Can 'Open Science' be Protected from the Evolving Regime of IPR Protections?

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ABSTRACT

Increasing access charges and transactions costs arising from monopoly rights in data and information adversely affect the conduct of science, especially exploratory research programs. The latter are widely acknowledged to be critical for the sustained growth of knowledge-driven economies, but are most efficiently pursued in the "open science" mode. In some fields, informal cooperative norms of behavior among researchers– in regard to the sharing of timely access to raw data-steams and documented database resources – are being undermined by legal institutional innovations that accommodate the further privatising of the public domain in information. A variety of corrective measures are needed to restore proper balance to the IPR.

Keywords: economics of information and knowledge, open science, public domain in data and information, intellectual property rights, copyright, database rights, technological "self help," "anti-commons" effects.

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I. Will better fences" make better neighbors in science and technology research?

The American poet Robert Frost's ode to individualism celebrates the stone fences that distinguish the rural landscape of upland New England: "good fences make good neighbors." Perhaps it is so, where the resource involved is land, onto which the livestock from neighboring farms otherwise may wander to graze and thereby destroy the provender of the animals already pastured there. But is it so, too, when one scientist pores over the data gathered by another, examines soundness of the deductive chain of inference leading to a new theory, or tests the efficacy of a proposed method of chemical synthesis? Simple consideration of the "public goods" nature of ideas, data and information tells us that such is not the case; that they are not at all like forage, depleted and degraded by use in consumption and production.

"Public goods" is a term of art in modern economics. It does not refer to the provenance of goods and services, that is to say, with whether they are produced by public agencies or in the private sector of the economy. Rather, this term denotes the class of goods possessing a particular set of properties that distinguish them from ordinary commodities – namely, substantial *indivisibility* or lumpiness, *limitless replicability* at negligibly low incremental cost, invariant availability for concurrent and repetitive use – sometimes described as the property of *infinite expansibility*, or *nonrival-ness* of use. The meaning and significance of these peculiar properties will be considered more fully in the course of the following discussion. For the moment, however, it should suffice to insist that ideas and data-sets are not at all like pastures subject to being "over-grazed."

Instead, they are likely to be enriched and rendered more accurate, more explicitly codified and more thoroughly documented and annotated the more that researchers are allowed to comb through them. It is by means of wide and complete disclosure, and the skeptical efforts to replicate novel research findings, that scientific research communities collectively build bodies of "reliable knowledge." Thus, there are sound reasons in modern economic analysis for hesitating to embrace "private property rights" as a universal panacea which should be applied evermore vigorously and extensively throughout the domain of intellectual and cultural production. This is not to claim that there is no place whatsoever for statutory measures that extend legal protection to the rights of creators of "intellectual property."

The system of resource allocation through competitive markets grounded upon the legal protections afforded to private property has been found to work well in the domain of conventional commodities that are exhausted in the process of use and cannot be simultaneously enjoyed by many. Some of the same beneficial effects observed in that context, undoubtedly, can extend also into the sphere of intellectual production and distribution. But as particularly perverse economic consequences are entailed by the establishment and modification of existing institutional arrangements to effect that extension within the realm of knowledge, information and scientific data, there is an evident need for public policy to be attentive to maintaining a healthy balance between the prospective gains and losses.

Unfortunately, the past two decades have seen the development of just the opposite trend. Most significantly, in my view, the current overly literal application of the metaphor of "property" – which accords exclusive emphasis to the desirability of socially enforced rights to exclude trespassers and to alienate "commodities" on terms set in contexts of voluntary exchange – has resulted in institutional innovations that have a potential to do serious damage in the field of scientific and technological research, with all the adverse implications that this may carry for the long-term course of innovation and economic welfare growth in the advanced, "knowledge-driven" economies and the developing economies alike. By its very nature, the alternative to proprietary research – the pursuit of "open science" – requires patronage from external sources of grant and contract funding, or from those who are personally engaged, and often from both.

Given the budgetary restraints placed upon the use of tax revenues to support the system of devolved patronage of academic-style, "open science" research carried on in universities and other public sector research establishments (PSREs), it has been is tempting to urge the researchers themselves to embrace proprietary research as the solution to the income constraints under which they presently labor. This course of "self-help" in meeting the rising costs of modern scientific research demonstrably has proved attractive to the administrators of many comparatively well-endowed private universities, as well as public institutes in the industrially advanced societies. Yet, in the US, where the latter developments are well advanced and have offered a model that has attracted mimetic policy-makers in the UK and the EU, at best only a small margin of incremental research support, averaging 8-10 per cent among the research universities. Furthermore, in a few specific research fields, and particularly in the life sciences (biotechnology, pharmaceuticals and medical devices), where the share of funding from industrial sources approaches 25 per cent at the leading institutions, the commercialization movement is perceptibly encroaching upon the culture of academic research and challenging the ethos of collaborative, open science.

If there are only rather modest revenue benefits to be gained by PSREs and their researchers through the incentives effects that intellectual property rights protections create for devoting greater attention to commercially-oriented R&D, the same cannot be said about the potential costs. We must worry that further and sustained policies of applying the same "remedy" for the current fiscal situation of the global open science system is likely to have profound and seriously adverse transformative effects. In the end it could result in the paradoxical rise of excessively duplicative research projects by scientists and engineers who find themselves effectively isolated from recent additions to the stock of codified knowledge by increasingly dense "patent thickets," and by steeper "royalty stacking" in the licenses imposed collectively by owners of copyrights and database rights. Whether or not social relations among academic colleagues are radically altered by the new spirit of entrepreneurship and "intellectual capitalism," it seems altogether too possible that the introduction of encryption technologies in digital rights management systems by their institutional hosts could effectively deprive them of electronic access to the flow of datastreams, working memoranda, pre-prints customarily transmitted through cooperative, reciprocal exchange with publicly supported colleagues and institutions elsewhere. Indeed, under the terms of the Digatal Millennium Copyright Act (US), and parallel proposals for the EU, serve legal sanctions could be enforced against researchers within (as well as outside) a university or public institute – and equally within a corporate laboratory – who disabled the institutional digital rights management apparatus in order to continue to engage in the tradition of cooperative exchanges of knowledge.

Yes, the private property rights system offers a readily prescribed and potentially potent "cure" for the condition of impoverished open science. Unfortunately, it is one in which the patients

can be gravely damaged. And it is not only they who may be at risk. The statutory reinforcement of technological "self help" – in the form of digital rights management systems, including increasingly aggressive electronic-countermeasures against possessors of authorized digital content – carries a potential to undo the entire regime whereby public policy regulated the terms that owners of protected intellectual property could make it available to users. In other words, the law of contract – and of one-way, non-negotiable contacts (on the model of the "shrink-wrap," "click-wrap" and "browse-wrap" licensing schemes that are proliferating on the Internet – threatens to displace intellectual property law, along with intellectual property lawyers as we have know them.[1] Surely that consideration, if not a concern for the future of science, technological innovation and long-term social and economic welfare, should provide an impetus for legal scholars and others concerned with the evolution of intellectual property laws to join in the work of devising remedial measures that would counteract this perilous institutional drift.

A very modest contribution to that challenging undertaking is offered in this essay. Starting from a review of the economic rationales that may be provided for legal protection of intellectual property rights, it examines the concatenation of forces that have been driving the privatizing of the public domain in data and information, and the recent direction taken by the evolution of the IPR regime. Focusing upon statutory changes affecting the protections available to owners of copyright in the U.S., and of database rights in the European Union, the analysis points to potentially serious adverse consequences for research in science and technology. Quite clearly, these have not been accorded adequate weight by the proponents of those "institutional adaptations" to the new environment that has been formed by the advance of digital information technologies. This analysis has a purpose beyond that of highlighting problematic developments that are emblematic of the more general contemporary trend towards broadening and strengthening the regime of IPR protections. It points to a variety of practical measures that may be used to construct counter-vailing protections for the pursuit of knowledge through "open science."

II. The simple economics of intellectual property rights

Even when considered in isolation from its possible implications for long-term economic growth, the nature and consequences of recent trends that are altering the world's intellectual property rights regimes is a topic that is attracting great interest and no little disagreement. In some respects this merely continues the long history of antiphony in economics. One set of voices, still carrying the theme enunciated by John Locke and Adam Smith, celebrates the protection of intellectual property – along private property of all forms – as essential for motivating the formation and application of productive resources; whereas, contrapuntal voices deliver variations on Adam Smith's jeremiads against the harms that are certain to befall the ultimate consumers of a good or service whenever an unregulated monopoly is allowed to persist in the chain of production and distribution.

For many economists today the trouble is that they hear both of these voices clearly – inside their own heads. Thus, against the contention that intellectual property monopolies raise prices above unit production costs, and thereby curtail the benefits that consumers derive from the use of "protected" innovations, it is argued that the rights accorded under national statutes and international conventions on patents and copyrights (and, in some jurisdictions, databases) provide a significant inducement – both directly and indirectly encouraging the formation of new "knowledge-

[1] On this prospect, see the contribution by Margaret Jane Radin (2003) in this issue.

assets" through investment in R&D. How strong such effects are in different branches of industry and product markets, gauged either in absolute terms or in relationship to other R&D investment incentives (such as investment tax credits, or vigorous enforcement of trade secrecy laws) remains a quite different, and much vexed empirical question.

There is widespread agreement, nonetheless, on the significance of the fact that for many modern enterprises the performance of R&D and the acquisition and management of R&D-performing entities, are now vital elements in competitive strategies of integrated innovation, production and marketing. For one side of the argument, this suggests that all means of augmenting incentives for R&D – IPR protection among them – will promote the growth, or at least the competitive survival of a nation's industries. Yet, for the opposite side of the argument, what has to be recognized is that whether or not an R&D-intensive firm secures the profitability of its innovations by obtaining intellectual property rights, its own R&D will not go unaffected by the actions of other firms that are acquiring and exploiting patents and copyrights. When intellectual property owners exploit their rights in search of greater profits, the effect almost invariably raises the costs that other parties are obliged incur in order to access and utilize existing knowledge. This applies no less to the uses which such knowledge may have in generating new discoveries and inventions.

Thus, the conclusion at which these analytical excursions arrive is indecisive: the existence of IPR protection provides a positive incentive for investing in the production of scientific and technological knowledge, and, at the same time adversely impacts either the efficiency of the R&D process, or the volume of such investment, or both. So, were you to ask the representative economist to pronounce upon the rightness or wrongness of intellectual property protections, you would get the same inconclusive conclusion that was offered more than four decades ago by a pioneer student of the economics of knowledge. In a submission to the Judiciary Committee of the U.S. Senate in 1958, the widely respected economist Fritz Machlup observed:[2]

> "If we did not have a patent system, it would be irresponsible, on the basis of our present knowledge of its economic consequences, to recommend instituting one. But since we have had a patent system for a long time, it would be irresponsible, on the basis of our present knowledge, to recommend abolishing it."

Although economic analysis still has not been able to offer policy-makers with a basis for choosing between "all or nothing" where intellectual property protection is concerned, as MACHLUP [1958: p. 80] rightly went on to observe, "it does provide a sufficiently firm basis for decisions about 'a little more or a little less' of various ingredients of the patent system." Indeed, in this more limited task quite substantial progress has been made in recent years.[3] It is for these and related reasons that the effects of the *changes* which have been taking place at the national and international levels in IPR regimes not only deserves explicit notice in any serious discussion of "knowledge-driven" economic development, but also is a matter on which modern economics has something helpfully clear-cut to contribute.

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[2] MACHLUP, FRITZ [1958], p. 80.

[3] For reviews of the analytical literature in this vein, see, e.g., DAVID, P. A. [1993].

To properly grasp the key to the economics of intellectual property, one should start with the fact that knowledge is not like any other kind of good, and certainly does not resemble conventional commodities of the sort that are widely traded in markets. Intellectual property cannot be placed on an equal footing with physical property, for the simple reason that knowledge and information possess a specific characteristic that economists refer to as "non-rival in use": the same idea and its expression may be used repeatedly, and concurrently by many people, without being thereby "depleted."

This hardly is a modern insight, for the point was made almost two hundred years ago with precision and elegance in a letter penned to a Baltimore inventor by Thomas Jefferson in 1813: "He who receives an idea from me, receives instruction himself without lessening mine; as he who lights his taper at mine, receives light without darkening me." For Jefferson, this was a consequence of nature having "peculiarly and benevolently" arranged that "ideas should freely spread from one to another over the globe, for the moral and mutual instruction of man...when she designed them, like fire, expansible over all space, without lessening their density at any point, and like the air in which we breathe, move, and have our physical being, incapable of confinement or exclusive appropriation."[4]

Modern economics identifies this property of information (infinite expansibility) as one of the two characteristics defining that special category of commodities known as "pure public goods," the other being the costliness of excluding others from possession of an idea once it has been disclosed. More is at stake in the present context than a definition: the economic significance of the public goods nature of ideas and data is that the operation of competitive markets cannot be relied upon to yield price signals that lead to socially efficient outcomes with respect to the production and distribution of such commodities. From this condition flows the logic of public patronage for fundamental, exploratory research, the outcomes of which constitute vital informational "inputs" that guide and enhance the expected rate of economic returns from investment in commercial applications-oriented R&D. Adhering to the analytical economics perspective that what is being protected by patents and copyrights is the exclusive right to the commercial exploitation of *information*, proves especially useful when one comes to consider the implications for scientific research activities of statutory obstacles to information access that have been created, and may yet be given force by the movement to strengthen and extend protection for intellectual property.

The creation and assigning of intellectual property rights convey a monopoly right to the beneficial economic exploitation of an idea (in the case of patent rights) or of a particular expression of an idea (in the case of copyright) in return for the disclosure of the idea or its expression. This device allows the organisation of market exchanges of "exploitation rights," which, by assigning pecuniary value to commercially exploitable ideas, creates economic incentives for people to go on creating new ones, as well as finding new applications for old ones. By allocating these rights to those who are prepared to pay the most for them, the workings of intellectual property markets also tend to prevent ideas from remaining in the exclusive (secret) possession of discoverers and inventors who might be quite uninterested in seeing their creations used to satisfy the wants and needs of other members of society.

Thus a potential economic problem that is addressed by instituting a system of intellectual property rights is the threat that unfair competition, particularly the misappropriation of the benefits of someone else's expenditure of effort, may destroy the provision of information-goods as a

[4] DAVID [1993] may be consulted for references, and further discussions of these passages in Jefferson's writings.

commercially viable activity. The nub of the problem here is that the cost of making a particular information good available to a second, third, or thousandth user are not significantly greater than those of making it available to the first one. Ever since the Gutenberg revolution, the technical advances that have lowered the costs of reproducing "encoded" material (text, images, sounds) also has permitted "pirates" to appropriate the contents of the first copy without bearing the expense of its development. Unchecked, this form of unfair competition could render unprofitable the investment entailed in obtaining that critical first copy.

Producers of ideas, texts, and other creative works (including graphic images and music) are subject to economic constraints, even when they do not invariably respond to variation in the incentives offered by the market. If they had no rights enabling them to derive income from the publication of their works, they might create less, and quite possibly be compelled to spend their time doing something entirely different but more lucrative. So, there is an important economic rationale for establishing intellectual property rights.

To summarize, the "property" solution, which creates rights the fruits of intellectual creations, possesses a number of definite virtues. These may be quickly adumbrated for the case of patents:

- The patent provides an obvious and recognised solution to the economic problem of the intellectual creator. By increasing the expected private returns from innovation, it acts as an incentive mechanism to private investment in knowledge production.
- Patents facilitate the market test of new invention because they allow disclosure of the related information while (in principle) protecting against imitation.
- Patents create transferable rights (by granting a license, the owner of the knowledge allows it to be exploited by other agents) and, therefore, it can help to structure a complex transaction that also concerns unpatented knowledge.
- Patents are a means to signal and evaluate the future value of the technological effort of the companies that own them (which is particularly useful in the cases of new or young companies for which other classes of "intangibles" cannot be used for proper evaluation).
- This way of providing market incentives for certain kinds of creative effort leaves the valuation of the intellectual production to be determined *ex post*, by the willingness of users to pay; it thereby avoids having society try to place a value on the creative work *ex ante* – as would be required under alternative incentive schemes, such as offering prospective authors and inventors prizes, or awarding individual procurement contracts for specified works

But, establishing a monopoly right to exploit that "first copy" (the idea protected by the patent or the expressive material protected by copyright), alas, turns out not to be a perfect one. The monopolist will raise the price of every copy above the negligible costs of its reproduction, and, as a result, there will be some potential users of the information good who will be excluded from enjoying it. The latter represents a waste of resources, referred to by economists as the "deadweight burden of monopoly": some people's desires will remain unsatisfied even though they could have been fulfilled at virtually no additional cost. This is but one of the things that are likely to go awry in the case of patent protection, as may be seen from the list of "vices" that is appended to the "virtues" of patents; and a similar catalogue can be given for copyright : see the box]. Not surprisingly, then, the subject of intellectual property policies has proved troublesome for the

economics profession, as it presents numerous situations in which the effort to limit unfair competition and provide adequate "market incentives" for innovation demonstrably results in a socially inefficient allocation of resources.

From both the viewpoints of legal theory and economic analysis there is much to be said for interpreting patent and copyright institutions as a remarkably ingenious social contrivances, whereby protection of the discoverer's or inventor's exclusive right to commercially exploit new knowledge is exchanged for the disclosure of information that creates a public good; and, moreover, a public good that may be drawn upon to produce additional discoveries and inventions.[5] Nevertheless, it ought not to be supposed that the actual provisions of the laws affecting intellectual property rights fully honor this social bargain. True, no patent is valid that does not describe the invention in "clear, precise, and exact terms," thereby disclosing sufficient information to enable second-comers to practice the invention without "undue experimentation." American patent law is unusual in going farther than this, in requiring the patent applicants to disclose the best mode in which they contemplate implementing their invention. But, in practice these provisions often prove insufficient to overcome the effects of the economic incentives that patentees usually have to withhold some pertinent information, either for their private use or as a basis to extract additional rents for the transfer of know-how that is complementary to that disclosed by the patent.

Delays in the release of information add to the academic research community's concerns over the way that the workings of the patent system restrict access to new scientific and technological findings. U.S. patent law follows the principle that priority in invention, rather than being first to file a patent application is what matters; it therefore allows applicants a one-year grace period after publication. But most foreign systems award patents on a "first to file" basis, which means that even American researchers are induced – by their own or their supporting organization's commercial goals – to delay publication of their findings and inventions until they have prepared patent applications to secure rights in other countries. During the two decades following the passage of the 1980 Bayh-Dole Act, which authorized universities in the U.S. to seek patents on innovations arising from federally funded research projects, there has been more-or-less continuous modification of institutional rules in the direction of lengthening the permissible duration of delays placed on the publication of research findings for purposes of allowing the filing of patent applications.[6]

From the standpoint of academic researchers the greatest deficiency of the statutory disclosure requirements imposed by patent laws is simply that little scientific or technical data may be divulged in meeting this stipulation, so that the patent itself is of only limited interest and serves mainly as a notice that the patentees may be willing to supply more useful information, for some fee. Moreover, researchers' ability to make use of such information as the patent does divulge is by no means assured until the end of its life; the patent not only excludes others from selling the invention, but also prohibits them from making and using it. That the use of an invention for purposes of research, and hence in generating further discoveries and innovations, ought not be proscribed has long been recognized by patent case law in the U.S: researchers have been allowed to defend

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[5] For the legal and economic interpretations, respectively, see, e.g., EISENBERG, R.S. [1989]; DASGUPTA, P. and DAVID, P.A. [1987]; DASGUPTA, P. and DAVID, P.A. [1994]; DAVID, P.A. [1994].

[6] The effects of the Bayh-Dole legislation (U.S.C. §§200-211: 291-307) on university patenting activity are reviewed by MOWERY *et al.* [2001]; COHEN, FLORIDA and R. GOE [1994] report findings from a survey of U.S. university-industry research centers on the distribution of permitted restraints on publication to allow for the filing of patent applications. The significance of these delays and other restrictions is discussed by DAVID, P.A. [1996].

themselves from infringement suits on grounds of "experimental use" – so long as the infringer is able to show that no commercial benefit was derived thereby. Given the case law precedents in the U.S. that reject this defense when the infringing researcher is found to have profited, the drive on the part of university administrators to exploit patent rights under the provisions of the 1980 Bayh-Dole Act may thus be seen as contributing indirectly as well as directly to creating more formidable barriers to the ability of academic researchers to rapidly access new research tools and results.[7]

The same situation does not arise with conventional copyright protection, since what is being protected is the published form in which ideas have been expressed; only that which is fully disclosed can qualify the author for legal protection against infringers. Inasmuch as it is difficult, if not impossible to establish that unauthorized copies were made of a text that had not been made public in some way, authors seeking legal protection for their work have every incentive to hasten its disclosure. Moreover, in recognition of the cultural and scientific benefits of exegetical and critical writings, and further research based upon published information and data – not to mention the interests of authors in having such usage made on the basis of accurate representations of their work – statutory exceptions traditionally are provided to permit "fair use" infringements of copyrighted material. Largely for these reasons, this form of intellectual property protection historically has not raised serious objections on the grounds of impeding rapid access to new scientific or technological data and information. But, the situation has changed.

III. The recent renewed push for stronger, more extensive intellectual property rights…

The economic prominence of intellectual property, and concerns to strengthen the legal protections afforded patents, copyrights and trademarks, have been rising in recent years. In the U.S. over the past decade both patent applications and patent grants have increased at a rate of about 6 per cent per annum, compared to about one per cent per annum in the preceding forty years. The value of intellectual property is increasing as a share of average total firm value; the number of patent applications is growing at double-digit rates in the major patent offices; and licensing and cross-licensing are being employed with greater frequency than ever, particularly so in high-technology industries. The greater intensity of innovation, characteristic of the knowledge-based economy, and the increase in the propensity to patent (that is, the elevation of the ratio number of patents/number of innovations or number of patents per real R&D spending), which indicates the emergence of new research and innovation management techniques, are proximate developments driving these quantitative trends.[8]

There is a qualitative aspect to the growth of patenting as well. Patents are being registered on new types of objects such as software, genetic creations and devices for electronic trade over the Internet, and by new actors (universities, researchers in the public sector). This general trend is also reflected in the increase in exclusivity rights over instruments, research materials and data bases. All

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[7] DAM [1999: pp. 7-8] points out that because the case law has tended to reject the "experimental use" defense against infringement suits whenever the researcher might profit, this exception to patent protection is less likely to prove beneficial for academic researchers in fields like biomedical sciences, where even publicly-funded "basic" research may yield short-term economic payoffs.

[8] See, e.g., KORTUM, S. AND J. LERNER [1998], "Stronger Protection or Technological Revolution: What is Behind the Recent Surge in Patenting?" *Carnegie-Rochester Conference Series on Public Policy*, 48, pp. 247-307.

this contributes to the unprecedented expansion of the knowledge market and the proliferation of exclusive rights on whole areas of intellectual creation.

Numerous economic forces are driving these developments. First, patents have acquired increased importance among the intangible assets of new and/or small companies, and more broadly for many firms involved in innovation-based competition, because this is sometimes the only effective way to signal the enterprise's value to potential investors. Second, patents have acquired greater strategic value in industries where previously they were acquired more-or-less as a by-product of the R&D process: extensive portfolios of legal rights have come to be valued as means of deterring other firms from entering a market niche, and as weapons to counter infringement suits filed by rivals.[9] Even for mid-size firms, however, the goal of building an effective "defensive" patent portfolio is likely to remain excessively costly, and so the new defensive environment has elicited the emergence of an alternative strategy: "defensive publishing." By openly describing an invention, and so establishing it's place in the "prior art," the strategy of pre-emptive disclosure aims to preserve the option eventually to employ an invention free from the interference of anyone else who might come upon and manage to patent the same idea.[10]

The third set of "drivers" has been the policy changes taking place in the U.S. and Europe. Patenting policy as decided by the patent offices and courts deals with the interpretation of the three basic patentability criteria. They always played a role of regulation, blocking or slowing down private appropriation in certain fields. Since the 1980's pro-patenting attitudes at high levels of government have reflect themselves in the rules followed by patent offices: patentability criteria have gradually been eased and extended to new subject matter areas. The increasing ability of researchers to obtain patents on fundamental knowledge, research tools and databases is part and parcel of the broader movement towards strengthening IPRs whose implications for the conduct of scientific research have become increasingly problematic.

Lastly, it is important to briefly notice the reinforcing effects of alterations in the behaviors of commercial firms, non-profit organizations and public institutions. Prominent under this heading are:

(1) Major investment commitments to basic research by private firms in certain sectors (notably in the genomics area, where a new generation of firms has emerged with research specialisations that bring them into direct rivalries with the fundamental research programs being carried on in universities and other public sector research establishments (PSRE's) .

(2) Changes in the behavior of universities and public institutes have contributed significantly to increased patenting in the U.S., particularly in the biotechnology and medical devices fields; more generally universities have become more and more oriented towards exploiting the intellectual property system as a means of capturing revenue, and demonstrating a commitment to the promotion of economic development in their regions. (See Henderson et al., (1998) [R. Henderson, A. B. Jaffe, and M. Trajtenberg, " Universities as a Source of

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[9] See e.g. GRANSTRAND, O. [1999], *The Economics and Management of Intellectual Property: Towards Intellectual Capital*, Edward Elgar: Cheltenham; HALL, B.H. AND R.H. ZIEDONIS [2001].

[10] See MILSTEIN, S. [2002], "New Economy—Many midsize companies find the 'defensive publishing' is a quick and cheap way to protect intellectual property," *New York Times*, 18 February, p. C3. This strategy would appear to be most effective in the cases of process inventions that are quite specific in nature, and have strong complementarities with the firm's line of business.

Commercial Technology: A Detailed Analysis of University Patenting, 1965-1988," Review of Economics and Statistics, 1998: pp. 119-127] ; Mowery et al. (2001.)

(3) Privatization of some of the activities of governmental civilian agencies which become major players in the contractual research market. (See Jaffe and Lerner (1999) [A. B. Jaffe and J. Lerner, "Privatizing R&D: Patent Policy and the Commercialization of National Laboratory Technologies," National Bureau of Economic Research Working Paper No. 7064 (April), 1999.]

These trends toward commodification of information do not necessarily lead to an *excessive* privatization of knowledge. In many cases the establishment of intellectual property rights strengthens private incentives, allows the commitment of substantial private resources, and thereby improves the conditions for the commercialization of inventions to benefit ultimate users. Moreover, the establishment of private rights does not totally prevent the diffusion of knowledge, even if it does limit it. Finally, a large proportion of private knowledge is disseminated outside the market system, either within consortia or by means of networks of trading and sharing of knowledge, the foundation of the unintentional spillovers.

Further, too much should not be made of the separation between the spheres in which information-goods are freely shared, and that in which access to them is tightly controlled by private profit-seeking agents. At least, it is important to notice that there is a region in which the two can overlap. Indeed, business publishers actually may find it possible to enhance their profits by permitting and even facilitating free sharing of information goods among *socially connected* producer- and consumer-groups – that is to say, among bounded entities (such as families, social clubs, and work-groups) in which membership is limited by conditions other than payment of fees, and within which there is considerably less heterogeneity of demands for the goods in question than that which exists in the population at large.

Allowing free sharing in this sphere, in effect, permits self-aggregation of potential customers into collectivities whose joint "willingness to pay" will significantly excess the sum of the constituent members' willingness to pay on for the good or service in question.[11] In the context of the present discussion, therefore, it is especially appropriate to point out that academic scientific research *networks* are in a sense paradigmatic of the self-selected producer groupings whose information goods requirements might be more profitably met by publisher/vendors who permitted, or actually facilitated free (intra-group) sharing.[12] Viewed from this perspective, the current rush to tighten the copyright regime and encourage strict enforcement of "anti-piracy" provisions of all kinds, may at some date in the not-so-distant future come to be perceived as having been a serious mistake, not only because its consequences were injurious to the conduct of open science, but because they were antithetical to the development and exploitation of new and more profitable business opportunities. Nevertheless, its evident that additional information about the

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[11] On the conditions under which publishers' profits are raised by permitting free sharing of copyrighted material, see, e.g., LIEBOWITZ [1985], Besen [1986], BESEN AND KIRBY [1989] and BAKOS, BRYNJOLFSSON AND LICHTMAN [1999]. These contributions represent important qualifications of the widely asserted claim that digitally assisted, low marginal cost reproduction encourages "piracy" (unlicensed copying and redistribution) which must be injurious to copyright holders, and therefore warrants introduction of stronger protections against all unauthorized copying.

[12] Moreover, in "the knowledge society" – where collaborative generation of new ideas and practices is expected to characterized a larger and large segment of business activity – the scientific research network conceived of as a form of "competence based club," may become a paradigm for an economically much larger part of the market for information-goods that are research inputs.

distribution of potential customers for information goods is required to exploit the opportunities to profit by permitting free sharing, and that many vendors are content to avoid the costs of such strategies altogether, along with the possibilities that they could be abused.

There are clear grounds for concern that virtually the recent trends contribute to a general shift towards enlargement of the domain of private property in information-goods, and the strengthening of protections for such rights. This reflects a sea-change in attitudes regarding the proper role of IPRs: traditionally, IPRs have been considered as one among a number of policy instruments that modern societies can use to elicit the disclosure of technological information, and to spur innovative efforts. On this view, they co-exist with other incentive structures, each of which has its drawback as well as its peculiar advantages, so that there are system level complementarities to be gained when they are employed in proper balance with one another.[13] The new view that has come to dominate recent policy discussions, however, is that IPRs are the only satisfactory instrument because they provide automatic commodification and "valorization" of the intangible capital represented by knowledge; they are therefore the common currency or 'ruler' for measuring the output of activities devoted to knowledge generation and the basis for markets in knowledge exchange.

Leaving aside the matter of its analytical defects, the strength of support this policy stance has enjoyed in government circles is puzzling in light of the repeated survey findings which reveal that patents are not regarded by industrial firms as the most important means of appropriating the economic benefits of their innovations, or of protecting their competitive advantage vis-à-vis rivals.[14]

IV . . . and its impacts on open science

The restructuring of the legal regimes relating to patents and copyrights, and the adjustments of behavior to the new incentives created by those institutional innovations are likely to impact the organization and conduct of scientific research and publishing. Indeed, they seem bound to figure among the more prominent unexpected consequences of the very same digital infrastructure technologies that were created by publicly sponsored scientists and engineers. Unfortunately, at least some of these repercussions now appear to be detrimental to the long-term vitality of the practice of "open" science in the world's academic research communities. Such an untoward effect will not follow from the technology itself. It comes, instead, from the lack of appropriate concern for maintaining a healthy balance between the domain of publicly supported knowledge production and exchanges, and the sphere in which flourish private, proprietary R&D and profitable businesses based upon information goods.

One source of difficulty in preserving such balance is quite immediately apparent. An attractive short-run strategy of business development entails utilizing enhanced information processing and telecommunications in conjunction with the assertion of private property rights over the mass of publicly provided data and information products. Rather than having to produce wholly new content for distribution via the new and more effective technical facilities, an obvious first line of enterprise is to make use of what comes freely and most readily to hand. Ever since the introduction of printing with moveable type, the history of new publication and broadcast media has

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[13] This formulation is presented in DAVID [1993]; DASGUPTA AND DAVID [1994].

[14] See, LEVINE, R.C. *et al.* [1987]; ARUNDEL, A. [2000]; COWAN, R. AND E. HARRISON [2000].

shown how automatic it is for entrepreneurs to seek first to draw upon content that was already available in the public domain.

Hence, one can expect that this approach will continue to be tried, exploiting larger and larger portions of the body of codified scientific knowledge and observational data that has been built up under public patronage and maintained as a common, readily accessible research resource. Sometimes the commercialization of public databases makes good economic sense: because private firms may have technical or marketing capabilities that would add value for a variety of end users of publicly generated data, whereas existing government agencies or NGOs lack that competence. Such was shown to be the case in regard to the distribution and packaging by commercial weather information services of data gathered by the U.S. National Oceanic and Atmospheric Administration (NOAA).[15]

But, the possibility of seriously adverse consequences elsewhere in the national research system, from ill-designed policies and programs to promote proprietary exploitation of public knowledge resources, also needs to be recognized. Consider what ensued in those circumstances from the Reagan Administration's sponsorship of the Land-Remote Sensing Commercialization Act (1984), under which the responsibility for the operations of the Landsat system of remote sensing satellites was transferred from NOAA management, and a monopoly on Landsat images was awarded in 1985 to the Earth Observation Satellite (EOSAT) Company, a joint venture of Hughes and RCA. The price of Landsat images immediately rose 10-fold, from $400 per image to $4000. This permitted EOSAT to attract profitable business from commercial customers and the federal government, although virtually none from academic and independent researchers. Indeed, the impact of the privatization of Landsat operations upon basic research being conducted by university groups around the world was quite devastating, as, they suddenly went from being "data rich" into a condition not of actual "data poverty" so much as one of data "non-entitlement."[16]

The EOSAT Co. secured its monopoly position in the market for satellite images by virtue of being given physical control over the source of (Landsat) images. Yet it is equally possible to imagine that a similarly damaging outcome for academic researchers would follow from the exercise of the market power that a commercial provider of a scientific database might gain under intellectual property protection; especially under a legal regime that granted indefinitely renewable copyright protection to the database contents, whether or not the data was otherwise copyrightable.[17]

The recent extension of copyright to software has itself permitted a breach of the disclosure principle that parallels the one already noted in regard to patents. Under American copyright law (in order to qualify to pursue infringers for damages) it is sufficient to register only some sample extracts of a computer program's "text," rather than the entire body of code. Moreover, there is no requirement whatsoever to disclose the underlying "source code"; copyright protection can be obtained on the basis of a disclosure of just the machine language instructions, which, even were they to be divulged in their entirety would be difficult and costly to interpret and re-utilize without

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[15] See National Research Council [1997], pp. 116-124, for material underlying this and the following discussion.

[16] The introduction here of the term "non-entitlement" is a deliberate allusion to Amartya Sen's observation that people starved in the Indian famine of 1918 not because the harvest was inadequate to feed them, but because the rise in grain prices had deprived them of "entitlement" to the food that actually was available.

[17] It will be seen (from the discussion below) that such also may be the import of the European Commission's Directive on the Legal Protection of Databases, issued on March 11 1996.

access to the source code. While this practice surely can be seen to violate the principle that no burden of "undue experimentation" should be placed upon second comers, the latter requirement is one that holds only in the case of patent law. It never was contemplated that one might be able to register a text for full copyright protection without practically disclosing its contents to interested readers.

A further, more generally disconcerting set of developments may prove quite destructive to the effectiveness of traditional safeguards against "fair use" exemptions for research (and educational) purposes – even where such provisions continue to be made. This threat has emerged only recently in the form of digital technologies that limit "on line" copying of electronic information. Advanced encryption systems now underpin many computing and communications security services, and permit a wide variety of security objectives to be achieved by establishing discretionary control over access to encrypted data, along with assurance for both users and service provider of message authentication and data integrity, as well as privacy and confidentiality goals. There are other techniques for marking and monitoring the use of distributed digital information, such as "water marking," which attaches a signal to digital data that can be detected or extracted later to make documentable assertions about its provenance, authenticity, or ownership; "fingerprinting" embeds a mark in each copy that uniquely identifies the authorized recipient.

"Self help" or "copyright management" systems that make use of encryption or prevent unauthorized copying of "cleartext" allow copyright holders to enforce their legal claim to capture economic value from users of the protected material, and, moreover enable selective access to elements of content that makes it more feasible for the vendor to engage in price discrimination. Marking and monitoring techniques, in contrast, do not allow direct enforcement of copyrights, but can be used to deter unauthorized copying and distribution of information by facilitating tracking of errant data to the original recipients who were responsible for its improper use.

These advances in digital technology have a direct economic effect that is efficiency enhancing, insofar as they reduce the costs of enforcing a statutory property right and thereby securing whatever societal benefits copyright legislation is designed to promote. Yet, in the currently prevailing enthusiasm for stronger intellectual property protection, the American drafters of the 1998 Digital Millennium Copyright Act included a provision that prohibits the circumvention of "any technological measure that effectively controls access" to a copyrighted work, and outlawed the manufacture, importation or public distribution of any technology primarily produced for the purpose of such circumvention.[18] The problem posed by this statutory reinforcement for applications of novel self-help technologies is simply that it may render impossible the exercise "fair use" of copyrighted material by researchers and educators, leaving the provision of information access for such purposes as a matter for the discretion of copyright holders.

This, however, is not the only serious assault upon the traditional means of permitting publicly supported open science communities to pursue their work untrammeled by the protections afforded to copyright owners. As attractive as the prospect of more powerful "self help" technologies may appear to be in curtailing "digital piracy," such remedies would create a threat to the achievement of a reasonably regime for the allocation of scientific and technological information goods while providing protection for private investments in information goods. One way in which it is feasible to approximate the efficient workings of a system of discriminatory pricing for data and

[18] See Digital Millennium Copyright Act (1998), United States Code, 17, §1201; also, DAM [1998].

information is to allow educators, scholars and researchers to invoke "fair use" exemptions from the requirements for licensing material that is copyrighted or otherwise legally protected by statute. In effect, this approach would set differentially lower prices for the use of information goods in producing and distributing knowledge – indeed, prices that approximate the negligibly small marginal costs of digital reproduction and transmission.

But, so far we have considered only the most straightforward and obvious of the potentially adverse consequences of turning over parts of the public knowledge domain to information monopolists. The staking out of property rights to scientific knowledge has potentially serious and subtler implications for the circulation of information and its use in research. These may be grouped, for the sake of convenience, under the general heading of "transaction costs increases." Firstly, it is possible that IPR-related transaction costs may increase so much that the result can be the blockage of knowledge exploitation and accumulation. Attention has lately come to focus on the potential "tragedy of the anti-commons" in biotechnology, which envisages a state of affairs in which the knowledge domain has been so minutely sub-divided by property claims on what are essentially complementary pieces of information that the costs of assembling the constituent "properties" needed to engage in further research will pose a crushing burden upon further technological advance.[19]

The language here is perhaps rather overdrawn; rather than the "destruction the commons by overgrazing" (something that actually was rare in the history of Europe's agrarian communes), a more informative metaphor is that of the erection of so many toll stations along the research paths that only journeys promising the highest, and most certain economic payoffs would be undertaken. The point brought out by the latter formulation is that one should not expect to find evidence of a blockage of R&D projects in general, or frequent cases of breakdowns of negotiations when projects are well underway.[20] Anticipations of numerous costly negotiations to secure critical licenses would have the effect of discouraging attempts to pursue certain classes of projects, particularly the higher risk, exploratory lines of research that combine the use of protected research tools or assemble protected technological sub-components in to more complex systems.[21]

Secondly, efforts and costs devoted to sorting out conflicting and overlapping claims to IPR will increase as will uncertainty about the nature and extent of legal liability in using knowledge inputs. Again policy makers and academics are concerned with the increase of litigation costs, including indirect costs, which may distort the innovative behavior of small companies. As put well by John Barton, there is a problem when "the number of intellectual property lawyers is growing faster than the amount of research."[22] That is what has been happening in the U.S., and there are trends emerging in western Europe that suggest it is not exclusively an American pathology.

V. Property rights in scientific databases: a "digital technology boomerang"

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[19] In regard to the argument regarding the perverse influence of IPR upon innovation, much interest recently has been stirred by the "anti-commons" formulation in HELLER, M.A. and R.S. EISENBERG [1998]. The general point, however, has been in circulation among economists and IPR lawyers for some time: see, for example, MERGES, R.P. AND R.R. NELSON [1994]; DAVID, P.A. AND D. FORAY [1995].

[20] Historical cases of bargaining breakdown, and refusals to license key patents are documented by MERGES, R. [1994].

[21] This is the essence of the more nuanced view developed in EISENBERG, R.S. [1999].

[22] BARTON, J.H. [2000], "Reforming the patent system," *Science*, v.287, n. 5460.

A new and quite unexpected direct threat to the academic research enterprise in science and engineering has emerged since the mid-1990's, as a result of the extension of *sui generis* copyright protection to databases, even to databases containing non-copyrightable material. This institutional innovation emerged first in the European Union Directive on the Legal Protection of Databases (issued March 11,1996), which directed member states to create a new broadly comprehensive type of intellectual property that was free from a number of the important and long-standing limitations and exceptions traditionally provided by copyright law, in order to safeguard access to information used in socially beneficial, knowledge-creating activities such as research and teaching. The EU Database Directive applies equally to non-electronic and electronic databases, even though, as will be seen, it originated as a strategic "industrial policy" response to the commercial development of on-line (electronic) databases in America.

Further, as a device to secure international acceptance of the new approach initiated by this directive (which remains binding upon the member states of the European Union, in the sense of requiring implementation in each of their national statutes) reciprocity provisions were included. The latter in effect threatened the commercial creators of databases who were nationals of foreign states outside the EU with retaliatory infringement of copyright material in their products, unless their respective governments became signatories to a World Intellectual Property Organization (WIPO) draft convention on databases which had been framed to embody the essential provisions of the *sui generis* copyright protection established under the 1996 EU Directive.[23]

The European Commission's strategy succeeded in setting in motion an Administration-initiated legislative response in the U.S. Congress, which has now led to two competing draft statutes being actively debated. The response began in May 1996 with the introduction at the behest of the U.S. Patent and Trademark Office of House of Representatives of a bill, H.R. 3531, short-titled the "Database Investment and Intellectual Property Antipiracy Act of 1996." This first and ill-considered rush to legislate soon encountered opposition from the U.S. academic research community and non-commercial publishers of scientific information. But although that attempt proved unavailing, the legislative genie has been let out of the bottle, with the result that the 104th Congress presently has before it two further pieces of proposed legislation. The first of these is "The Collections of Information Antipiracy Act," H.R. 345, which was introduced in January 1999 and represents a re-incarnation of the quite pernicious approach taken in the original Administration-inspired legislative proposal in 1996. A second bill, "The Consumer and Investors Access to Information Act," H.R. 1858, was introduced in May 1999, and contains provisions protecting access to database information that are rather more responsive to the objections raised during 1997 against H.R. 3531. This too failed to gain support in the Senate, but its proponents have promised to try once again in the new session of Congress.

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[23] The 1996 draft was entitled: "Basic Proposal for the Substantive Provisions of the Treaty on Intellectual Property in Respect of Databases...", WIPO Doc. CRNR/DC, Geneva, August 30. It has been pointed out that in this regard, as well as in others, the EU Directive called for a departure from the principle of administering commercial laws on a "national treatment" basis, under which a country's domestic laws (whether for intellectual property production, or unfair business practices) should treat foreign nationals like one of the country's citizens. The principle of national treatment is embodied in Article 3 of the TRIPs Agreement, as well as more generally in the Paris Convention (on patents and trademark protection) and the Berne Convention (on copyright protection). Objections to this departure were recorded in the testimony of the General Counsel of the U.S. Department of Commerce (Andrew J. Pincus), in the 106th Congress House Hearings on H.R. 1858 (1999): section F.

A rapid review of the main features of the EC's Database Directive of 1996 highlights the following problematic points:[24]

- The Directive's *sui generis* approach departs from the long established principles of intellectual property law by removing the distinction between protection of expression and protection of ideas, a distinction that is central in US copyright law and was embodied in the TRIPS agreement adopted by the WTO.
- Compilers of databases in the EU will now be able to assert ownership and demand payment for licensing the use of content, which already is in the public domain, including material that could not be otherwise copyright-protected.

- A second distinction fundamental in copyright law, that between original expressive matter and pre-existing expressive matter, has been discarded by language of the Directive, because the latter fails to attach any legal significance to the difference between expressive matter that already exists in the public domain, and matter that is original and newly disclosed. Domestic laws and national courts that reaffirm this omission in effect will allow a database maker to qualify for renewal of the 15-year term of exclusive rights over the database as a whole – by virtue of having made a "significant investment" in updates, additions, revisions.[25]

- Strict limitations upon re-use of database contents are imposed by the Directive, requiring third party regeneration or payment for licenses to extract such material. This would inhibit integration and recombination of existing scientific database contents with new material to provide more useful, specialized research resources.

- Regardless of whether or not it is possible in theory to regenerate the raw contents of a database from publicly available sources, under the terms of the Directive, investors in database production can always deny third parties the right to use pre-existing data in value-added applications, even when the third parties are willing to pay royalties on licenses for such use. (An initial database producer simply could block subsequent creation of new, special-purpose databases which reproduced parts of existing compilations, wherever the regeneration of such data *de novo* was infeasible or terribly costly – e.g. in the case of years of remote-sensing satellite observations, or data-tracks from high energy particle collision detectors, or multi-year bibliographic compilations of scientific publications and citations thereto.)

- Where a database maker also held the exclusive rights to license previously copyright-protected publications, it would be entirely proper under the terms of the Directive to refuse third parties licenses in that material, while incorporating it within a database

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[24] The following draws upon the documented legal analysis in National Research Council (1997), pp. 148-153.

[25] See EC Directive on Databases, note 52, articles 7(1), providing an initial 15-year term from the date of completion; 7(2) extending protection for an additional 15 years if the database "is made available to the public in whatever manner" before the initial term expires; 7(3) allowing 15-year renewals for "[a]ny substantial change, evaluated qualitatively or quantitatively, to the contents of a database…from the accumulation of successive additions, deletions or alterations, which …result in …a substantial new investment." Under U.S copyright only the additions and revisions themselves – which would be considered as "derivative work" from the prior original expressive matter – would be entitled to fresh legal protection.

protected under the terms of the EC Directive. By excluding conditions for compulsory licensing, as well as omitting to provide remedies for abuse of the legal protections newly accorded to database investors, the Directive opens the door for the construction of indefinitely renewable monopolies in both non-re-generatable and non-re-generatable scientific data.

- The Directive abandons the principle of "fair use" for research, as distinct from extraction and use of data for purposes of "illustration in teaching or research." How "illustrative use" is to be interpreted remains ill defined, pending some infringement litigation that would provide opportunity for a court ruling in the matter. But the current consensus among IPR scholars is that "illustration" falls far short of the normal scope of research use of copyrighted material. Such an interpretation is consistent with the fact that

The absence of fair use exclusions for research (and research training) creates the prospect of a two-way squeeze on public sector funded research programs, as the costs of obtaining commercially supplied data are likely to rise. The 10-fold rise in the unit prices of remote-sensing satellite images that immediately followed the privatization of LANSAT satellite operations in 1985, and its withering effects upon university-based research projects, should be recalled in this connection.[26] Continuing pressures for cuts in government budgets, taken in combination with the priority that tends to be accorded to near-term applications-oriented research vis-à-vis exploratory science, is likely to encourage derogation to commercial database generators of the function of compiling, updating and publishing databases that were created by, and remain of continuing relevance for basic public sector research. There is a two-fold risk in this situation: one is the threat to data quality in the separating of the database creation and maintenance from the scientific expertise of the research community that creates and uses the data; the other is the resulting squeeze on public research resources, as already restrictive appropriations would have to be spent on purchasing data and database licenses.

When considering the benefits to society of enabling the appropriation of the value of this facility (and ones like it in other research fields) for users who seek to exploit it in conducting commercially oriented research – say, in developing new genetic diagnostic kits, or new drug therapies – the question to be asked is what effect doing so will have on the probability of valuable discoveries both in the near term and over the longer run. Seeking to apply the rights granted by the EC's Database Directive, and to partition and restructure the "information space" so as to readily extract licensing fees from users, would have the predictable effect of curtailing searches that were not thought to have a high expectation of quickly finding something with high "applications value." In other words, the probabilities of unexpected discoveries would be further reduced by the economically restricted utilization of the facility. Targeted searches may be quite affordable, but wholesale extraction of the data-spaces' contents to permit exploratory search activities is especially likely to be curtailed.

The adverse influences of the consequent "lost discoveries" also are likely to ripple outwards. This is so because the development of new and more powerful search devices, and techniques of pattern recognition, statistical analysis, and so forth, are more likely to figure among the discoveries that would be made collectively through the exploratory use of facility by a larger

[26] See the discussion in section IV, above.

number of searchers. Therefore, some cost of extracting economic rents from this construct today will most likely come in the form of smaller benefits (and the sacrifice of reduced applications-oriented research costs) in the future. In addition, one should consider the possibly serious inhibiting effect of setting up a "model" of IPR exploitation of such structures upon the construction of some new, presently unimagined information tools that would require the assembly (and licensing) of myriad information components from many, diverse sources.

A concrete illustration of the creative power of collaborations built to exploit enhanced digital technologies is provided by the vast, multi-dimensional "information space" that has been built up over the course of many years by the research community whose activities are coordinated today by the European Bioinformatics Institute (EBI). This "virtual library" is a dynamic collective research tool rather than a simple repository of information. The ordinary conceptualization of "a database" is too static, and, in a sense too pre-structured, to comprehend the potential for discoveries that has been created by this collective construct. Yet, as Graham Cameron, the EBI's Director, told the Workshop (in his statement to the opening session, on 22nd January), this information space began to be formed long before the research communities involved gave any consideration to intellectual property right restrictions on the use of the information contents that were being linked for subsequent retrieval and analysis. The implication was clear that it would be far more difficult in today's environment to create this particular research tool.

VI. Using IPR to make "good neighbors" in science: some modest proposals

What sort of intellectual property arrangements will make for "good fences" in the "information spaces" where collaborative research enterprises are most likely to thrive? My conclusion is that such institutional innovations such as the EU Database Directive, and the US MDCA provision of legal reinforcements for the application by IPR-owners of digital "self help" technologies .exemplify the wrong direction in which to be moving. In the domain of scientific and technological information, the "best fences" are likely to be "low and penetrable."

IPR regimes when implemented in that manner can serve a socially valuable informational purpose, by helping potential collaboration members locate and access various sources of scientific and technological knowledge, and it would be desireable to improve the patent and copyright registration systems towards that end. There are some well known circumstances where significant patent protection is warranted by the high fixed costs that public regulatory policies impose upon the private developers of innovative commodities that are readily "reverse engineered" and cheaply copied – e.g., the extensive field testing requirements for pharmaceutical products and medical devices. But, these represent the exception rather than the rule, and the end products themselves typically do not have the essential 'public goods' properties associated with information-good and information-tools.

Thus, the important broad principle to be established is a simple one: whatever are the legal rights that societies construct regarding "intellectual property," whether under international patent and copyright regimes or by *sui generis* protections (inadvisable as these may be, on other grounds), the licensing terms available to "owners" never should be allowed to create inefficient artificial impediments to the intensive utilization of the contents of virtual archives and information tools.

In the view of most economists, the "first best" allocation system in situations where goods are produced with high fixed costs but far lower marginal costs, is to apply what is known as the "Ramsey pricing" rule. This fits the case of information products such as scientific publication and

data, where the first-copy costs are very great in relationship to the negligible unit costs of copies. Ramsey pricing in essence amounts to price discrimination between users whose demands are inelastic and those users for whom the quantity purchased is extremely price-sensitive. The former class of buyers therefore will bear high prices without curtailing the quantity purchased of the goods in question, and hence not suffer great reductions in consumption utility on that account, whereas the low prices offered to those in the second category will spare them the burden of economic welfare reducing cutbacks in their use of the good.

The case might then be made for treating scholars and public sector, university-based researchers as having highly elastic information and data demands. Such a characterization would follow from considering that this category of knowledge-workers is employed on projects that have fixed budget allocations from public (or non-profit) entities, organizations that are expected to promote the interests of society at large. Since there is strong complementarity between their data and information requirements, on the one hand, and on the other resources they use in their research, the effects of raising the real price of this input are tantamount to sharply reducing the quantity of useful work that such projects can accomplish so long as their budgets remain fixed. Obviously, there is no workable economic or political mechanism that would serve to "index" the nominal value of public research budgets on the prices of commercially provided data. Even were such mechanisms to be found, commitment to implement them on the part of the rich societies would most likely result in pricing the use of scientific information and data beyond the reach of many poorer societies.

The general thrust of the policy advocated here is thus quite simple: statutes that would establish legal ownership rights for compilers of scientific and technological databases also should include provisions mandating compulsory licensing of scientific database contents at marginal costs (of data extraction and distribution) to accredited individuals and research institutions. The implication is that the fixed costs should be covered by lump sum subscription charges, which would be waived in the case of researchers engaged in constructing and maintaining these databases under the auspices of publicly supported projects.

Those provisions could well be extended to all the users of such data and information resources who agreed to distribute the data they generated on the same basis as that on which they had been able to access the data and information used in creating it. That generalization of the so-called "Copyleft" principle, found in the GNU General Public License, would not have to be achieved through the licensing terms of copyrights – which would be a significant limitation of its scope in the context of scientific data. It could be implemented by the administrative action of public agencies that funded science and engineering research, and equally by the policies of private foundations with similar public goods-creating missions. The terms of the restrictions thus placed upon researchers receiving public (and quasi-public) patronage might well seek to mimic the so-called "viral" features of the GNU GPL in their application to industry-university collaborative research programs: neither the cooperating firms nor the PSERs should be able to block others from using the (published) findings of publicly funded research by combining them with results that were obtained with the support of privately funding. Of course, commercial ventures should not be restrained from obtaining intellectual property rights in the distinct information obtained by their R&D expenditures, nor from marketing ancillary and complementary goods and services. This would preserve at least some means of recouping the fixed costs of their contribution to the public "information infrastructures" that they undertook to create through cooperative R&D efforts with PSER researchers. .

Venturing a bit farther afield, to address the problems surrounding the increasing trend towards patenting of research tools, would be quite consistent with the spirit of the foregoing modest proposals. The second-best reform measure in this case would be to institute a public policy of "patent buy-outs," under which public tax revenues would be used to purchase the rights to this class of inventions and place them in the public domain. Of course, some mechanisms probably would be sought to prevent public authorities from confiscating valuable patents at arbitrarily low compensation, or awarding inappropriately high "prizes" in the form of compensation to certain (favored) patentees. This complications calls for a somewhat more complicated bit of institutional machinery: inventions falling into the class of "research tools" would be made legally subject to compulsory licensing at a "reasonable" royalty rate, and the (regulated) rights to the revenue stream would then be publicly auctioned. The public agency would stand ready to acquire the rights for the public domain by default, if the "reservation" price pre-announced by the patent-holder was not reached in the private bidding.

None of the foregoing proposals directly address the troubling possibility that one day soon either the U.S., or the E.U., or both jurisdictions may have statutes providing for *both* legal protection of database rights –such as now exist under the EU Directive, and criminal law sanctions reinforcing IP owners' reliance upon technological "self-help" –such as now exist under the U.S. Digital Millennium Copyright Act. Non-copyrightable and out-of-copyright material then could be locked up indefinitely in encrypted databases. What to do about the jeopardy into which that seemingly incremental, evolutionary step would place the future of the entire regime of limited legal protections for intellectual property, is a problem that lies beyond the scope of this paper. Conceivably, a concerted campaign to mitigate the already existing threats to "open science" could contribute to public awareness of those dangers, and so contribute to forestalling their materialization.

References

ARUNDEL, A. [2000], "Patent – The Viagra of innovation Policy?" Internal Report to the Expert Group in the Project "Innovation Policy in a Knowledge-Based Economy," Maastricht: MERIT.

BAKOS, YANNIS, ERIK BRYNJOLFSSON AND DOUGLAS LICHTMAN [1999], "Shared information goods," University of Chicago Law and Economics Working Paper No. 67 (2nd Series), February

BESEN, STANLEY M. AND SHEILA M. KIRBY [1989], "Private copying, appropriability and optimal copyright royalties," *Journal of Law and Economics*, 32, pp. 255ff.

BESEN, STANLEY M. [1986], "Private copying, reproduction costs, and the supply of intellectual property," *Information Economics and Policy*, 5(2)

COHEN, WESLEY M, RICHARD FLORIDA AND W. RICHARD GOE [1994], *University-Industry Research Centers in the United States*, Center for Economic Development, School of Public Policy Management, Carnegie Mellon University, Pittsburgh, PA. (July).

COWAN, R. AND E. HARRISON [2000], Intellectual Property Rights in a Knowledge-Based Economy (A MERIT Study –Prepared for Adviesraad Voor Het Wetenschaps en Technologiebeleid [AWT]), Maastricht, Novermber.

DAM, K.W. [1998], "Self-help in the digital jungle," University of Chicago Law and Economics Working Paper No. 59, (August)] for discussion of the policy issues raised by self-help systems.

--. [1999], "Intellectual property and the academic enterprise," University of Chicago Law and Economics Working Paper No. 68, February.

DASGUPTA, P. and DAVID, P.A. [1987], "Information disclosure and the economics of science and technology," Ch. 16 in: G. Fiewel (ed.), *Arrow and the Ascent of Modern Economic Theory*, New York University Press: New York, pp. 519–542

-- and P.A. DAVID [1994], "Towards a new economics of science," *Research Policy*, 23, pp. 487-521.

DAVID, P.A. [1992], "Knowledge, Property and the System Dynamics of Technological Change," in *Proceedings of the World Bank Annual Conference on Development Economics: 1992*, L. Summers and S.

Shah (eds), Supplement to *World Bank Review*, Washington, D.C.: International Bank for Reconstruction and Development, 1993, pp. 215-248.

DAVID, P.A. [1993], "Intellectual Property Institutions and the Panda's Thumb: Patents, Copyrights, and Trade Secrets in Economic Theory and History," in: M. Wallerstein, M. Mogee, and R. Schoen (eds), *Global Dimensions of Intellectual Property Rights in Science and Technology*, National Academy Press: Washington, DC.

DAVID, P.A. [1994], "The evolution of intellectual property institutions," in: A. Aganbegyan, O. Bogmolov and M. Kaser (eds), *System Transformations: Eastern and Western Assessments* (Proceedings of the Tenth Congress of the International Economic Association), Vol. I, Macmillan: London.

DAVID, P.A. [1996], "Science Reorganized? Post-Modern Visions of Research and the Curse of Success," *Proceedings of the 2nd International Symposium on Research Funding*, Ottawa.

-- AND D. FORAY [1995], "Accessing and Expanding the Science and Technology Knowledge Base," *STI Review: O.E.C.D. Science, Technology, Industry*, No.16, Fall, 1995, 13–68.

EISENBERG, R.S. [1989], "Patents and the progress of science: exclusive rights and experimental uses," *University of Chicago Law Review*, 56, 000–000.

EISENBERG, R.S. [1999], "Bargaining over the transfer of proprietary research tools: is this market failing or emerging?," Working Paper, University of Michigan School of Law.

GALLINI, NANCY AND SUZANNE SCOTCHMER [2001], "Intellectual Property: When is it the best incentive system?, Working Paper (May 6 version) presented at the Franco-American Conference on the Economics of Intellectual Property, U.C. Berkeley, October 5-6.

GRANSTRAND, O. [1999], *The Economics and Management of Intellectual Property: Towards Intellectual Capital*, Edward Elgar: Cheltenham.

HALL, B.H. AND R.H. ZIEDONIS [2001], "The Patent Paradox Revisited: Firm Strategy and Patenting in the U. S. Semiconductor Industry," *Rand Journal of Economics*, 32, pp. 101-128

HELLER, M.A. and R.S. EISENBERG [1998], "Can patents deter innovation: the anticommons in biomedical research," *Science*, 280 (May 1), 698-701.

KORTUM, S. AND J. LERNER [1998], "Stronger Protection or Technological Revolution: What is Behind the Recent Surge in Patenting?" *Carnegie-Rochester Conference Series on Public Policy*, 48, pp. 247-307.

LEVINE, R.C. *et al.* [1987], "Appropriating the Returns from Industrial Research and Development," Brookings Papers on Economic Activity, Vol. 3, Washington, D.C.: The Brookings Institution.

LIEBOWITZ, STAN J. [1985], "Copying and indirect appropriability: photocopying of journals," *Journal of Political Economy*, 93, pp. 945 ff.

MACHLUP, FRITZ [1958], "An Economic Review of the Patent System," Study no. 15 of the Subcommittee on Patents, Trademarks, and Copyrights of the Committee on the Judiciary, United States Senate, 85th Congress, Second Session (Washington, D.C.: Government Printing Office).

MERGES, R. [1994], "Intellectual Property Rights and Bargaining Breakdown: the Case of Blocking Patents," *Tennessee Law Review*, 62(1), pp. 74-106.

MERGES, R.P. AND R.R. NELSON [1994], "On limiting or encouraging rivalry in technical progress: the effect of patent scope decisions," *Journal of Economic Behavior and Organization*, 25, pp. 1-24.

MILSTEIN, S. [2002], "New Economy—Many midsize companies find the 'defensive publishing' is a quick and cheap way to protect intellectual property," *New York Times*, 18 February, p. C3.

MOWEREY *et al.* [2001], "The Growth of Patenting and Licensing by U. S. Universities: An Assessment of the Effects of the Bayh-Dole Act of 1980," *Research Policy*, 30, 000–000

RADIN, M.J. [2003], " The Decline of the Public Dimensions of Property and Contract in the Digital Environment," presented to the Conference on "The Generation and Distribution of Knowledge," held at Kloster Wienhausen, 26-28 June.