Open access : toward a new economic model of scholarly publications

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Open Access: Toward a New Economic Model of Scholarly Publications

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ABSTRACT: The mean price of scholarly journals is now three times higher than it was in the mid-1980s. In the meantime, the development of Internet and of informal exchanges between researchers progressively led to the *Open Access Initiative* which aims at freely disseminating scientific publications. This article introduces to the consequences of this evolution and presents the path toward a new economic model of scholarly publications.

"If I have seen further it is by standing upon the shoulders of giants." The famous statement of Sir Isaac Newton demonstrates that the progress of science relies on the dissemination of discoveries and scientific knowledge. Even though scientific progress is not strictly cumulative (Kuhn, 1970) information sharing is the heart of this progress. Nowadays, scientific knowledge is mainly spread through scholarly journals, that is, highly specialized journals where quality controls and certifications are achieved through peer-review.

The first section of this article will present the specificity of the current economic model of scientific publications. The second section will introduce to the open access movement and to its emerging economic model. The third section will point out the potential contribution of Open Access to developing countries.

THE ECONOMIC MODEL OF SCIENTIFIC PUBLICATIONS

The growing complexity of modern science induces a growing need of knowledge dissemination media. The number of academic journals is very difficult to estimate, but according to the "Ulrich's International Periodicals Directory" (http://www.ulrichsweb.com) there were about 164,000 scientific periodicals in 2001 in all disciplines (see Figure 1).

The largest publishers like *Elsevier-Reed*, *Blackwell* or *Wiley* own most of these journals. Over the last twenty years, commercial firms -especially the largest ones- have raised prices at a rate which cannot be justified by cost or quality increase (McCabe, 2000). The evolution of the median cost of serials is summarized in Table 1; it is now three times higher than it was in the mid eighties. Former president of the University of California recently stated: *"University librarians are now being forced to work with faculty members to choose more of the publications they can do without."* (Atkinson, 2003, p.1, original emphasis). As a consequence, Figure 2 shows that, in the USA, acquisition expenditures have tremendously grown and that part of the budgets had to be reallocated from monographs to journals. The rise of journals prices has a multiple origin, one of the most important being provisions to invest in electronic publications (Chartron & Salaun, 2000). Paradoxically, electronic publication, which should reduce costs, is one cause of cost increase. These provisions are nevertheless insufficient to explain the current prices. Elsevier-Reed gross-profit margin is estimated 32% (Wellen, 2004). Such "Microsoft like" margins are very unusual and demonstrate the inefficiency of the scientific publication market. There are four main reasons to this inefficiency:

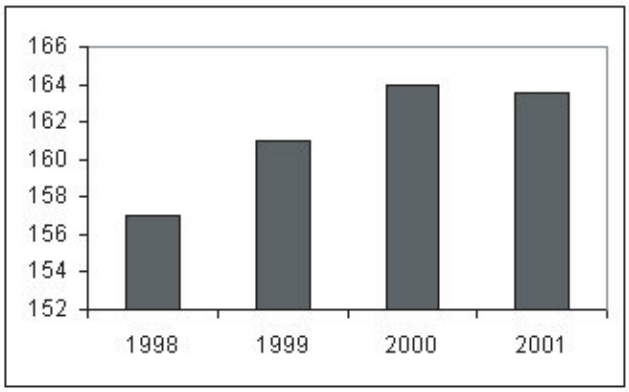

Figure 1. Number of periodicals published worldwide ('000s) 1998-2001. (Source: Ulrich's International Periodicals Directory)

- Researchers publish to popularize their works and to improve peers recognition (which has a great impact on their careers). They are "giveaway authors" (Harnad, 2001) and do not receive any royalties or fees. Furthermore, they do not have to pay to access to scientific information since all the expenses are paid by academic libraries. Authors are then not concerned with the price of journals, they only consider the reputation and the citation impact of the journals they publish in.
- The demand is price-inelastic (that is prices have few impact on the volume of the demand) since prices are not important for researchers and journals are not easily substitutable.
- Libraries evolve on a commercial market but do not have any commercial approach. They buy up to their budget limit and not according to any price equilibrium.

Table 1
Evolution of the Median Value of Serial Unit Cost, 1986-2003. (Source: Association of Research Libraries)

Year	Serial Unit Cost US$	Annual percentage changes	Cumulative percentage changes
1986	89.77	N/A	N/A
1988	117.25	10.94%	30.60%
1990	134.09	4.18%	49.36%
1992	173.67	13.93%	93.46%
1994	200.85	6.67%	123.72%
1996	222.89	3.95%	148.28%
1998	245.05	-1.97%	172.96%
2000	303.19	12.30%	237.73%
2001	282.54	-6.81%	214.72%
2002	296.50	4.94%	230.27%
2003	283.08	-4.53%	215.32%

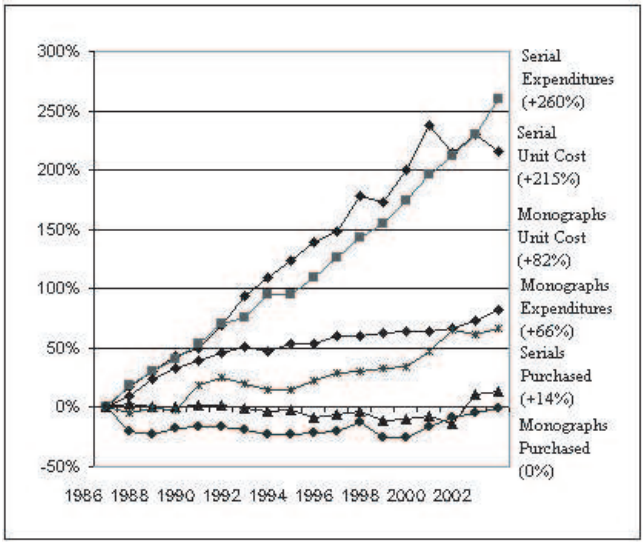

Figure 2. Monograph and Serial Costs in ARL Libraries, 1986-2003. (Source : ARL Statistics 2002-2003)

• The multiplication of mergers among publishers has strongly contributed to the increase of prices (McCabe, 2000).

Moreover, commercial publishers now have a growing aggressive commercial attitude with, for example, journal bundling that obliges libraries to buy journals they do not need if they want to subscribe to prestigious "must-have" journals. The "Big Deal" (Frazier, 2001) -an online aggregation of journals- is so expensive and restrictive that prestigious universities like Stanford or Cornell created sensation in late 2003 by canceling their "Big Deal" (Wellen, 2004).

Symptomatic of this evolution, the new CEO of Elsevier-Reed previously worked in firms operating in highly competitive markets like Procter&Gamble or Guiness (Wellcome-Trust, 2003).

In this context, public research institutions pay twice for scientific knowledge. They pay researchers who publish freely, and publishers to have access to journals (Anderson, 2004).

The growing conflict between researchers, who aim at disseminating their works as widely as possible, and libraries, which have a limited budget on the one hand and publishers who mainly have financials objectives on the other hand, gave rise to an accelerated development of the practice of open access to electronic publications. Governments concerned about research budgets are more and more interested in that movement and try to support it. At the end of January 2004, OECD ministers "(...) recognized that fostering broader, open access to and wide use of research data will enhance the quality and productivity of science systems worldwide. They therefore adopted a Declaration on Access to Research Data from Public Funding." (OECD, 2004). One of the principles of this declaration is to promote "Openness", that is open access to public-funding researches.

THE OPEN ACCESS MOVEMENT

In the Gutenberg Era researchers had no alternative, publishers were the only way to reach readers. In the PostGutenberg Era, digital networks offer a powerful alternative which can lead in the long term to a new organization of scientific publications (Harnad, 1999). Preserving quality controls and certifications through peer-review, this organization should be based on open access to electronic publications. Beginning with self-archiving and repositories, the open access movement is now moving towards free electronic publications.

Self-archiving

From the very beginning, scientists have exchanged information, consulted peers about a given idea or tested colleagues' reactions to an innovative concept. Up to the second half of last century, the main transmission tool was private correspondence via postal mail. With the development of Internet and electronic communications, informal exchanges have exploded since it is now easy and very common to contact a researcher by e-mail to ask him for a copy of a given work.

In order to ease informal exchanges and to increase their visibility, many researchers have used Internet for a long time to self-archive their works, that is to make either preprints (before refereeing) or postprints (after refereeing) available on their own (personal or institutional) web site.

Due to the pressure of the open access movement, the copyright policy of journals and publishers has changed a lot over the last years. The Project RoMEO (Rights Metadata for Open archiving, http://www.lboro.ac.uk/departments/ls/disresearch/romeo/) lists publisher's copyright transfer agreement. Figure 3 shows that 83% of the 10,673 journals listed in September

2004 now accept at least preprint archiving. This percentage was only 55% in 2003. Self-archiving undoubtedly increases

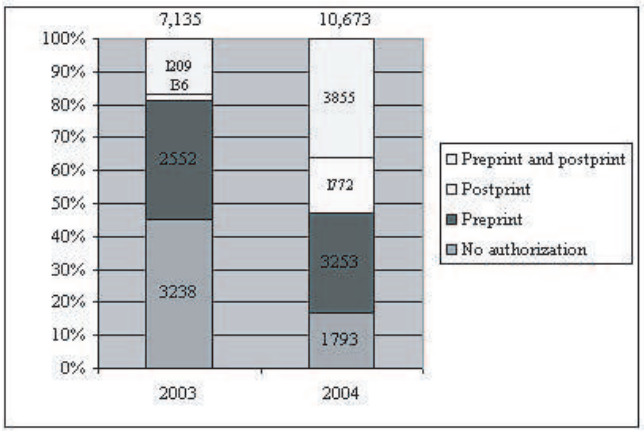

Figure 3. Evolution of journals' self-archiving policies, 2003-2004. (Source: RoMEO)

visibility but, since these archives can only be found through usual search engines, their access is very difficult without the knowledge of the existence of a given work.

Repositories

The success of self-archiving and the difficulty to find self-archived works led Paul Ginsparg, then physicist at the Los Alamos National Laboratory, to initiate in 1991 the *arXiv* archives (http://www.arXiv.org). It aimed at centralizing and easing access to free electronic publications. Researchers were asked to directly archive their works in the repository. With such tools, publications are no longer dispersed among many web sites and are available at once. There are now more than 275,000 articles in *arXiv* with a submission rate of about 3,500 papers per month.

Following this pioneer, other high-level archives emerged. Some of the most important being:

- *Cogprints* (http://cogprints.ecs.soton.ac.uk) specialized in cognitive sciences.
- *PubMed Central* (http://www.pubmedcentral.gov/) specialized in life sciences.
- *Repec* (http://www.repec.org/) and *WoPEc* (http://netec.mcc.ac.uk/WoPEc.html) specialized in economics.
- *Math-Net* (http://www.math-net.org/) specialized in mathematics.
- *NCSTRL* (http://www.ncstrl.org/) and *CiteSeer* (http://citeseer.ist.psu.edu/) specialized in computer science.

The development of repositories and self-archives led to a standardization need, notably to build services permitting to search across multiple repositories. Repositories also needed capabilities to properly identify and copy articles stored in other repositories (Lynch, 2001). These needs, identified by Herbert van de Sompel, led to the Open Archives Initiative (http://www.openarchives.org) initiated by P. Ginsparg in 1999 with "The Santa Fe Convention of the Open Archives Initiative". The Open Archives Initiative designed specific metadata tagging standards (standard format of keywords) to make archives easily harvestable. Even though the Open Archives Metadata Harvesting Protocol is mainly used by free repositories, it is also employed by servers housing commercial products (the term *Open* refers to the technical architecture, not to the fact that the content should be free).

Specific directories like *OAIster* (http://www.oaister.org) or Eprints.org (http://www.eprints.org) now provide lists of OAI-compliant archives. This initiative knows a tremendous success. In May 2005 *OAIster* managed nearly 5.4 million records originated from more than 450 institutions.

Online journals

Publishers could not ignore the progress of electronic publication and distribution. Considering the quick development of knowledge dissemination through Internet, many among them have thus decided to make their journals available online. Apart from their usual paper edition, those journals so try to improve their diffusion and reputation.

Some publishers or institutions also decided to adopt a more radical solution: purely electronic journals. Considering the prices of printing and postal diffusion, electronic publications can reduce the cost of journals (Wellcome-Trust, 2003). Publishers only have to support the organization of the review process and the cost of diffusion tools (software and hardware).

The access to electronic articles originated in classical or electronic journals is usually reserved to subscribers, but a growing number of them are now free on certain condition (such as time-delayed release). In May 2005, the Directory of Open Access Journals (http://www.doaj.org) listed more than 1,500 journals in all disciplines.

One of the reasons of the growing success of open access journals is that open access articles have a greater citation impact than others. Studying 119,924 conference articles in computer science and related disciplines, Lawrence found that the number of citations of open access articles was 2.6 times greater than the number for offline articles (Lawrence, 2001). A recent study based on the ISI CD-ROM citation database concluded that for the year 2001, the citation impact in all physics fields was 5.5 times higher for open access articles (Brody et al., 2004).

THE SEARCH FOR A NEW ECONOMIC MODEL

The transition to electronic journals reduces the costs but is of course insufficient to economically validate the open access model. Apart from subsidy-based free journals, a growing economic model is based on the payment by the authors' institutions. An author-pays model is substituted to the classical subscriber-pays system.

A recent study by the Wellcome Trust tries to compare the costs of classical subscriber-pays journals and of electronic author-pays journals (Wellcome-Trust, 2004). The results are summarized in Table 2. The structure of fixed costs is similar for both types of journals (editorial costs, review

Table 2
Estimates of journal costs.

Cost element[1]	Subscriber-pays journal Cost in US$		Author-pays journal Cost in US$	
	Good to high-quality journal[2]	Medium-quality journal[3]	Good to high-quality journal[1]	Medium-quality journal[2]
First-copy costs per article	1500	750	1500	750
Fixed-costs per article	1650	825	1850	925
Variable costs per article	1100	600	100	100
Total costs per article	2750	1425	1590	1025

[2]Source: (Wellcome-Trust, 2004).
[2]eight articles reviewed for each article accepted.
[3]two articles reviewed for each article accepted.

costs, articles preparation...), but fixed costs are estimated higher for author-pays journals because they have to cover the administration of the charging system to authors. Variable costs differ since the marginal cost of electronic distribution is very low. According to Wellcome Trust: "In terms of costs of production, system costs and the implication of those for levels of fees, the author-pays model is a viable option. Open-access author-pays models appear to be less costly and to have the potential to serve the scientific community successfully." (Wellcome-Trust, 2004).

One of the first author-funded journals was the *New Journal of Physics* launched at the end of 1998 (Haynes, 1999). This journal requires authors of published papers to pay a publication fee of £300. The beginnings were difficult since online journals were not considered as "100% serious" but *NJP* is now ranked 14 of 68 titles in the Physics Multidisciplinary category of ISI's Journal Citation Reports (Haynes, 2004).

The most prestigious initiative yet is that of the Public Library of Science (http://www.plos.org) founded in October 2000 by Nobel Prize recipient Harold E. Varmus, Patrick O. Brown from Stanford University and Michael Eisen from the University of California Berkeley. They received a 9 million grant from the Gordon and Betty Moore foundation and launched a high level journal, *PLoS Biology*, in October 2003. *PLoS Biology* charged authors about 1,500US per accepted article, but, thanks to an equalization system, publications in *PLoS Biology* could be affordable to any laboratory in developing countries (Delbecq, 2004).

The *NJP* as well as *PLoS Biology* do not cover their direct costs yet with authors fees and strongly rely on subsidies. The *NJP* should increase the number of published articles by 150%, the proportion of authors paying articles from the present 60% to 95% and the fee from the present £400 to £600 in order to cover its costs (Haynes, 2004).

The economic model of free publications then remains to be constructed. A pure author-pays system cannot be implemented immediately. Prosser (Prosser, 2003) proposes a transition model where journals would give authors two options:

- To pay for publication and the article will then be freely available.
- Not to pay for publication and the article will only be available to subscribers.

According to Prosser, the numerous advantages of open access, particularly in terms of visibility and citation frequency (Harnad, 2004) should lead to a growing share of author-pays articles.

Prosser's model as well as the propositions of the Open Society Institute (Crow & Goldstein, 2004) remain to be validated. No open-access journal covers its fixed costs yet and the solutions to bring them to financial equilibrium are still to be invented. Furthermore the open-access model undoubtedly has undesired effects:.

- Many scientific societies live by their publications. These non-profit organizations use the publication incomes to finance conferences or scholarships. The development of open-access could threaten their activities.
- By succeeding, the open-access movement will threaten largest publishers. They should be tempted to concentrate their publications on core collections. Loosing economies of scales from successful publications, the cost of marginal highly specialized journals could explode (Okerson, 2003).
- The author-pays model could result in a simple shift from library subscription to research budgets. In 2003, Duke University published about 4,500 papers. If authors had paid 1,500US$ per article the total cost of 6.75 millions would have been close to the current budget for journals which is about 6.6 millions (Guterman, 2004).
- Author-pays journal will inevitably be tempted to accept a growing number of articles in order to cover their fixed costs, the global quality of these publications could then decrease.
- Authors who do not have the budget to finance a publication might look to think tank and corporations to find extra funding. These scientific works will paradoxically be more influenced by political and commercial agendas (Wellen, 2004).

OPEN ACCESS AND DEVELOPING COUNTRIES

During 1998-2000, UK published 4,729 scientific articles per million inhabitants, Czech. Republic published only 1,401 and Turkey 278 (Sandelin & Sarafoglou, 2003). Each year, researchers produce about 2,000,000 refereed articles for 20,000 scientific journals (Harnad, 2003), the huge majority of them being printed in western countries. The contribution of developing countries to these publications is

marginal. In 2000 India published less than 2 percent of world scientific articles; China's share was about 3 percent and Brazil 1 percent (OST, 2004).

The importance of education, research and innovation for economic growth is well known at least since Schumpeter (Schumpeter, 1912). According to Jones (Jones, 2000), between 1965 and 1990, 35 percent of the U.S. growth can be attributable to the rise in educational attainment and 40 percent can be attributable to the rise in worldwide research intensity. From the 1980s, researches and investments in ICT have played a leading role in productivity growth (OECD, 2003). Most developing countries have been unable to be part of this movement, and the tremendous education and research gap between advanced and developing countries has never ceased to expand. Figure 4 summarizes this gap in tertiary education and Table 3 shows that research and development (R&D) expenditures as well as ICT diffusion are strongly correlated to wealth (GDI per capita).

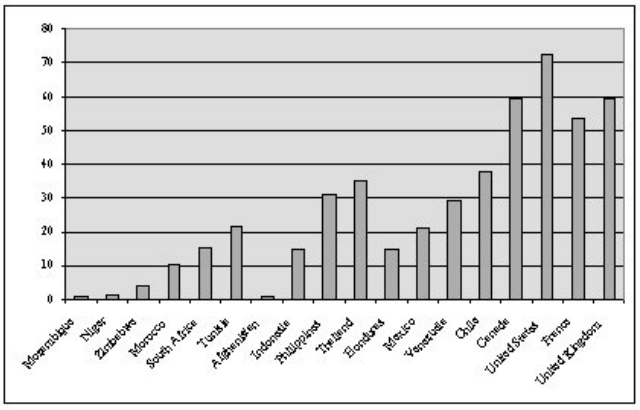

Figure 4. Gross Enrolment Ratio in Tertiary Education 2000/2001. (Source: UNESCO)

The evolution toward open access could contribute to scientific progress in developing countries in at least two ways. It could enlarge the available information base and strengthen regional networks as well as regional organizations visibility.

INFORMATION BASE

We have pointed out the fact that even rich universities cannot afford access to many scholarly journals. This problem is obviously far more intense for low budget institutions particularly in developing countries.

The development of free online journals, of repositories and self-archiving could allow any laboratory in the world to access to some of the most recent publications. Over a million research articles were freely available on the web in 2001 (Lawrence, 2001) and this figure has never ceased to grow. By encouraging specific training for graduate and undergraduate students, teaching them how to access to these free publications, universities in developing countries could both reduce the need of journals subscriptions and enlarge their information base.

Researchers belonging to regional communities could also benefit from these networks. Even though high level researches will still require the acquisition of some specific works, free publications are now sufficient to do the groundwork.

VISIBILITY AND REGIONAL NETWORKS

The development of free journals and repositories stimulate the visibility of researchers and academic institutions (Lawrence, 2001). Regional communities are fully aware of it and are more and more involved in that movement. In South America for example, the project Scientific Electronic Library Online (http://www.scielo.org) is now gathering Brazil, Chile, Cuba and Spain. In Africa, the African Journals OnLine (http://www.ajol.info) promotes African publications and already proposes free abstracts.

Since many institutions and laboratories in developing countries are highly specialized in very specific fields like rural development, tropical diseases or agriculture, the implementation of regional repositories could promote these specific researches and give them a better visibility. The constitution of specific local networks could thus ease the development of works in fields that are considered marginal in developed countries.

Furthermore, the constitution of free access tools to local language literature would help local engineers communities to be aware of recent developments in their field and ease the elaboration of specific solutions.

Implementing a repository is technically relatively easy (Crow, 2002) and specific freely available tools have been developed to help their creation, mainly:

- *Eprints* (http://www.eprints.org) developed by Southampton University.
- *DSpace* (http://www.dspace.org) developed by MIT libraries and Hewlett-Packard.
- *CDSware* (http://cdsware.cern.ch) developed by the CERN.

Such tools allow the quick development both of specific or general repositories and of institution-based self-archiving. Specific regional repositories can then easily be implemented. Sharing the hardware costs between regional institutions could permit to create original exchange systems that would have been impossible to set-up before Internet. Existing initiatives like for example CARINDEX (http://www.mainlib.uwi.tt/), which indexes the content of 70 West Indian Journals, or LATINDEX (http://www.latindex.org/) which promotes Latin America scholarly publications, could initiate at relatively low cost such regional repositories.

Regional institutions could also benefit from the realization of electronic journals. Such journals are cheaper than paper publications and have a greater impact. *PLoS Biology* provides a significant demonstration of the growing reputation of these journals.

International institutions and non governmental organizations working with developing countries are more and more aware of the importance of open access, and

Table 3
Selected R&D and ICT Indicators, 2001. (Compiled form selected UNESCO and World Bank data)

Continent	Countries	Researchers per million inhabitants	Expenditure for RD in million of US$	Expenditure for RD as percent of GDI	Personal Computers per 1,000 people	Internet users per 1,000 people	GDI per capita (2002)
Africa	7	104	1,350	0.24	23	20	1,000
South and Central America	13	221	9,000	0.34	62	53	3,000
Eastern Europe	14	1,634	8,000	0.79	55	49	3,500
Asia [1]	11	1,211	30,500	0.75	30	48	5,500
Oceania	2	2,818	7,000	1.28	495	353	16,000
Western Europe	17	3,142	180,000	2.04	315	327	23,500
North America	2	3,538	305,000	2.37	609	489	29,000

[1]Japan excluded

could help financing initial set-up costs. The United Nations already contribute to disseminate scientific works in developing countries with initiatives like HINARI (http://www.healthinternetwork.org/), which provides free or very low cost online access to the major journals in biomedical sciences to non-profit institutions in developing countries. Some non governmental organizations like the International Council for Science which set-up the International Network for the Availability of Scientific Publications (http://www.inasp.info), also give a great importance to the scientific information gap and could participate to regional electronic journals financing.

CONCLUSION

Open-access is by no way a panacea. It is not economically viable yet and it could have important undesired effects. Nevertheless, the pressure induced on commercial publishers is now very high and they cannot ignore this movement any more. It is now very difficult to imagine that in a decade or more, commercial publications will disappear and be replaced by free publications, but the open-access movement will undoubtedly brake the exploding dynamic of prices.

The Journal of Comparative Neurology cost 18,000US$ a year; Brain Research cost about 21,000US$ and Nuclear Physics A and B more than 23,000US$ (Guterman, 2004). Such exploding prices explain the growing conflict between academics and publishers. The development of the open-access movement is then not the mere consequence of the diffusion of Internet, but also a clear symptom of the inefficiency of the current market and the future equilibrium will inevitably associate commercial and open-access publications. The debate on free publications remains very passionate and is not always rational, but it has the merit to raise a real problem. By modifying the balance of power between researchers and publishers, the success of the open access movement will ease scientific knowledge dissemination, reduce the information gap between wealthy and low budget institutions and help the advent of an efficient market.

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