
Are Intellectual Property Rights Hindering Technological Advance? The Need for Technological Commons¹

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Abstract

In the last quarter century, the scope of patenting has been expanded, the requirements for patentability have been lowered, the experimental use exemption has been narrowed, and patent holders' rights have been strengthened. New actors, most notably universities, have become involved. These changes threaten technological advance by hindering the emergence and utilization of design spaces, understood as metaphorical toolboxes shared by professions and comprised of basic elements and their relations routinely used for problem solving. While abstract, broad, and low-quality intellectual property per se constitutes a problem, it is particularly so when it comes to a design space, in the context of which knowledge has to be accessed in bundles, and large domains of further inquiry are at stake. The article calls for action in securing technological commons that, at least historically, have been provided via publicly funded research at universities and elsewhere.

KEY WORDS: design space, intellectual property, science and technology policy, university patenting, technological development

Introduction

Several core industries of the twentieth century—for example electrical lighting, radio, automobile, and aircraft—drifted into gridlocks that were not resolved without public intervention or industry consolidation (Merges & Nelson, 1990; Rai & Eisenberg, 2003). We fear that in the new millennium similar gridlocks are quite possible especially in emerging industries nurtured under the current expansive intellectual property rights (IPR) regime.

This article considers the implications of the prevailing U.S. IPR regime and the related raise in academic patenting on the emergence and utilization of design spaces, defined as sets of basic elements and their relations routinely used to solve engineering or similar problems. The article's key argument is that the recent changes threaten not only the ethos of open science but also technological advance per se by hindering the emergence and utilization of design spaces.

The evolution of the patent system reflects, on one hand, its economic, political, and social context, and, on the other, the features and properties of underlying technologies. With a few minor exceptions, the system is not adjusted for the idiosyncrasies of various fields or for diverse inventor characteristics. Thus, the effectiveness and consequences of the system necessarily vary by industry and actor as well as over time (Cohen, Nelson, & Walsh, 2000; Granstrand, 1999). Much of the recent debate is strongly focused on two technologies—software and biotechnology—and on the increasing role of universities on the patenting scene.

A variety of policies have been introduced to facilitate and encourage academic patenting based on the assumptions that universities are increasingly important sources of new technologies and that university patenting contributes greatly to the transfer and utilization of technology (Mowery, Nelson, Sampat, & Ziedonis, 2004). At the same time, however, the net benefits of academic patenting are being questioned on various grounds: It is often claimed that increased patenting seriously undermines the open science system, thus hampering the effective production of scientific knowledge, and by extension, of technology (Nelson, 2004). It is therefore argued that knowledge created using public resources should be treated as public good (David, 2004). It has also been shown that the financial rewards of academic patenting have so far been meager (Mowery et al., 2004). It can also be argued that academic patenting, at least in some of its forms, actually slows down technological advance.²

This article emphasizes the need for “technological commons” that, at least historically, have in considerable part been provided via publicly funded research at universities and elsewhere. While most technical knowledge remains accessible free-of-charge, in the case of new design spaces—such as the ones in biotechnology—risks are mounting: large application domains may become controlled by few intellectual property (IP) holders, patent hold-ups might lead to industry gridlocks, or industries might be locked-in to suboptimal standards. Four major lines of inquiry are suggested in calibrating the current IP system: modification of patent law and praxis, regulation of licensing, science and technology policy measures, and considerations regarding new types of IP regime such as open source.

In what follows, the concept of a design space, properties of the U.S. patent system, as well as their interaction are first considered. Then three software and three biotechnology patents are reviewed as real-world examples of potentially design-space-blocking IP. Particular emphasis is paid to the role of universities. Policy issues are discussed in the concluding section.

Before proceeding, let us acknowledge that this article is one-sided in criticizing the prevailing IP regime. We agree with Jaffe and Lerner (2004) suggesting that after seemingly minor changes, the system is now “broken.” While abstract, broad, and low-quality IP per se constitutes a problem, this is particularly true in the context of design spaces, where broad domains of further inquiry are at stake. Thus, we suggest that the creation and maintenance of technological commons should be among the explicit objectives of science and technology policy. We wish to emphasize that we are *not* against strong protection of private IP; we simply wish to suggest that—with the recent changes in the regime and the altered role of universities—the public interest is no longer served unless the system is enhanced. While we solely discuss the U.S. case, it should be pointed out that it largely sets the global scene in this domain: any actor who operates in the U.S. market *or* whose products and services are embodied into local offerings is directly influenced; as the United States is active in formulating and enforcing international IP regulation as well as serves as a global benchmark to be emulated by other countries, indirect effects are also considerable.

In discussing the U.S. case, we find ourselves in agreement with other contributors to this special edition, such as Cowhey, Aronson, and Richards (2009) and Kushida and Zysman (2009), all of whom likewise emphasize the importance of domestic

institutions in shaping technological outcomes. This is in contrast to Taylor (2009), who sees international linkages as potentially playing a far stronger role, although we also emphasize particularly the U.S. clout in the international scene.

The Concept of a Design Space

Stankiewicz (2000) coins the term “design space” to characterize a set of basic elements and their relationships routinely used to solve given types of engineering, scientific, or similar problems: For instance, most engineering fields have a set of well-established conventions and procedures, typically implanted to the generations entering the profession from the 101 course syllabus on. Lego blocks—sometimes touted the “toy of the century”—constitute an “artificial” design space. A design space consists of a relatively well-defined set of basic elements used in tandem.

Both as individuals and as a group, the profession has incentives to promote and enforce the established design space. For an individual, employing it economizes the cost of searching for a solution to a given problem as well as hides the complexities related to the structures of the basic elements and their relations. For the profession, the design space creates markets for complementing up- and downstream products and services as well as makes it easier to share ideas and distribute tasks. The design space provides a metaphorical toolbox shared across the profession; while constantly changing, its foundations tend to be relatively stable.

In a broader context, design spaces may be seen as transitory systems between the feasible combinations of current knowledge and their actual use in the provision of goods and services. Virtually any act of putting knowledge to a productive use employs one or more design spaces (or similar constructions), although their importance and degree of formality varies. In fact, employing design spaces is almost a prerequisite for technological progress, simply because without them any feasible amount of innovative effort would be more than exhausted by “re-inventing wheels.” Figure 1 illustrates the concept of a design space.

A Silent Revolution of the Patent System

The U.S. Constitution states that the congress shall have the power “To promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries.”³ Thus, from its very foundations, the U.S. IPR system harnesses the profit motive in promoting artistic, scientific, and technological progress (Abramson, 2002).

For over 200 years, (utility) patents have been the primary vehicle for rewarding inventors and providing them with an opportunity to recover the associated costs with temporary monopolies over the commercial uses of their inventions. The patent system contributes to economic progress in several major ways: It provides private incentives for knowledge generation, it arguably increases the likelihood of a discovery’s commercial introduction, and—by requiring disclosure—it forces commercially relevant information out in the open, thus expanding publicly available knowledge. By many accounts, the system has been phenomenally successful in promoting innovation; indeed, “[f]or more than half a century the United States has led the world in the development of new technologies and creation of new

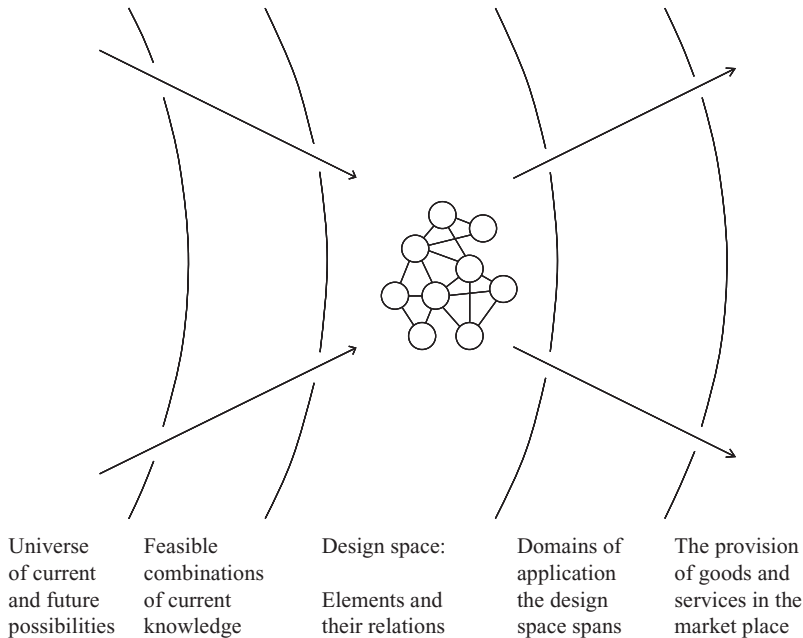


Figure 1. The Concept of a Design Space

products” (Merrill, Levin, & Myers, 2004, p. 18). It seems, however, that because of the recent adjustments, the system is now “broken” (Jaffe & Lerner, 2004).

According to the U.S. law “any *new* and *useful* process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent” (35 USC § 101, p. L-20, emphasis added).⁴ The invention must be *novel* (35 USC § 102, p. L-21), i.e., not anticipated by prior art or described in published documents. It must be *nonobvious*, i.e., “the subject matter as a whole would [not] have been obvious at the time the invention was made to a person having ordinary skill in the art” (35 USC § 103(a), p. L-21). The *disclosure* requirements comprise a written description, enablement, best mode, and definiteness (Paradise, Andrews, & Holbrook, 2005).⁵ The disclosure must be sufficiently complete to allow replication without undue experimentation, it must be adequate to ensure that the claimed invention was indeed made, and it must define the inventor’s proprietary interest in terms of one or more distinct and definite claims (Merrill & Elliott, 2004). The holder of the patent has “the right to *exclude* others from making, using, offering for sale, or selling the invention . . . [for] 20 years from the date on which the application for the patent was filed” (35 USC § 154(a1–2), p. L-33, emphasis added).⁶

Patent rights are exercised by suing to stop the unauthorized use and possibly to seek damages and/or an injunctive relief, i.e., a court order to discontinue the alleged infringement upon initiating the legal process.⁷ Patents are tried in federal district courts normally by juries—most suits are, however, settled out of court. Decisions of district courts may be appealed to the Court of Appeals for the Federal Circuit specializing (among a few other things) on patents; on rare cases the Supreme Court reviews appeals from the Federal Circuit (Merrill & Elliott, 2004).⁸

Without much fanfare to the U.S. Patent Act of 1952, the system has undergone a silent revolution since 1980. The effective scope of patenting is determined by court cases. Since 1980, the patentability of genes and genetically altered organisms,⁹ computer software,¹⁰ and business methods¹¹ has been confirmed and durations of some patents have been extended.¹² With statutory changes of introducing a special court of appeals in 1982 as well as restructuring of fee and financing of the United States Patent and Trademark Office (USPTO) in the early 1990s, the requirement for patentability has arguably become lower and, at the same time, the position of the patent holders as opposed to alleged infringers has strengthened (Jaffe & Lerner, 2004).¹³ These have increased the number of patents and arguably lowered the average patent quality.¹⁴

The Bayh–Dole and Stevenson–Wydler Acts endorse and encourage patenting results of publicly funded research conducted primarily in universities.¹⁵ This legislation—attempting “to use the patent system to promote the utilization of inventions arising from federally funded research and development” (35 USC § 200)—takes particular care in making sure that the patent-holding organizations have the right to grant exclusive licenses to their inventions at their discretion, thus considerably reducing the powers of the specialized federal funding agencies (Rai & Eisenberg, 2003).

There have been major efforts to harmonize patent systems internationally, most notably as a part of the General Agreement on Tariffs and Trade (GATT) Uruguay Round negotiations in the mid-1990s. Antitrust authorities have become more lenient when it comes to the use of patents to the extent that their views are rarely a hindrance to the exchange of IP.¹⁶

With the afore mentioned changes currently “anything under the sun that is made by the man” (The Supreme Court in *Diamond v. Chakrabarty*, as cited in Merrill et al., 2004, p. 43) seems to be eligible for a patent.¹⁷

Despite the considerable scope of the changes, there is “little evidence, one way or the other, of the economic effects of the many steps taken” (Merrill et al., 2004, p. 9). In fact some studies suggest that there appears to be no (verifiable) causal link between patents and R&D (Arora, Ceccagnoli, & Cohen, 2003). The adjustments to the patent system are in part a reflection of the changes in underlying technologies and partly the result of pressures exercised by the economic actors seeking a stronger IP protection. So far, the institutional response has largely been to widen the scope of patenting, relax statutory requirements, and strengthen patent holders’ position. Patenting has gone upstream “from commercial products to scientific research tools, materials, and discoveries” (Merrill et al., 2004, p. 1).

The relaxation of the statutory requirements for patentability makes IP relevant to all aspects of a design space. As compared to the earlier praxis, patents tend to be more abstract and broader as well as tend to be granted to more elementary and thus “upstream” pieces of knowledge, all of which increase the likelihood that they need to be pooled with other elements in the context of a design space and decrease the possibilities of inventing around the IP. These tendencies are further reinforced by the more liberal interpretations of the depth and width of the patents.¹⁸ The increasing enforceability raises the stakes for the actors involved as well as creates greater power asymmetries among them. The reaping of revenues from IP by

predatory behavior—as opposed to providing goods and/or services in the marketplace—has become an increasingly attractive business strategy. With the more permissive views of the antitrust authorities, cross-licensing, patent pools, and similar arrangements can be turned into potent weapons allowing a handful of actors to control large design spaces and their application domains.

Design Spaces and Proprietary Knowledge

Basic models of industrial economics (see, e.g., Tirole, 1988) can be employed to formally show that virtually *any* fee for employing a design space or *any* discrimination in relation to its use produces socially inferior outcomes as opposed to free and open access.¹⁹ Any positive fee in employing a design space will, at the margin, reduce its use, contribute to production costs, and increase end-user prices. Given that proprietary IP and related profit motives are involved, the first best solution of free access to a nondiscriminatory design space is often unfeasible. Thus, it is worthwhile to consider the role of proprietary IP in the context of a design space.

Under a fairly general set of conditions, licensing of IP is socially beneficial (Katz & Shapiro, 1985). Furthermore, Coase's (1960) theorem suggests that IP is licensed to those who are able to make the most of its use regardless of the initial allocation of rights.²⁰ The theorem does, however, only hold under a very restrictive set of conditions including: the absence of transaction costs; lack of other licensing-related economic motives or need to bundle IP; ability to negotiate licensing before committing to the use of the invention in any way; complete knowledge of the nature, usefulness, validity, and value of the IP; and that the parties involved will always agree to carry out the transaction.²¹ In fact none of these conditions hold (or are reasonable approximations) in the context of a design space. Even in the case of a “modest” design space—say having a few dozen parties holding necessary IP to be exploited by the same number of users—the number of necessarily bilateral negotiations would be in the order of hundreds. Even assuming away any coordination needs, strategic behavior, and cost-inflating complexities and uncertainties of the legal environment, transaction costs would be sizable. Furthermore, each of the bilateral transactions would be complicated by the asymmetric nature of information regarding the IP as well as by uncertainties related to its usefulness and economic value, all of which would be colored by the cognitive biases and strategic motives of the actors involved.

Shapiro (2001) shows that uncoordinated bundling of upstream IP will harm both producers (as direct users of IP) and consumers (as indirect users of IP embodied in goods and services) even against the second worst alternative of having a single upstream IP monopoly. Package licensing, patent pooling, and cross-licensing are among the proposed solutions to the problem. The history of patent pools (and the like) has shown that they tend to work with relatively homogenous and mutually interdependent actors having long term relationships (Merrill et al., 2004). Modern design spaces—and emerging technologies in general—tend to be complex in ways that make satisfying these conditions unlikely. Thus, it is argued that the upstream IP market introduced by the recent legal changes and expanded by the active involvement of universities is probably unable to solve the IP allocation

problem. Thus, the emergence of anticommons (Heller & Eisenberg, 1998), patent thickets (Shapiro, 2001), or lacking scientific commons (Nelson, 2004) is a real threat especially in the current context because of several inherent tensions between the IP system and design spaces.

Hold-up, the exercise of the exclusionary right embedded in a patent by not licensing, can certainly vary in its scope, intensity, and duration. Whether a patent hinders or blocks the emergence, utilization, and/or evolution of a design space clearly depends on the type, depth, and breadth of the IPR and on how it is exercised. There are three conditions under which a hold-up has the potential to bring a whole design space to a gridlock: (1) the patent is hard to invent around, (2) it is not licensed at acceptable terms, and (3) the basic element covered by the patent controls a large section of the design space by being abstract, broad, upstream in the flow of knowledge, and/or crucial for establishing connections with other elements of the design space. Although occurrences of major industry-blocking patents are historically quite rare (Merrill et al., 2004), they do happen: For instance, electrical lighting, radio, automobile, and aircraft industries drifted into gridlocks that were not resolved without public intervention or industry consolidation (Merges & Nelson, 1990; Rai & Eisenberg, 2003). It should be noted, however, that researchers' definitions of industries tend to be quite broad; in narrower domains blocking might take place much more frequently.

A downstream invention (an improvement) builds on an upstream invention (the original). The improvement cannot be commercially exploited (without risking litigation) unless a license for the original is secured; likewise the improved version of the original cannot be exploited even by the holder of the original without a license—the two patents are said to be mutually blocking (Merges & Nelson, 1990). While with appropriate contracting this does not pose problems, the related negotiation is certainly complicated by the fact that the respective merits of the original and the improvement are hard to disentangle. In the context of a modern design space, the bargaining between the inventors of the original and the improvement is often further complicated by the fact that the original is not necessarily to be exploited by its inventor. This asymmetry removes a major leveraging force arguably driving the reasonably well-functioning cross-licensing in semiconductors. A further problem, pointed out by Rai and Eisenberg (2003), is that the potential improver may have to reveal her research plan to the original's holder, thus exposing the improver to her plan's misappropriation.

Upon licensing of the original, the action's market-mediated consequences are considered. With respect to the "vertical" aspect, it seems plausible to argue that an accessible and well-functioning design space brings about more competitive downstream markets, which in turn brings down profits of some actors and possibly even the industry as a whole. The process of maximizing the original's value is thus necessarily biased against the "socially optimal" alternative of nonexclusive and nondiscriminatory licensing, as the holder of the original is not interested in market-mediated shift of welfare to downstream producers and end-users.²² With respect to the "horizontal" aspect, the holder of the original may take into account potential developments in separate but nevertheless related markets. If licensing cannibalizes profits in other markets, it may not take place regardless of what the isolated optimization problem might suggest.²³

The basic elements of a design space are by definition complementary—denying access to one of them may render parts of the space obsolete. One consequence of this interrelatedness is that such elements have to be accessed in bundles.²⁴ This in turn means that—at least in the case of a series of bilateral negotiations—licensing fees trivially “line-up,” i.e., multiple elements have to be licensed. In case of upstream IP, they may also “stack”—the original as well as its improvement(s) need to be licensed. A further possibility is that they may “multiply”—often granted patents are not mutually exclusive, i.e., elements might be covered by more than one patent making it necessary to license all or risk litigation.²⁵

While the direct licensing costs of certain elements of design spaces in themselves cause problems, two further issues are even more troubling: the mounting transaction costs of negotiating the licensing agreements, and the structure of the fees and other conditions for licensing.

To the extent that the evolution of a design space is sequential and interactive, the value of its elements cannot be known a priori, even if technological and end-market uncertainties could somehow be gauged. While simple economic models would suggest that a fixed fee for employing a design space would be preferred,²⁶ a fractional fee based on the usage and/or output is, however, a more likely negotiation outcome given the uncertainties and the nature of the design space.

A disturbing aspect of some licensing schemes currently employed is that they dictate the manner in which knowledge is being used. They can, for instance, grant the upstream IP holders rights to downstream discoveries enabling the IP holders to bias industry and technology developments in their favor, thus reducing the motives of other actors to further develop and exploit the design space.

Examples: Software and Biotechnology

This section discusses three software and three biotechnology patents as real-world examples of potentially design space-blocking IP.²⁷ The selected two domains are interesting for several reasons: their patentability has only recently been established; some of their features pose a challenge to the existing IPR regime; universities have played and are still playing a central role in both domains; and they illustrate different aspects of the design spaces in high technologies.

Encryption and Digital Signatures

In September 1983 the USPTO granted Ronald Rivest, Adi Shamir, and Leonard Adleman of Massachusetts Institute of Technology a public-key cryptography patent (dubbed RSA after the authors’ surname initials) enabling encryption and digital signatures, nearly seven years after the application.²⁸ In 1976—preceding the RSA patent considered here—Whitfield Diffie and Martin Hellman of Stanford published and soon patented an idea revolutionizing cryptography (Lauzon, 1998).²⁹ They suggested that secure communications could be established by employing two distinct but mathematically related keys: the sender would acquire the public key of the intended receiver to encrypt the message; upon receiving the message the receiver would use her private key to decrypt the message—in a sense

the public key is used to construct a virtual lock that can easily be opened only by those possessing the appropriate key (Black, 2001). RSA—the example patent here—was a practical implementation of the concept solving the problem of assigning the public and private keys. The underlying mathematics is based on the fact that the product of two large prime numbers is easy to calculate whereas factoring them requires considerable computational capacity (Lauzon, 1998). If run in reverse, the method can be used to provide digital signatures (Herson, 2000).

Stanford licensed its patent to Cylink and MIT to RSA Security (Carlson, 1999). The two patents block each other in the sense that neither can be exploited without infringing the other. The resulting litigation of the patents was settled by forming the Public Key Partners patent pool eventually dissolving due to various disputes among the partners; the pool nevertheless defeated the development of a competing standard by the government not least because the two firms focused their litigation efforts—instead of on each other—on the government (Carlson, 1999). In part because of the lengthy time before publishing the patent, the software industry had employed RSA extensively turning it to a de facto standard with the (implicit) assumption that it was in the public domain. Indeed, its licensing for noncommercial use was lenient, although RSA Security was—according to unidentified industry sources—a feared “kingpin” of the industry, and especially towards the end of the patent life adopted questionable licensing practices (Messmer, 2000). Employing RSA is costly: upfront fees can be up to ten per cent of the cost of the product, on top of which comes a per-units-sold royalty (Messmer, 2000).³⁰

The RSA case illustrates how the public sector (via its funding and military interests)—while successfully anticipating the society’s needs and pre-empting the private sector in securing IP—let the invention be monopolistically exploited, which with the employed licensing practices created a toll-booth for online commerce, privacy, and security. The initial oversight also nullified attempts to undo the harm. The case also shows how crucial timing is in IP issues especially in the context of a design space. While the RSA patent could be invented around—the idea of prime numbers is one of three major alternatives used to reach the same end—it remained hidden or “submarine” (Graham & Mowery, 2005) for seven years, well enough for lock-in to occur in the form of being embodied in market offerings and to the relevant software design space. As the RSA patent, and especially the preceding Stanford patent, are granted to a relatively abstract idea, one may question whether they should have been granted in the first place.

Hyper-Linking to an External Application

In November 1998 the USPTO granted Michael Doyle, David Martin, and Cheong Ang of University of California, Berkeley, a patent (commonly known as the “906 patent in reference to the last three digits of its number) for “[d]istributed hypermedia method for automatically invoking external application” (the title of the patent).³¹ In 1995 the university licensed the invention exclusively to Eolas, a spin-off company founded by Doyle in 1994 (http://www.eolas.com/about_us.html visited 15 May 2005), which was making an effort to enter the web browser (add-on) market at the time (Hicks, 2003). The main application of the ‘906 patent is the

embedding and controlling of plug-ins and applets through a web browser, which was among the key features of Microsoft's Internet Explorer upon its introduction in 1995.

In February 1999 Eolas filed a complaint against Microsoft alleged infringement (TLJ, 2005); in August 2003 the jury found that Internet Explorer was infringing and awarded Eolas \$521 million (plus \$45 million in interest) in damages—\$1.47 for each copy of Windows sold globally in 1998–2001 (Andersen, 2004). The decision created havoc among Internet developers—fearing that millions of web pages would have to be revised and that some online material could be lost altogether—causing their standardization body World Wide Web Consortium to call for re-examination of the patent (the letter of Tim Berners-Lee to James Rogan dated 28 Oct. 2003, <http://www.w3.org/2003/10/27-rogan.html> visited 11 May 2005). In March 2005 the Federal Circuit reversed in part the ruling of the lower court sending the case for a re-trial (Pallatto, 2005).

The '906 case illustrates the considerable power of broad and abstract claims. Had the patent been ultimately found valid, the patent would have been licensed or circumvented by those developing or interacting with web browsers. Re-tooling the browsers to access applets would have made parts of older web pages inaccessible and would have broken the seamless integration of hypertext and web content in other formats. Even without legal and licensing fees, the costs would have been enormous. At the time of the Eolas–Microsoft ruling legal experts suggested that the case would vitalize the efforts of small software IP holders to prey on established firms in the industry (Andersen, 2004).

On-the-Fly Application of Textual Styles

In January 1999 the USPTO granted Patrick Ferrel and six other Microsoft employees a patent for the use of style sheets—collections of formatting settings for textual information—in electronic publishing:³² styles are applied on-the-fly as the document embodying them is being rendered at a client system (McKenzie & Walter, 1999). The patent resembles the World Wide Web Consortium's (W3C) cascading style sheets standard (<http://www.w3.org/Style/> visited 15 May 2005), which was under developed at the time of the application. Microsoft was actively participating in the standard formation (Stern, 1999). After an outcry against the patent,³³ Microsoft offered free and reciprocal licensing but came short of turning the patent over to the standardization body, as several observers had requested (McKenzie & Walter, 1999).³⁴

Although the U.S. patent system, unlike for instance its European counterpart, honors the first-to-invent as opposed to first-to-file principle, a granted patent gives considerable powers to its holder even if the priority of the invention is in doubt. This is driven by two facts: first, the patent is assumed valid unless otherwise proven; and second, costly and unpredictable courts are the primary way to challenge the claims put forward. In the case of this patent, no single party has enough commercial interest at stake to challenge Microsoft's claims. Yet the IP in question is one of the cornerstones of the Web 2.0 design space enabling the separation of content and visual design as well as economizing on the use of bandwidth.

Transgenic Nonhuman Mammals

In April 1988 the USPTO granted Philip Leder and Timothy Stewart of Harvard University the first of three patents for “[t]ransgenic non-human mammals.”³⁵ The work was supported by DuPont, which was entitled to an exclusive license of the patents.³⁶ The patent concerns a mammal with an added gene making it prone to cancer. This oncogene is injected into the gene sequence of a fertile egg. If successful, the host female will give birth to a founder bearing the altered gene. Every second offspring of a female founder and an unaltered male will have the oncogene (Kamber, 2003).³⁷

Initially, DuPont licensed its OncoMouse[®] liberally for basic research but around the mid-1990s the monetary fees sprang and the licensing terms became restrictive (Blaug, Chien, & Shuster, 2004). Even noncommercial research licensing “seem[ed] to require licensees to return to DuPont for further approval before any new discoveries or materials resulting from the use of licensed mice are passed along to others or used for commercial purposes” (Heller & Eisenberg, 1998, p. 699; footnote omitted). As a response the National Institute of Health (NIH) initiated a four-year quest for an exception for academic research it supports. A memorandum of understanding (<http://ott.od.nih.gov/pdfs/oncomouse.pdf> visited 11 Mar. 2005) was signed in July 1999, although apparently this proved to be only a poor solution to the problem (for discussion see Blaug et al., 2004).

The broad claim of the OncoMouse[®] patent—well beyond the actual invention—have made other commercial actors cautious upon engaging in cancer research. Also the licensing practices are quite disturbing: DuPont vigorously enforced its IP also on universities with restrictions and reach-through claims that potentially gave it rights over the outcomes of employing the cancer research design space.³⁸

Breast and Ovarian Cancer Genes

In December 1997 the USPTO granted Donna Shattuck-Eidens of Myriad Genetics Inc., Jacques Simard of Centre de Recherche du Chul (Ste-Foy, Canada) as well as Mitsuuru Emi and Yusuke Nakamura of the Cancer Institute (Tokyo, Japan) the first of several patents on two genes (BRCA1 and BRCA2) linked to breast and ovarian cancer as well as on related testing.³⁹ The work was supported by Eli Lilly holding the licensing privileges for diagnostics and therapeutics for BRCA1.⁴⁰ The work depended on linking of the Utah Population Database—containing information on Mormon family groups and most descendants of the initial settlers—and the Utah Cancer Registry at the University of Utah (Taylor, 2004; Williams-Jones, 2002).

Myriad is a spin-off company from cancer research at the University of Utah founded in 1991. It became virtually a monopoly in providing BRCA testing in the United States and to a lesser extent also in other countries in the late 1990s (Williams-Jones, 2002).⁴¹ It licensed to several leading medical schools, universities, and hospitals enabling them to study breast and ovarian cancer. The licenses were, however, quite limited in scope; for instance, they were confined to laboratory research and did not extend to clinical settings (Jaffe & Lerner, 2004). Testing is to be carried out by Myriad or labs it has approved (Koechlin, 2003). As a consequence “a number of medical school researchers have been forced to abandon their

research programs due to the licensing terms” (Jaffe & Lerner, 2004, p. 16); Allen Bale of Yale University School of Medicine has noted that “[*Myriad’s* patents] have a chilling effect on the work we do. There are things which I won’t even think about doing anymore” (The Boston Globe Magazine, as cited in Hemphill, 2003). Also in the case of the BRCA patents NIH and the National Cancer Institutes negotiated exceptions for research they sponsor; *Myriad* agreed to provide screening for about half of the commercial cost (Reynolds, 2000).⁴²

The BRCA illustrates a patent that has the potential to block an important area of research. While not altogether blocking, its licensing practice arguably hindered scientific advance, not least because *Myriad* effectively dictates what is being done and how. This might be rational for the company as it minimizes the changes of inventing-around its IP as well as ensures that its own and affiliate researchers maintain an upper hand in the field. As for the particular research domain, however, it dictates the ways of using the relevant design space and thus limits the application domain, which in turn potentially hinders technological advance.

DNA Cotransformation

In September 2002 the USPTO granted Richard Axel, Michael Wigler, and Saul Silverstein of the Columbia University a cotransformation patent titled “DNA construct for producing proteinaceous materials in eucaryotic cells,”⁴³ arguably to an invention covered by three previous patents dating back to as far as August 1983 (with February 1980 as the earliest priority date).⁴⁴ The latter two of these three patents are divisional, i.e., disclose and claim parts of the original invention, and include terminal disclaimers, i.e., expire with the original underlying patent; the 2002 patent is neither divisional nor includes the disclaimer, implying that it covers a completely new invention.⁴⁵ The patents cover a cotransformation process simultaneously targeting the recipient cell with two foreign DNA molecules: one molecule delivers the desired gene coding whereas the other alters properties related to the cell’s survival. The process is critical in providing modern pharmaceuticals, and it has been used to produce several blockbuster drugs. The patents have grossed the university \$300–\$400 million (Agnes, 2003), making them financially the most successful set of university patents.⁴⁶

With the September 2002 patent in Columbia’s argument unrelated, the university engaged in a questionable tactic of extending the life of its cash cow. The filing date of 7 June 1995 narrowly escaped the GATT-related amendment to the U.S. patent law rigidly capping patent life to 20 years from the original application date (HJLT, 2004). In early 2000 Columbia engaged U.S. Senator Judd Gregg (R-NH) in an unsuccessful effort to extend the life of the original patent through congress (NB, 2003) with the argument that the Hatch–Waxman Act—extending patent terms of pharmaceuticals in case of FDA approval delays—should apply to the case (Agnes, 2003).

The case illustrates that even the most prestigious universities cannot be assumed to be guardians of ethics and public interest in the domain of IP. In the current IP regime they in fact have exactly the reverse financial incentives and also legal

possibilities to do so. Public financing and other bodies have largely been stripped of their powers to directly influence universities' IP practices.

Software and Biotechnology Design Spaces

Currently relatively little programming is being done in machine language (composed essentially of zeros and ones) or in low-level languages such as Assembler. In many situations high languages—black-boxing some details—can be employed to create important design economies. The object-oriented software development and various similar development platforms further illustrate the trend. The software design spaces and its various designed subspaces are codified to an exceptional degree. The foundations of these digital design spaces have been laid in the absence of patenting. In part this can be explained by the fact that commercial actors could initially rely on hardware patents. Also the awareness of the commercial potential of freestanding software increased only gradually; its formal patentability was also in doubt until the early 1980s. Since then, however, it grew explosively.

An official or a de facto standard often defines a part of a design space. Standardization bodies remain a bit blue-eyed when it comes to IP. Seemingly the World Wide Web Consortium has, until recently, ignored the issue. Some, like the Internet Engineering Task Force in the RSA case, have resisted proprietary IP in standards as a matter of policy. Private IP was quite successfully pooled upon establishing the GSM standard for the second-generation wireless telecommunications; the same was attempted with the third generation with less stellar results.

It is commonly believed that many of the “new economy” boom patents of the late 1990s are invalid, although the system has often failed to make this clear as many cases are settled out of court. The infamous Amazon.com “one-click” patent is well and alive,⁴⁷ even though the Federal Circuit relieved Barnesandnobles.com from the injunction issued by the lower court (Smith, 2002) and all-but invalidated the patent. Many questionable patents from the boom years and later are going to be around for a long time. The initial success of Eolas is a warning to be heeded.

In contrast to design-driven software, biotechnology continues to be fundamentally discovery-driven. Despite the rhetoric of “bio-engineering” and “rational molecular design,” most problem solving in biotechnology involves massive empirical search operations. The solutions found tend to be context specific. Basic research is one of the key sources of search clues; it also helps to rationalize the empirical search operations (Drews, 1999). Much of the knowledge transfer from basic research to biotechnology is mediated by instrumentation and laboratory procedures, which is a source of many controversial patents (Heller & Eisenberg, 1998). Overall the biotechnology design space remains fragmented and poorly articulated (Stankiewicz, 2002). There is no well-defined set of basic elements. The hope that the human genome would furnish such a set is fading.⁴⁸ Little-by-little, however, the massive reverse-engineering of nature (in both bio-medical and bio-agricultural research) is bearing fruit and bio-molecular design space is beginning to take shape, which will also be felt in the court of law with the potentially design space-blocking patents among the most heatedly debated IP.

Also in the case of biotechnology initially patenting ran into formal and informal difficulties. It was not firmly established until early 1980s. The birth of

modern biotechnology—science and industry originally based on the recombinant DNA—has been aided by the liberal licensing of patents granted to Stanley Cohen of Stanford and Herbert Boyer of the University of California, San Francisco (Hughes, 2001).⁴⁹ This, however, has not prevented biotech patents from becoming a hotly disputed issue. The attitudes of academics were at first predominantly negative, although in many instances they changed surprisingly quickly once the flood gates had been opened. The field continues to arouse heated ethical and political debates.

Conclusion

A standard argument following from Coase's (1960) theorem is that if there are gains from licensing IP, the market will not only short itself out but also reach an optimal outcome in the sense that IP is licensed to those able to make the most of its use. As discussed above, however, *none* of the conditions underlying the theorem hold in the context of design spaces. In order for a design space to be operational in the sense that its key elements can be accessed simultaneously, it must be *privately* optimal for *each and every* relevant IP holder to license—a condition that is easily violated in practice regardless of the magnitude of gains to the industry and society at large.⁵⁰

In the last quarter of a century the scope of patenting has been expanded, the requirements for patentability have been lowered, the scope of the otherwise important experimental use exemption has been narrowed, and the rights of patent holders have been strengthened. Simultaneously several ethical, moral, social, political, and regulatory constraints on gaining and exploiting privatized knowledge have been weakened; international harmonization increased; and new actors—most notably universities—have become deeply involved. With the Patent Act of 1952 largely intact, the U.S. system has undergone a silent revolution, both reflecting and feeding the growing role of IP in business models and competitive strategies. Deteriorating U.S. competitiveness in the 1980s and the pressures to cut public spending—including university funding—played an important role in nurturing the revolution. Similar developments have been taking place in Europe and Japan, even if to a lesser extent.

The consequences of the revolution are manifold: more patents—many of debatable quality—have been granted (Mowery & Ziedonis, 2002); patent prosecution and litigation have become more elaborate and costly; and patents themselves have become more complex and heterogeneous (Allison & Lemley, 2002). Consequently IP is increasingly important in the strategies of research organizations whether for-profit or nonprofit.

This article argues that the already discussed changes threaten not only the ethos of open science but also technological advance per se by hindering the emergence and utilization of design spaces. The socio-economic value of design spaces depends on how they are shared. The potential of the technological division of labor and the full range of applications created by the evolving spaces can be realized only if their basic elements are widely shared. The world needs “technological commons.”

The potential conflict between IP and the ethos of open science has been extensively debated (David, 1993, 2004; Nelson, 2004); technological commons

are a related issue. Arguably the developmental trends in design spaces increasingly favor universities as the institutional base for their development: movement towards ever smaller particles in the hierarchy of the matter, as illustrated first by bio- and then by nanotechnology, emphasizes close links between doing basic research and nurturing design spaces; the need to articulate, codify, and disseminate complex design languages dovetails with the teaching functions of universities; the teaching obligations and the relative freedom from strong ties to particularistic interests prompt universities to formulate and execute research agendas enhancing the generic capabilities of design spaces. The histories of software and biotechnology demonstrate these points. Therefore a case can be made for the university as the developer and defender of technological commons, even if in the current IP regime it is not necessarily so. The university perhaps rather cannibalizes commons and its own research effort for instance by being both the developer and applier of research tools as well as enforcing related IP on itself and others.

Obviously technological commons have always existed and most technical knowledge remains accessible free-of-charge. In the case of new and fast evolving design spaces nurtured under the current expansive IPR regime, however, there is also the risk that large domains of the emerging design spaces come to be controlled by few IP owners with a risk of a lock-in into sub-optimal standards.⁵¹

What could be done to fix the current “broken” IP system that is increasingly hindering rather than promoting technological advance? Do universities (and their public funding) play any role in this?

Merely to deny the academics (and other public research organization researchers) the right to patent is hardly a realistic proposition. It would probably result in the flight of creative technologists from academia, make cooperation between universities and industry more difficult, and discourage the circulation of R&D personnel. The importance of patents for effective transfer of academic technology may have been overstated, but is hard to deny altogether. New technology is the basis of competitive advantage and therefore the appropriation pressures are bound to be important. These pressures are not likely to ease and, in any case, most academic patents appear entirely innocuously. But the system must be calibrated and managed. We suggest developments along four main lines discussed below.

Modifications of the Patent Law and Praxis

Both statutory provisions and rules regarding such matters as the patent protection time could be differentiated and adapted to fit the dynamics of different technologies. It is often claimed that granting 20-year protection to software is excessive while it might be insufficient for drugs. The rules for patenting naturally occurring objects can be made more sensitive to the peculiarities of different fields of technology. Unfortunately much of this runs up against the traditional preference of the patent systems for one-size-fits-all solutions. There may be some good reasons for those preferences. Still, the monitoring and critique of the patenting praxis can make a real difference as shown in the case of genome patents. Particularly abstract, broad, and upstream patents tend to be problematic,

especially when comes to the need to pool them with other basic elements in the context of a design space. It could be advantageous to formulate, what would the public response be, if an IP dispute was indeed blocking important domains of application, as the mere treat of an intervention would encourage private solutions.

Regulation of Licensing

This might be the most promising means of removing the dysfunctions in the patent system. Voluntary, and if necessary mandatory, limitations on exclusive patenting could be introduced when there are solid grounds for believing that a patented basic element is inherently multi-functional or blocks an important design space or large domains of further inquiry, particularly when it comes to partly or wholly publicly funded research in universities and elsewhere. Since in some cases the problems do not arise immediately, the possibility of changing the licensing status of a patent should exist. These licensing regimes could be particularly effective if applied to well-designed patent pools.

Science and Technology (S&T) Policy Measures

The creation and maintenance of technological commons should be an *explicit objective of S&T policy*. Since much of the fundamental technological knowledge is produced in public research organizations or otherwise publicly financed, the effective means of selectively preventing highly generic technologies from becoming excessively privatized exist. Disclosure through publication and/or judicious patenting in combination with suitable licensing rules are proven means of creating technological commons. Continued and even increased involvement of public institutions in technologically strategic research could be encouraged even in the absence of immediate interest and support by the private sector.

New Types of IP Regimes

Conventional patenting is of course not the only IP regime. Its importance has been increasing because of the relative weakening of the alternative means of protection, such as copyright. But there are also emerging entirely new approaches to IP offering attractive solutions to many problems caused by the mismatch between the patent system and the dynamics of design spaces. The open source approach is among the more interesting alternatives. Its essence is the joint creation and sharing of the growing core of a design space by the members of the community. They profit by exploiting the expanding fringe of the space, where genuinely new applications are to be found. Another important feature of the open source regime is that it encourages organic cumulative growth of shared design spaces. This, in part, explains why it has been so effective in the development of operating systems and various web applications.⁵²

Unless significant progress is made on one or more of the afore mentioned four domains, the phenomenally successful United States, and recently increasingly global, innovation locomotive might start loosing steam. While the U.S. system has

many virtues, other countries are ill-advised to imitate *every* aspect of its current IPR regime; for instance expanding patentability and national incarnations of the Bayh-Dole Act are not necessarily changes for the better. As Dunning and Lundan (2009) point out, even if innovative activities of multinational enterprises have also become increasingly global, they nevertheless remain quite “sticky” and are tied to the home base. Thus, a well-functioning IPR regime can be a source of sustainable national advantage even in today’s world.

Notes

- 1 Prepared as a part of the collaborative research of BRIE, The Berkeley Roundtable on the International Economy at the University of California at Berkeley, and ETLA, The Research Institute of the Finnish Economy. The first version of this article was written in the context of the 2004–5 European Forum lead by Rikard Stankiewicz and Aldo Geuna of the Robert Schuman Centre for Advanced Studies at the European University Institute. Petri Rouvinen participated in the Forum as a Jean Monnet Fellow with the kind support of the Academy of Finland and the Yrjö Jahnsson Foundation. The authors would like to thank the Forum Fellows as well as the participants of the Forum conference in 17–18 June 2005 (Florence, Italy) for comments and suggestions; it is also gratefully acknowledged that the editors, two anonymous referees, as well as the authors participating at the special issue workshop on 28 March 2008 at University of California, Berkeley, provided their valuable insights. Special thanks to Terttu Luukkonen, Ed Steinmueller, and Pekka Ylä-Anttila for their remarks. The usual disclaimer applies.
- 2 This point has recently been stressed by the opponents of software patenting (see, e.g., Hunt & Bessen, 2004).
- 3 <http://www.house.gov/Constitution/Constitution.html>, art. I, § 8, cl. 8, visited 8 Apr. 2005.
- 4 Source for citations of Title 35: http://www.uspto.gov/web/offices/pac/mpep/consolidated_laws.pdf visited 8 Apr. 2005.
- 5 The application “. . . shall contain a written description of the invention . . . in such full, clear, concise, and exact terms as to enable any person skilled in the art . . . to make and use the same, and shall set forth the best mode contemplated by the inventor of carrying out his invention” (35 USC § 112, p. L-24).
- 6 By implication there is a right to refuse to license. Furthermore, “[w]ith rare exceptions, licensing cannot be compelled in the United States” (Merrill & Elliott, 2004, p. 150).
- 7 Getting and especially enforcing a patent is an expensive undertaking (Merrill et al., 2004). An average U.S. corporate patent costs \$10,000–\$30,000 (p. 38) in direct fees (of which some one tenth comprise the USPTO’s fees and the remainder of legal counsel). The median cost of an infringement suit for each party is upwards from \$500,000 (p. 38) when the stakes are small. In a large case (over \$25 million at risk) the median litigation cost for each party is \$4 million (p. 38). The costs associated with most aspects of patenting have been increasing at an annual rate of 10–17 percent according to the American Intellectual Property Law Association (as cited in Merrill et al., 2004, p. 38). These figures do not include the significant costs associated with attention and time of the involved management and personnel.
- 8 Also the Supreme Court *not* granting a review to a case has strong implications, as by doing so it lets the decision of the lower court stand as a matter of law.
- 9 The Supreme Court in *Diamond v. Chakrabarty* in 1980 (447 US 303). Extended by the Federal Circuit in *re Deuel* in 1995 (51 F.3d 1552) to cover DNA encoding of known proteins.
- 10 The Supreme Court in *Diamond v. Diehr* in 1981 (450 US 175): software enabled methods and processes are patentable. The Federal Circuit in *re Alappat* in 1994 (33 F.3d 1526): software per se is patentable.
- 11 The Federal Circuit in *State Street Bank & Trust Co. v. Signature Financial Group* in 1998 (149 F.3d 1368). Confirmed and arguably extended in by the Federal Circuit in *AT&T v. Excel Communications, Inc.* in 1999 (172 F.3d 1352).
- 12 Primarily that of pharmaceuticals experiencing delays in their market introductions due to the federal approval process.
- 13 On a related note the scope of the research or experimental use exemption—as far as design spaces are concerned a very useful concept in the patent law—narrowed considerably: In *Embrex, Inc. v.*

Service Engineering Corp. the Federal Circuit's Judge Rader notes that "the Patent Act leaves no room for any . . . experimental use excuses for infringement" (216 F.3d 1343, as cited in Lee, 2004). Furthermore, with the Federal Circuit's decision in *Madey v. Duke* (307 F.3d 1351), universities may be subject to infringement suits in relation to all unlicensed proprietary pieces of knowledge regardless of the purpose and manner of employing them. In fact universities might be particularly attractive targets for infringement suits, as willful infringement carries triple damages. This might make it prohibitively expensive to both nurture and teach design spaces. Thus, the removal of research or experimental use exception, which has in practice largely taken place, has potentially severe consequences for design spaces. For instance in biotechnology licensing of multiple genes and research tools might be needed to write a reasonable research plan and certainly for carrying it out regardless of whether the findings are solely of academic interest or what will be the IP domain of the outcomes.

- 14 The upward trend in both patent applications and issues is an observed fact. Solid and conclusive evidence on deteriorating patent quality remains unavailable but "[t]here is nevertheless several reasons to suspect that more issued patents are substandard, particularly in technologies newly subject to patenting" (Merrill et al., 2004, p. 3). Mowery and Ziedonis (2002) suggest that the Bayh–Dole Act might be to blame for the apparently declining importance and quality of university patents. Paradise and others (2005), with a team comprised of licensed members of the Patent Bar, law students, and molecular biologists, analyze 1,167 claims in 74 human gene patents granted between January 2003 and May 2004. They find that, despite being quite conservative in some aspects of their methodology, 38% of the claims did not meet one or more patentability requirements. If otherwise nonproblematic claims with references to problematic ones are included, 57% of the claims are in some way invalid.
- 15 Codified primarily in Title 35 of the United States Code (Chapter 18: Patent Rights in Inventions Made with Federal Assistance).
- 16 The Justice Department and the Federal Trade Commission: *Guidelines for the Licensing of Intellectual Property* issued in 1995; for instance patent pools became generally accepted.
- 17 In a qualifying note (as cited in Merrill et al., 2004, p. 44) in *Diamond v. Chakrabarty* (447 US 303), the Supreme Court nevertheless stated that laws of nature, physical phenomena, and abstract ideas remain nonpatentable.
- 18 Under the "doctrine of equivalents" (recently revisited by the Supreme Court in *Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co.*, 535 US 722), an over hundred fifty year old principle stating that a device or process is infringing a patented one if it does substantially the same to achieve similar result, the scope of a patent might be considerably broader than what meets the eye.
- 19 There are, however, a few possible caveats. First, in theory establishing a design space can reduce variety. In practice this is not likely to be a major issue due to the flexibility, nonboundedness, and evolutionary nature of the space itself. The space is less about reducing downstream production possibilities and more about reducing upstream (re)search cost. Second, the statement assumes away some of technological dynamics, more specifically, that the licensed basic elements would have been discovered and/or developed also in the absence of the licensing opportunity. At least as far as publicly funded research is concerned, this is arguably the case. While in principle patents do create a market for technology thus encouraging both development and diffusion of innovations, in practice this is not necessary the case (Bessen, 2005). Patents also have increasingly important secondary uses (Thumm, 2004), which, as a rule, impose additional problems in the context of a design space. For instance, defensive patents are acquired for insurance; with nondiscriminatory licensing the insurance aspect of these patents is gone, as they cannot be used to counter-suit any licensee of the design space. Third, without proprietary motives, the space might be less eagerly developed and promoted reducing its usefulness and the level of use.
- 20 The finding that the market will—under a suitable set of assumptions—solve "everything" is reasonably common in microeconomics as suggested by, e.g., the fundamental welfare theorems (see, e.g. Varian, 1992).
- 21 An exchange of IP takes place if a mutually satisfactory fixed-point is reached in negotiations. As shown by Merges (1994), for a range of values such a point does not exist.
- 22 A further issue is that the interests of the ultimate beneficiaries—may that be consumers or the profession employing the design space—are not necessarily represented at all upon the IP bargaining. Yet another issue is network effects briefly mentioned above; unless internalized in some manner, they will cause the market to fail, i.e., to depart from the socially optimal outcome.

- 23 For instance in the case of PCs, in hindsight it seems that IBM would certainly have had a motive to suppress the PC market in favor of mainframes and dumb terminals at least in corporate environments.
- 24 This in its own right arouses strategic behavior on behalf of the holders of necessary IP but we do not elaborate on this complex issue.
- 25 This is a problem of the patent system we do not elaborate on here, although it should be pointed out that for each of the six patents discussed below another patent (or in one case a web standard) can be found with significantly overlapping subject matter. With the effects mentioned in the text the licensing fees begin to add up: for example gene and research tool-related royalties currently amount to over one tenth of the cost of developing a new drug (Pollack, 2000).
- 26 As a fixed fee does not influence the producer's cost of providing an extra unit of the good or services, his profit maximizing output is unaffected. A fractional fee will, however, reduce output causing a "deadweight loss"—a reduction in total welfare defined as the sum of the producers' and consumers' surpluses.
- 27 The intention here is neither to challenge the validity of these patents nor to question the morale of the inventors or assignees and least of all the professionalism of the hard working employees of the United States Patent and Trademark Office (USPTO). All of the example are officially granted by the USPTO and thus legally binding.
- 28 The U.S. patent 4,405,829. As noted in the patent documentation, the research leading to the invention was funded by the U.S. Navy (N00014-67-A-0204) and the National Science Foundation (MCS76-14249).
- 29 The U.S. patent 4,200,770 (Apr. 1980).
- 30 In the late 1990s the Internet Engineering Task Force (IETF), the industry standardization body, was able to pressure *RSA Security* to surrender some of its IP upon establishing a standard for secure email communications (Carlson, 1999).
- 31 The U.S. patent 5,838,906.
- 32 The U.S. Patent 5,860,073.
- 33 Among other things arguably there were (ignored) examples of prior art and implementations since the 1960s (McKenzie & Walter, 1999).
- 34 *Microsoft's* seemingly noble gesture may have disguised more questionable motives (Stern, 1999).
- 35 The U.S. Patents 4,736,866 (Apr. 1988); 5,087,571 (Feb. 1992); and 5,925,803 (July 1999).
- 36 Arguably also Leder's eight NIH grants (1Z01HD000074-04 to 1Z01HD000074-11) to study the "genes of man and the mouse" (1Z01HD000074-11, Abstract) contributed to the work (Blaug et al., 2004).
- 37 While unaltered animals could be used for cancer research, one "would probably need three or four times as many animals and carry on the study twice as long" (Dan Dumount, a director of a biotech lab in Toronto, as cited in Ungar, 2002). Given the broadness of the patent covering all nonhuman mammals and their offsprings with transgenes making them more susceptible to cancer (Blaug et al., 2004; Dubois & McCallie, 2003), doing this type of mainstream cancer research without the transgenic mice would arguably be prohibitively expensive.
- 38 It has been suggested, that similar reach-through claims are increasingly a part of normal academic intercourse: material transfer agreements (MTAs) "from both private firms and universities also typically prohibit researchers from sharing these tools with other institutions and call for pre-publication review of research results. Similar restrictions now appear in MTAs that govern purely academic exchanges of unpatented research tools *between* academic institutions" (Rai & Eisenberg, 2003, p. 295, original emphasis, a footnote citing the 4 June 1998 report of the NIH Working Group on Research tools as the source omitted).
- 39 The U.S. Patents 5,693,473 (Dec. 1997); 5,709,999 (Jan. 1998); 5,710,001 (Jan. 1998); 5,747,282 (May 1998); 5,753,441 (May 1998); 5,837,492 (Nov. 1998); 6,030,832 (Feb. 2000); 5,837,492 (Mar. 2000); 6,162,897 (Dec. 2000); and 6,235,263 (May 2001)—various inventors but Myriad always among the assignees.
- 40 Several NIH grants (especially 5R01CA055914-02 and 1R01CA055914-01A1 but also 2R44GM040794-02, 5R44GM040794-03, 1P01CA048711-01A1, 5P01CA048711-02-05, and 1R01CA063720-01) may have contributed to the research.
- 41 Upon securing the patent Myriad informed all laboratories engaging in independent research or clinical trials involving BRCA that they should cease these activities (Henry, 2007). OncorMed, another company with a patent granted on BRCA1, settled out of court with Myriad retaining exclusive rights (Hemphill, 2003).

- 42 A comprehensive (i.e., covering several mutations; it has been suggested that Myriad's test is inferior to some alternatives and does not uncover some mutations and might also otherwise be suboptimal for clinical and research purposes) BRACAnalysis® of the BRCA1 and BRCA2 genes costs \$2,975 (SEC, 2004).
- 43 The U.S. patent 6,455,275.
- 44 The U.S. patents 4,399,216 (Aug. 1983); 4,634,665 (Jan. 1987); and 5,179,017 (Jan. 1993). It has been pointed out that "the written descriptions . . . for all four patents are *identical*—save for isolated, minor corrections limited to spelling and grammar" (HJLT, 2004, p. 601—emphasis as in the original).
- 45 As noted in the two earliest related patent applications, "[t]he invention described herein was made in the course of work under grants numbers CA-23767 and CA-76346 from the National Institutes of Health." As the invention was made in the pre-Bayh-Dole era, Columbia and NIH negotiated an agreement allowing the university to license the technology, provided that it would "include adequate safeguards against unreasonable royalties and repressive practices" (as cited in HJLT, 2004, p. 590).
- 46 Possibly at par with the Cohen–Boyer patents of Stanford and University of California, San Francisco, grossing some \$300 million (Malakoff, 2004).
- 47 The U.S. Patent 5,960,411 (Sep. 1999).
- 48 For a skeptical appraisal of the mighty gene see, among others, Keller (2000).
- 49 The U.S. Patents 4,237,224 (Dec. 1980); 4,468,464 (Aug. 1984); and 4,740,470 (Apr. 1988). As noted in the documentation of the initial patent, "[t]he invention was supported by generous grants of NIH, NSF and the American Cancer Society."
- 50 In the absence of transaction costs the problem would be solved by appropriate transfer payments; as discussed above, in practice the problem remains.
- 51 While some patents are easy to circumvent a priori, before a design space has been standardized, it can become enormously costly ex post. Thus, an opportunistically behaving firm has an incentive to attempt to make a basic element it controls a part of the standard and, once successful, let the patent surface and start pumping up the licensing fees. Litigation is not always an effective defense against such tactics. Both in biotechnology and software, the upfront investments are often quite sizable and in large measure intangible. They are also sunk, i.e., not recoverable in alternatives uses unlike, say, buildings or machinery. Even relatively brief interruptions in the normal flow of business, say in the form of a preliminary injunction, might cause intellectual capital to walk out with the frustrated employees.
- 52 There exists a natural affinity between the open source and the open science ethos. Indeed, the open source movement has had its roots at the university campuses. But what is special about it is that it works also outside academia. And this is a huge advantage given the institutional heterogeneity of technological communities. Interestingly open source is now spreading beyond the software community into, among other areas, biotechnology. It is too early to tell whether these experiments will result in a major new IP regime. Interest and support of the academic community could help. Also helpful would be intensified research on the relationship between cognitive processes and the institutional structures of both science and technology.

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