Producing and Sharing Free Advanced Scientific and Technological Knowledge Using the Internet

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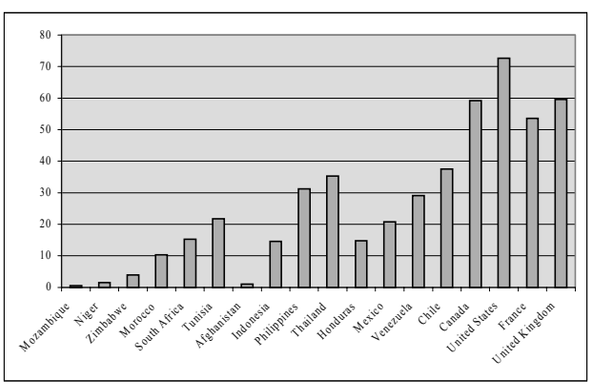
INTRODUCTION

During 1998-2000, the UK published 4,729 scientific articles per million inhabitants, the 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% of world scientific articles. China's share was about 3% and Brazil 1% (OST, 2004).

The importance of education, research and innovation for economic growth is well known at least since Schumpeter (1912). According to Jones (2000), between 1965 and 1990, 35% of the U.S. growth can be attributable to the rise in educational attainment and 40% 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. Chart 1 summarizes this gap in tertiary education and Table 1 shows that research and development (R&D) expenditures as well as ICT diffusion are strongly correlated to wealth (GDI per capita).

Chart 1. Gross enrollment ratio in tertiary education 2000/2001 (Source: UNESCO)



The access to scientific information is a fundamental prerequisite for scientific development. Even though scientific knowledge is not only cumulative (Kuhn, 1970), information sharing is the heart of scientific progress. Like Isaac Newton, contemporary researchers are standing "on the shoulders of giants." Nowadays, this knowledge is mainly spread through scientific journals. These highly specialized publications are very expensive and their cost has tremendously increased over the last years. The median cost of serials is now three times higher than it was in the mid-eighties (Table 2).

The cost of scientific journals is now so high that even wealthy institutions often cannot afford access to many important scholarly publications. In 1999, Yale University had an acquisition budget of about 10 million US$; Harvard had about 17 million US$ and the (relatively low) global acquisition budget for French universities was about 63 million US$ (Chartron & Salaun, 2000) quite equivalent to Peru's total R&D expenditures. In this context, the scientific information access gap between advanced and developing countries seems to be insurmountable.

The Internet is a ground-breaking technology to share information. It allows instantaneous diffusion at a very low cost. We will see that it can become a powerful tool to help developing countries reducing the information gap. The first section will introduce the open access movement. The second section will present the ways scientific information diffusion through the Internet can contribute to developing communities.

INTERNET AND OPEN ACCESS TO SCIENTIFIC INFORMATION

There is now a growing debate on the cost of academic journals and on free access to scientific information. The question here is not to discuss the justifications for these prices (see discussion in Odlyzko, 1998), but to

Table 1. Selected R&D and ICT indicators, 2001 ([a]Japan excluded. Compiled from selected UNESCO and World Bank data.)

	Countries	Researchers per million inhabitants	Expenditure for R&D in million of US$	Expenditure for R&D as % of GDI	Personal Computers per 1,000 people	Internet users per 1,000 people	GDI per capita (2002)
Africa	7	104	1 350	0.34	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[a]	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

insist on the specificity of scientific publications where authors do not aim at making financial profit. Researchers publish to popularize their works and to improve peer recognition (which has a great impact on their careers). They are "giveaway authors" (Harnad, 2001) and do not receive any royalties or fees.

The conflict of interest between researchers and publishers is quickly increasing since the exploding prices of academic journals strongly reduce the diffusion of scientific works. In the Gutenberg Era there was no alternative, publishers were the only way to reach readers. In the Post-Gutenberg 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.

Over the last years, the development of the Internet and the growing conflict between researchers and publishers gave rise to an accelerated development of the practice of open access. Beginning with repositories and self-archiving, it is now moving towards free electronic publications.

Repositories

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 the Internet and electronic communications, informal exchanges have exploded:

- 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 increase their visibility, many researchers use the Internet for a long time to self-archive their works and to make either pre-prints (before refereeing) or post-prints (after refereeing) available on their own Web site.

Considering the success of these informal exchanges, Paul Ginsparg, a physicist at the Los Alamos National Laboratory, initiated in 1991 the *arXiv* archives (http://www.arXiv.org). The objective was to centralize and ease access to free electronic publications. Researchers are asked to directly archive their work in the repository. With such tools, publications are not dispersed among many Web sites and are immediately available. There are now more than 300,000 articles in *arXiv* with a submission rate of about 3,500 papers per month.

Following this pioneer, other high-level archives emerged. The two most famous being *Cogprints* (http://cogprints.ecs.soton.ac.uk) specialized in cognitive sciences and *PubMed Central* (http://www. pubmedcentral.gov/) in life sciences. More specific projects have also been implemented like *Bioline Eprints Archives* (http://bioline.utsc.utoronto.ca/), which specifically aims at increasing visibility and providing open access to research publications from developing countries.