value on the traditional roles of the journal in providing certification and validation of their work and the peer review system appears to be functioning very effectively: internationally, 84.6% agreed that the reviewers had improved the quality of their last article (pp. 5-6).

6. Immunologists and microbiologists are generally satisfied with their level of access to the journals system and a large majority, 83.7% agree that major improvements in journal accessibility have been made over the past five years (pp. 6-7).

7. Those researchers who voice dissatisfaction with the journals system are more likely to be involved in interdisciplinary work and to be struggling with research funding and time pressures. They are also much more likely to be found in smaller European countries, suggesting perhaps that there are some supply-side issues that need to be tackled (p.15).

8. A very large majority of researchers (97%), believe that they are very up-to-date with the current literature in their area (pp. 9-10). This and earlier work by CIBER supports the view that biomedical researchers are generally satisfied with the journals system.

9. Our survey work confirms earlier studies: desktop access to high quality published information results in significant time savings for researchers and they feel that this has helped them to be more effective knowledge workers (p.10).

10. The linkages between information consumption (reading) and information production are barely examined in the scientific literature. This is a serious gap in our knowledge, especially in the context of the current debate about new publishing models in the scholarly arena.

11. The key policy implication of this research is that Europe could improve its biomedical research performance by listening more carefully to its scientists. There is little evidence here, for example, that greater moves towards reader open access will make any significant difference. The really important issues are much more mundane and could be tackled relatively inexpensively.
Context

In the fevered atmosphere of the open access debate we sometimes seem to be in danger of losing sight of what the journals system is for, what value it adds, and where it fits into the bigger picture as a key element in keeping the whole research enterprise ticking over. This Summary Paper has been commissioned by the Publishing Research Consortium (PRC), to open up an important research agenda: what contribution does the scholarly communication system make to the science base, broadly defined, and how can it be improved? This is a critical issue for publishers, librarians and research managers as well as for funding agencies, and is especially timely against the backdrop of the arguments being deployed in the cause of reader open access. And to make progress, we need to collect a lot more evidence than is currently available. This is one of the key aims of this new series from the PRC.

The bigger picture

Future economic performance is now seen as direct function of present research and development activity. Increasingly, governments and boards of management look to research and development to bring them success in the global knowledge marketplace. With corporate and national pride at stake, it is not surprising that there is plenty of performance anxiety around. ISI Thomson Scientific’s aggregate publication figures show that the US share of world science article output is declining (National Science Foundation 2004), and Europe worries that its scientists generate fewer published papers per capita than their North American colleagues. In response, the US Academies of Science have recently warned that the US must dramatically increase its investment in R&D. The EU Lisbon summit in 2003 agreed that the proportion of EU GDP spent on R&D must rise from 2 to 3 percent. None of this is lost on the emerging economies, especially in East Asia which, according to Nature (2005) now account for more than half of global GDP. Not surprisingly it is in this part of the world that R&D expenditure and corresponding journal article output are rising most quickly (see Fig.1).

For these reasons, it is important for all of us that we focus on what practical things can be done to maximize European return on investments in scientific discovery.
Purpose
The purpose of this paper is to provide an up-to-date snapshot of the attitudes, perceptions and behaviour of a select group of biomedical scientists (immunologists and microbiologists) to the journals system. What do they want from the journals system as authors and as readers? What are their attitudes to journal prices and new business models? And what do they perceive to be the key things that could be done to help them become more productive in research terms?

This paper is in two main sections. In the first we tease out the results of two large-scale author surveys (CIBER 2004 and CIBER 2005), presenting the findings for immunology and microbiology for the first time. In the second part, we report on research specially commissioned for this report which focuses on the question of research productivity and specifically, what the role the journals systems plays. This involved a selective review of the literature and primary research in the form of online, telephone and face-to-face interviews with European and North American researchers in immunology and microbiology to try to get a little closer to answers to these questions.

Biomedical scientists and the journals system
The findings in this section are drawn from two large-scale surveys of senior authors that were commissioned by the Publishers Association (CIBER 2004) and by the PA and the International Association of STM Publishers (CIBER 2005). Where appropriate, the responses of immunologists and microbiologists are contrasted with the rest of the author population, which spanned the full range of disciplines indexed by ISI Thomson Scientific, including arts and humanities and social sciences.

What do they want from the journals system?
As authors, immunologists and microbiologists place great emphasis on the perceived quality of the outlets where they publish and on the ability of those outlets to target the right readers (Fig.2). There seems to be little enthusiasm for posting their articles (as pre- or post-prints) on their own or other public websites (e.g. institutional repositories).

Figure 2: What biomedical authors want from the journals system (n=175)
Source: CIBER 2005 author survey: immunologists and microbiologists, showing the percentages who agreed that these factors were ‘important’ or ‘very important’
By a very wide margin, biomedical scientists affirm the centrality of peer review: 95.4% agreed quite strongly or very strongly that this is an important aspect of journal publishing. When asked about their experience of peer review with regard to their last published paper, 84.6% agreed that the reviewers’ comments had improved the quality of their article (Fig.3). In this respect, immunologists and microbiologists seem to fare better than the rest of the researcher population by about 10 percentage points.

In the 2004 survey, respondents were asked to reflect on their satisfaction with the journals system (Fig.4) in terms of their ability to access the articles they need. Again, their responses are generally very positive and a little ahead of the rest of the academic population, with 67.4% indicating that they enjoy good or excellent access.

When reflecting further on this aspect, 83.7% agreed that, compared with five years earlier, major improvements in journal accessibility had become apparent (Fig.5).
It is clear that publishers’ investments in digital libraries have had a major impact on information access and availability. The popularity of electronic platforms for keeping up to date with the literature and for browsing, searching and retrieving articles from publishers’ websites is clearly shown in Fig.6. Researchers are far less dependent on physical libraries and hard copy personal subscriptions now that more convenient and time-saving media are available.

Biomedical scientists are generally better informed about open access journals than the academic population as a whole (38.9% of immunologists and microbiologists claim to know ‘a lot’ or ‘quite a lot’ open open access, compared with 25.4% of other researchers), yet only 32.0% say they have actually published in an open access journal. Like many other segments of the research population, they perceive that ‘high journal prices’ are a barrier to accessing the literature (Fig.7), although this does not translate into price sensitivity when they choose where to publish, such is the power of established brands.

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1 Unpublished research by Elsevier suggests that authors tend to over-report their publishing behaviour in open access journals, seemingly conflating the concept of open access and digitally accessible materials.
Immunologists and microbiologists are much more likely to have made some kind of payment to have their articles published, either in the form of conventional page charges or author-pays open access, than the population as a whole (63.0% as against 37.6% from the 2004 survey). For this reason, their attitudes towards where the costs of the journal publishing system should most fairly be borne are particularly interesting (Fig. 8). There is very little enthusiasm, on the basis of the evidence here for charging regimes that impact directly on readers or authors: most scientists seem to prefer a system where the costs are borne by funding bodies or other sponsors, such as commerce or government.

There is an obvious attraction in coupling the costs of the journal publishing system with the grants that make that production possible (a small majority, 51.4% of biomedical authors believed that “too much was being published” in the 2005 survey). There are practical issues to be overcome.
since by no means all published papers, even in immunology and microbiology are supported by a research grant or contract, especially in the case of clinical work (Fig. 9).

**Figure 9: How many of your recent articles were supported by a grant or contract? \(n=175\)**  
Source: CIBER 2005 author survey: immunologists and microbiologists, percentages

**Journals and research productivity**

In this section, we move from an overview of the findings of the two CIBER author surveys to some primary research conducted for this Summary Paper and based on face-to-face, telephone and online surveys with biomedical scientists in the UK and the US. The aim of this work was to find out more about how access to journal articles sits within the broader context of the factors that inhibit or promote research efficiency and productiveness.

**Biomedical scientists’ attitudes to the journals system**

In the next primary research phase, 883 Europe and North American biomedical scientists took part in a web-based survey, designed by CIBER and managed by the polling organisation GfK (formerly NOP).

**Figure 10: Biomedical scientists’ views on the journals system \(n=883\).**  
mean values, where 1=strongly disagree, 5=strongly agree
Irrespective of subject or broad region, researchers feel that they are well on top of the current literature in their field (Fig.10), and this would appear to be a difficult issue for only a very small minority of respondents (i.e. the 3% who disagreed with this proposition).

By a very large majority (90%), the respondents agreed with the proposition that desktop access to publishers’ digital libraries had enabled them to become more effective researchers and that this had resulted in significant time savings in finding and retrieving articles (97%).

Figure 11: Biomedical scientists’ views on the journals system \( (n=883) \).

While researchers appreciate the investments made in publishers’ digital libraries and realise the convenience benefits, they are still not satisfied with the scope of what is on offer and a minority (35%) experience some difficulty in getting access to all the articles they need. Overall, it seems that user satisfaction with publishers’ offerings are fairly high but that there are issues peculiar to the European context that need to be further explored: in particular, the finding that European scientists are significantly more likely (at the 10% level) to report difficulties in accessing the journals literature.

What would help biomedical scientists to become more research productive?

In framing our interviews we established from the outset that we wanted to understand scientific working patterns and what scientists themselves feel are the main issues that impacted on their ability to carry out research: we only mentioned our specific interests in journal-related issues right at the end of the interview so as not to lead the discussion in that direction. Our purpose was to validate, from the horse’s mouth, a short list of the key barriers to research productivity we had gleaned earlier from the literature. The interviews were wide-ranging, but a number of common themes emerged. They are summarised below, in no particular order:

Proposal writing researchers complained of a lack of support and training in writing grant proposals, the burden of paperwork and bureaucracy, the quality of reviewers, the time delays between submission and approval, and low success rates which increase the time they have to spend on proposals.

Interdisciplinary work researchers complained that the learning curves for writing joint proposals with other disciplines is very steep, of difficulties in getting the parties together, financial
and administrative complexities, and concerns about finding suitable journal outlets for interdisciplinary work

**Research staff** researchers complained that recruiting research staff is difficult: often not enough money or time is available to advertise posts, and that the human resource issues are very complicated

**Ethical approval** researchers complained of too many regulations, nit-picking forms, political correctness, the length of time taken to reach a decision, and a perception that ethics committees sometimes seemed `intent on sabotaging research’

**Research management and direction** researchers complained of ad hoc decision making and a lack of clear strategic direction and leadership, too much micro-management, poor communication and a lack of constructive criticism

**Conferences and networking** researchers complained of a lack of opportunity to attend conferences and, if they do, problems arranging the travel and sorting out the financing

**Bureaucracy and red tape** researchers complained of the enormous burden of paperwork and regulation that academics face, excessive and sometimes duplicate internal reporting, too many meetings, and a lack of clerical and administrative support

**Time for research** researchers complained of the many time pressures bearing down on their research (clinical, teaching and administrative duties in particular), and of a shortage of administrative and technical staff to support them

**Funding** researchers complained of poor success rates for competitive grants, insufficient allowances for staff and consumables, short-term funding and a `stop-go’ research culture in which it is impossible to make plans, the difficulty of finding bridging finance, and the small size of many grants (which exacerbates the need to carry on writing more proposals)

**Getting new ideas off the ground** researchers complained that the funding system discourages `risky’ projects (i.e. those not based on strong preliminary data), that funding mechanisms are too project- (rather than research-) oriented, making it difficult to follow up new leads as they emerge, and the scarcity of seed corn money to help to mature their ideas

**Equipment and materials** researchers complained of under-investment in the fabric of their laboratories and research infrastructure (more space, equipment, consumables and technicians)

**Management skills** researchers complained that they did not have enough training in management techniques, specifically time management skills

**Research staff** researchers complained of a shortage of suitably qualified young research staff and funding at PhD and post-doctoral levels

**Time to think** researchers complained of a lack of freedom and autonomy in their work and that research funders’ priorities discouraged creativity and original ideas

**Job security and prospects for research staff** researchers complained of the difficulty of attracting and retaining researchers, given the acute shortage of permanent and tenure-track positions, and the problem of `stop-go’ funding

The interview issues raised specifically about the journals system were mainly concerned with author-facing issues such as the incessant pressure to publish, the time spent on writing and
preparing manuscripts for publication, slow publication speeds, and the problems of getting work, especially interdisciplinary work accepted. The main reader-facing complaint was that not enough literature was available online. In the next phase of the online survey, a systematic attempt was made to put these journal-related issues into their wider research productivity context.

The findings of the face-to-face and telephone interviews generated a list of 16 recurrent issues that also feature prominently in the research literature as barriers to scientific productivity. While not in any way suggesting that any of these issues are not important - the passion with which scientists held their positions - showed otherwise, the question does needs to be asked: `Which are the most critical?’. We used a conjoint analysis technique to find out. The data in Table 1 (and Figure 12 overleaf) present a consensus view of the research productivity barriers facing biomedical researchers. The utility scores in the right-hand column allow us to rank-order these barriers and to indicate the relative weight that the community attaches to each. Relative to other productivity-limiting issues, the ability to be able to source to a wider range of journal materials, a key argument for reader open access, can be seen to be a third-division concern. Other issues are much more pressing: notably the need for better funding, research staff recruitment and retention, seed corn funding to help `risky' new areas of research to reach early maturity, and a clear message that research funders’ priorities are stymying individual creativity.

**Table 1: Perceived barriers to biomedical research productivity (n=883)**

<table>
<thead>
<tr>
<th>Utility Scores</th>
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<tbody>
<tr>
<td><strong>More funding</strong></td>
<td>83.0</td>
</tr>
<tr>
<td><strong>Ability to recruit suitable research staff</strong></td>
<td>76.9</td>
</tr>
<tr>
<td><strong>Seed corn funding</strong></td>
<td>69.6</td>
</tr>
<tr>
<td><strong>More autonomy in setting research direction</strong></td>
<td>65.9</td>
</tr>
<tr>
<td><strong>Cutting red tape</strong></td>
<td>61.2</td>
</tr>
<tr>
<td><strong>Job security for support staff</strong></td>
<td>61.0</td>
</tr>
<tr>
<td><strong>More time for research</strong></td>
<td>54.7</td>
</tr>
<tr>
<td><strong>More opportunities to talk about research</strong></td>
<td>53.5</td>
</tr>
<tr>
<td><strong>More support in writing and costing proposals</strong></td>
<td>47.4</td>
</tr>
<tr>
<td><strong>Upgrading the physical research infrastructure</strong></td>
<td>47.1</td>
</tr>
<tr>
<td><strong>More support for inter-disciplinary research</strong></td>
<td>43.7</td>
</tr>
<tr>
<td><strong>Access to a wider range of electronic journals</strong></td>
<td>34.9</td>
</tr>
<tr>
<td><strong>More conference and networking opportunities</strong></td>
<td>31.7</td>
</tr>
<tr>
<td><strong>Better research management and leadership</strong></td>
<td>27.5</td>
</tr>
<tr>
<td><strong>General management training</strong></td>
<td>26.2</td>
</tr>
<tr>
<td><strong>Clearer legal and ethical frameworks</strong></td>
<td>15.7</td>
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</table>
What determines biomedical research productivity?

In order to answer this question using the available survey data, authors were divided into two groups of 'high' and 'low' article productivity (as indicated by the number of papers published in the previous 24 months). The higher productivity category includes those authors (79.6%) who published four or more papers; the lower productivity category those (20.4%) who published three or fewer (it should be recalled that these are self-reporting data and possibly exaggerated\(^2\)).

The research question posed here is, “is it possible to predict an author’s level productivity level based on a knowledge of the other questions in the survey?” The tool used here (Table 2) is a binary logistic regression.

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\(^2\) The categories used for reporting numbers of publications in the survey were 0, 1, 2-3 and 4+ and were based on a preliminary bibliometric analysis of publication patterns in immunology and microbiology in ISI Thomson Scientific’s Science Citation Index. The categories were designed to capture roughly equal numbers of publications. This seems to point to exaggerated levels of self-reporting.
Table 2: Logistic regression model predicting author productivity (n=883)

<table>
<thead>
<tr>
<th>Predictor</th>
<th>B</th>
<th>Wald $\Sigma^2$</th>
<th>P</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grant-getting skills (Q18d)</td>
<td>-0.32</td>
<td>15.54</td>
<td>&lt; 0.001</td>
<td>0.72</td>
</tr>
<tr>
<td>Gender (Q21)</td>
<td>-0.61</td>
<td>12.52</td>
<td>&lt; 0.001</td>
<td>0.54</td>
</tr>
<tr>
<td>Motivation (Q18a)</td>
<td>-0.49</td>
<td>15.40</td>
<td>&lt; 0.001</td>
<td>0.61</td>
</tr>
<tr>
<td>Research type (clinical / basic) (Q24)</td>
<td>-0.32</td>
<td>7.74</td>
<td>0.01</td>
<td>0.73</td>
</tr>
<tr>
<td>Availability of e-journals (Q19d)</td>
<td>0.19</td>
<td>8.54</td>
<td>0.01</td>
<td>1.21</td>
</tr>
<tr>
<td>Professional networking (Q18e)</td>
<td>-0.24</td>
<td>8.05</td>
<td>0.01</td>
<td>0.79</td>
</tr>
</tbody>
</table>

Given their answers to the six questions above, we can correctly predict whether an author exhibits high or low productivity 77 times out of a hundred (this is a pretty good result for fuzzy, attitudinal data). It is possible to add extra variables to the model, they improve the predictive ability of the model by such a small margin as to be unhelpful. The key indicator is the `odds ratio’. If we take gender as an example, the odds are 1.85 (1/0.54) to 1 that a higher productivity author will be male than female.

In summary, we can predict high research producers to a surprising extent when the author exhibits the following characteristics:

- high levels of (self-reported) grant-getting skills and knowledge
- male
- high levels of (self-reported) motivation
- pursue a mix of clinical and basic research (researchers who classified themselves at either extreme of the research type spectrum, i.e. wholly clinical, or wholly basic, seem to be less productive)
- report fewer problems gaining access to “all the articles they need”
- report spending a lot of time and energy developing their professional contacts

These are interesting findings which raise major policy issues, urgently in respect of the gender productivity gap in biomedicine. There is also a hint that problems in accessing the journals literature may be a barrier to scientific productivity.

Why are some researchers dissatisfied with the journals system?
To explore this issue, the sample was divided into those researchers (300) who reported that they found it “difficult to get hold of all the articles I need” (Q19d) and those (443) who disagreed.

Table 3: Logistic regression model predicting level of satisfaction with journal access (n=743)

<table>
<thead>
<tr>
<th>Predictor</th>
<th>B</th>
<th>Wald $\Sigma^2$</th>
<th>P</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability of funding (Q12)</td>
<td>0.19</td>
<td>11.85</td>
<td>&lt; 0.001</td>
<td>1.21</td>
</tr>
<tr>
<td>Interdisciplinary work (Q3)</td>
<td>0.14</td>
<td>7.63</td>
<td>&lt; 0.01</td>
<td>1.15</td>
</tr>
<tr>
<td>Information anxiety (Q19c)</td>
<td>0.14</td>
<td>6.16</td>
<td>0.013</td>
<td>1.15</td>
</tr>
<tr>
<td>Bureaucracy (Q11)</td>
<td>0.10</td>
<td>12.69</td>
<td>&lt; 0.001</td>
<td>1.10</td>
</tr>
</tbody>
</table>
This time, a model (Table 3) based on four variables is able to predict the answer to that question 63 time out of 100. Researchers who reported a problem in accessing the literature are:

- more likely to perceive that access to research funding is a problem
- more likely to agree that they feel anxious about how much they don’t know
- more likely to need help and support to work with researchers in other disciplines
- more likely to perceive that bureaucracy and form-filling is a problem

This is difficult to interpret, without access to more data. Simple cross-tabs suggest further significant differences (at the 1% level) between ‘contents’ and ‘discontents’. Discontents are much more likely to be based in smaller European countries, to exhibit low article productivity, and to report that they have a problem attending conferences and other networking events. It is impossible to establish the direction of causality here, if there is any, but there does seem to be a specifically regional dimension to this issue.

**Policy implications**

**Implications for public policy**

The findings of this research represent a cry for help from a key sector of the scientific community. Naturally, they told us that they need more research funding. Money is of course an issue. Research is expensive and resources are tight for everyone. However, the absolute level of resourcing is by no means the only issue. Many respondents pointed out that low success rates for their proposals and short-term funding have combined to create a ‘stop go’ culture that is out of sync with the natural research cycle. Under these conditions, it is very difficult think strategically and to retain and nurture research staff and technicians.

But many of the barriers to scientists becoming more productive could be very effectively addressed without throwing huge amounts of money at the problem of declining European research productivity. Four of the top six issues that researchers highlighted concern the organisational and human resource context for successful research. They want to be able to attract and retain suitably qualified research staff and to offer them greater job security: this suggests that reform of the career structure and opportunities for young researchers is well overdue. Recent figures in The Economist (2005) suggest that Europe needs another 700,000 researchers if it is to meet its overall target of raising spending (private, national and EU) to 3% of GDP by 2010. Scientists also want to be freed from the burden of red tape: are we guilty of over-regulating academic life? They want more autonomy and the freedom to develop their own ideas, perhaps through new seed corn funding mechanisms. At the next level down, it is clear that greater networking opportunities, giving scientists time to breathe and talk to other researchers, especially in other disciplines, might pay handsome dividends. We could achieve a lot by addressing these issues at a small fraction of the cost of the science base.

Finally, how will we know whether these initiatives, were they to be implemented, will actually deliver? We need more creative ways to evaluate research productivity in the internet age: measures that relate information production and consumption to innovation and real-world impacts.

**Implications for publishers**

A rather mixed picture has emerged from this study. Researchers clearly appreciate the investments made in digital libraries of journal articles, realise the huge convenience benefits, yet
are still not wholly satisfied. It is quite likely that the gap identified in this question is more a function of raised expectations than really fundamental problems relating to literature access. However, we should not be complacent, and there is clearly a role for publishers, librarians and the policy community to engage constructively in bridging this gap.

**Conclusions**

It’s time we took a good hard look at maximizing return on scientific research. We don’t need yet another public forum to talk about open access. We need a genuine dialogue with librarians, universities, and funding bodies (with scientists involved) to examine the complete R&D value-chain, from research proposal through citation to exploitation. Changing work practices, addressing productivity bottlenecks, or coming up with alternative output measures may contribute more to scientific and economic progress than publishing model changes or even increased funding.

**Acknowledgments**

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