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The benefits and costs of strong patent protection: a contribution to the current debate

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Abstract

Today's conventional wisdom is that strong patent rights are conducive to economic progress. Yet not long ago students of the patent system took a more nuanced position, arguing that often strong patents were not necessary to induce invention, and entailed significant economic costs. Several empirical studies have supported this position. However, the current advocacy invokes theories of the positive benefits of patents that were repressed in the earlier more negative analyses. This essay reviews these theories, and the empirical evidence that might bear on them. The authors conclude that there is reason for concern that the present movement towards stronger patent protection may hinder rather than stimulate technological and economic progress.

Keywords: Patent protection; Current debate; Significant economic costs

1. The current climate of opinion

Today's conventional wisdom, among economists, lawyers, public officials, and many lay persons, is heavily weighted toward the proposition that strong and broad patent rights are conducive to economic progress. This is especially so in the United States. Through negotiations regarding GATT, and now the proceedings of the WTO, the United States has been pushing on other countries its beliefs about the economic value of strong patents. The U.S. position here is heavily freighted with national interest, but there also is honest belief in the rightness of the position. And other countries have been going along, not always simply as a reaction to the pressure, but also because of an honest belief, on the part of many parties, that in the long run strong patent protection will be good for their economic development (UNCTAD, 1994).

The conventional wisdom was not always so definitely in favor of strong patent protection. 'An Economic Review of the Patent System', the magisterial work of Machlup (1958), recounts a long history of doubts, indeed often overt hostility, about the patent system expressed by European and American economists and other analysts. Machlup's own position on the patent system expressed at that time is

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accepting but reluctant. F.M. Scherer's textbook on industrial organization, which probably fairly represented the opinion of informed economists in the 1970s and the 1980s, stressed the costs of the patent system as well as the benefits, and Scherer's position scarcely can be regarded as a ringing endorsement for stronger, broader patents (Scherer, 1980; Scherer and Ross, 1990).

The swing in the climate towards such an endorsement is specially puzzling in the light of the empirical research that has been done on the efficacy of patent protection. Since the 1960s, a series of empirical studies have explored the question of how important, and how effective, firm executives believe patent protection can be in enabling them to reap the rewards from their 'inventions.' We discuss these studies in more detail in Section 2 of this paper. Suffice it to say here, however, that those studies have been interpreted by knowledgeable economists as an indication that in most industries patents were not an important part of the incentives firms have for investing in R&D (Mansfield, 1986; Levin et al., 1987; Cohen et al., 1997). And these industries include many of those regarded as 'high-tech,' like computers and semiconductors (pharmaceuticals are an exception).

However, these studies can be faulted for focusing almost exclusively on established firms, generally large ones, operating within a particular industry, and for posing the questions in terms of how patents enable these firms to reap returns from their 'inventions'. A significant share of the recent arguments in favor of strong patent protection focuses on the importance of patents for new entrants, or small firms, or organizations outside of any particular industry (for example, universities), and stresses functions of patents that are often different from those presumed in the empirical studies in question.

The extent of the changes in the U.S. patent policy supported by these arguments is remarkable. In 1982 the Court of Appeal for the Federal Circuit (CAFC) was established to deal with patent litigation cases in a unified manner. The Court has, as intended, considerably strengthened the protection from infringement afforded to patent holders. From 1982 through 1987, 89% of the district court decisions of patent validity have been upheld by the appellate court, up from 30% prior to the creation of the CAFC (Dunner, 1988). In addition to this strengthening of patent protection, new policies have been enacted aimed at strengthening the regime of intellectual property on the results of government-funded research. In particular, legislation culminating in the Bayh–Dole Act of 1980 strongly encouraged universities performing government-sponsored research to apply for patents on the results of this research, while earlier the norm was to place such results in the public domain (Eisenberg, 1996). Since the 1980s there has also been a trend toward broadening the definition of patentable subject matter, partly in response to the perceived demands from emerging fields of research and technology, like biotechnology and software.

In view of the fact that patents entail social and economic costs, it would seem wise not to push for stronger patent protection, unless the evidence indicated that the economic benefits were significant. Such indications are certainly missing from the conventional interpretation of the available empirical studies. On the other hand, as we suggested above, much of the current argument points to a broader range of functions served by patents than these studies explored.

The question examined in this essay is whether or not recognition of a range of functions served by patents, that is wider than empirical research has explored to date, provides reasons for scholars of technical change to endorse the current beliefs about the value of strong, broad patents. We review various theories about the social functions of patents in Section 2. In Section 3 we present our evaluation. To tip our hand, we think the earlier skepticism and caution of a Machlup, or a Scherer, still is quite justified.

2. Theories about the benefits and costs of patents

We propose that there are at least four different broad theories about the purposes patents serve that are involved in the current debate: (I) The anticipation of patents provides motivation for useful invention; we will call this the 'invention motivation' theory. (II) Patents on inventions induce the needed investments to develop and commercialize them; this

we call the 'induce commercialization' theory. (III) Patents are society's award to individuals who disclose their inventions; we will refer to this as the 'information disclosure' theory. (IV) Patents enable the orderly exploration of a broad prospect; we call this the 'exploration control' theory.

Of course these theories are not mutually exclusive. Under certain circumstances the lure of a patent may induce invention and the holding of a patent may facilitate its commercialization. Also, it must be recognized that the lines between the theories are sometimes blurry. The invention motivation theory and the induce commercialization theory can overlap. To further complicate matters, each of the broad theories contains several different variants. As we shall see, the invention motivation theory looks different when focused on established firms in an industry than when the focus is on potential entrants or parties that have no capability for production or marketing. The induce commercialization theory takes on a special look when the focus is on university 'inventing'. Despite these complications, we think that recognizing that there are several different theories at work helps to illuminate the current discussion.

2.1. Theory I—patents motivate invention

The argument that patents motivate useful invention is unquestionably the most familiar theory about the economic function of patents. For our purposes, we want to highlight that one important aspect of Theory I is that granting patents entails economic costs as well as potential economic benefits. Strong broad patents should not be granted lightly.

In the standard version of Theory I, the costs to society of granting a patent stem from the monopoly on the technology that the patent awards (Arrow, 1962; Nordhaus, 1962; Scherer, 1972). In some cases, notably in pharmaceuticals—a technological field where patents clearly are effective—firms charge very high prices for their patented pharmaceuticals. And there are a number of examples of firms who have parlayed a few key patents into a monopoly or near monopoly position in important product fields. The Bell telephone patents were an important part of the package of elements that enabled AT&T to establish the near monopoly on telephone service which they held for many years. Light bulb patents enabled GE and Westinghouse to prevent entry into the light bulb business. While one should not exaggerate the extent to which patents give important monopolies—as we shall argue shortly, in many industries patents do not seem to be very effective—the fact that they create at least some monopoly power is good reason not to grant them when they are not needed to motivate invention, at least if Theory I correctly captures the functions of patents.

In addition to the 'static' costs associated with a patent-protected monopoly position, which has been the focus of most economic analyses (Klemperer, 1990; Gilbert and Shapiro, 1990), there are other 'costs' of prevailing patents that should be recognized, and in some areas these might be important. The holding of a broad patent by one firm in some cases deters other firms from trying themselves to invent 'in the neighborhood' (Scotchmer and Green, 1990; Green and Scotchmer, 1995). In particular, unless that patent is liberally licensed, other firms are deterred from themselves undertaking any of the wide variety of follow-on inventive work that improves, or variegates, on an initial invention (Merges and Nelson, 1990; Merges, 1994; Lerner, 1995). A possible silver lining is that the presence of a patent forces other firms, if they want to compete in the broad product field, to work on alternatives that may be very different from what is already patented.

The perception that granting patents is not costless to society implies, of course, that one should not grant patents where the benefits do not exceed the costs. The underlying assumption of Theory I is that patents are needed to provide firms with the requisite incentive to invent, and that this does justify the costs of the temporary monopoly their granting gives.

Motivated partly by this perception, over the last 30 years, there have been a number of empirical studies that have probed at the importance of patents to firms that do R&D in an industry. In the 1950s, Scherer et al. (1959) studied firms in the United States. In the 1970s, Taylor and Silberston (1973) studied firms in the UK. Both studies reached the then surprising conclusion that, aside from pharmaceuticals, firms in most industries reported that patents were neither particularly effective, nor necessary, for enabling them to appropriate returns from

their R&D. In the 1980s, Mansfield (1986) and Levin et al. (1987) undertook similar studies. The conclusions were similar. The very recent studies of Cohen et al. (1997) for the United States, Goto and Nagata (1996) for Japan, and Arundel and van de Paal (1995) for Europe, suggest that the situation in the 1990s is not very different.

In a wide range of 'high-tech' industries, firms rated a head start, establishment of effective production sales and service facilities, and rapid movement down the learning curve, as much more effective than patents in enabling them to profit from their R&D. Pharmaceuticals and other fine chemical products are exceptions, but the above is true for firms in the computer, semiconductor, and aircraft industries, for examples. A number of industries which do little R&D, and where technological advance is relatively slow, also reported that patents were not particularly effective for them. In such cases one might conjecture that stronger patents might spur more inventing. But this is not at all clear, and in any case the recent pressures for stronger patent protection have not been coming from 'low-tech' industries.

As we noted in Section 1, these studies have led a number of economists to be bearish on the net social value of strong patents. On the other hand, as we also noted, an important limitation of the studies reported above is that they all have been focused on a particular class of innovators, typically large firms with an established presence in their product markets and thus having access to the complementary assets needed to commercialize the end-product of their innovative efforts.

These studies, therefore, may miss the interests of a small firm in an industry where there are, as well, several large ones with deep pockets and strong market positions, may not be able to make much advantage out of a 'head start', or timely establishment of an effective production and sales program, or rapid movement down the learning curve, unless there is some way of holding off the large competitors. Perhaps for such firms patents are more important than they are for large established firms, either as a means to appropriate returns through licensing or as a means to maintain control of the technology while a production and sales capability is established.

Nor do these studies get at the question of whether the prospect of patents motivates firms and other organizations outside of a particular industry to undertake inventions which would be used inside that industry. This class of inventors, call them industry-outsiders, is likely to lack the complementary assets needed to appropriate the returns from innovation by being first to market or by rapidly moving down the learning curve. Studies such as that by Jewkes et al. (1969) have documented the importance of such outsiders to technical advance in a number of industries. For such outsiders, the prospect of a patent may be essential if there is to be incentive to invent. On the other hand, if such a firm can gain a strong patent, it may be in a good position to bargain a joint venture, or a license deal, with a firm that has production and market capabilities (Teece, 1986).

The collection of small and medium sized firms in the American biotechnology industry is, of course, a striking example of enterprises that would not have come into existence without the prospect of a patent, and which depend on patent protection to make their profits, and to attract capital, through one or another of these strategies.

The above discussion has begun to draw a distinction between inventing, and the follow on work that needs to be done to develop and commercialize new technology. Arrow (1962) and Arora and Gambardella (1994) have stressed this distinction. Once it is made, the door is open to a somewhat different view of the functions served by patents.

2.2. Theory II—patents induce the development and commercialization of inventions

The distinction drawn between invention on the one hand and development and commercialization on the other has been part of the conventional wisdom for a long time. Thus more than two centuries ago, Parliament extended Watt's steam engine patent explicitly to give him more time to effect commercialization. More recently, the same distinction has been the focus of the argumentation that led to the passage of the Bayh–Dole Act in 1980.

It is clear that many patents are granted quite early in the innovation process, with a lot of follow on work needing to be done before the crude inven-

tion is ready for actual use. This context is the focus of Theory II. The argument is that the holding of a patent at an early stage provides assurance that, if development is technologically successful, its economic rewards can be appropriated. Accordingly, Theory II suggests that an important role of patents is to induce the firms to commit resources to the development of inventions.

Theory I and Theory II obviously are not mutually exclusive: the prospect of a patent may provide the incentives for firms or individuals to invent, while the holding of a patent may provide them with the security that they will be able to appropriate the returns from the investment incurred during the development of commercial products. From the perspective of large established firms in an industry undertaking both the inventive work and the development activities, Theory II perhaps can be interpreted as a refined version of Theory I with the timing of the patent award during the innovation process playing an important role.

On the other hand, Theory II brings into view some matters that may be missed if the analytic orientation were strictly that of Theory I. As Rebecca Eisenberg has pointed out to us, Theory II enables us to recognize the role of the holding of a patent in the case where the inventor needs to go to the capital markets in order to obtain development financing. This capability might be crucial for small and/or new firms faced with substantial development costs before they can get their inventions to market.

The distinction between Theory I and Theory II becomes sharper, although there is still overlap, in situations where the firm that makes the original invention does not have the desire or the capability to carry it to market itself. Years ago Mueller (1962) pointed out that a large share of DuPont's product innovations were based on inventions bought from smaller firms. Similarly, in the 1920s General Electric bought and developed many inventions originally made by private inventors or small firms (Reich, 1985). What ought to be stressed about these cases, from the perspective of Theory II, is that the holding of a patent by the initial inventor may have been necessary for any such licensing to occur. On the other hand, the prospect of a patent may or may not have been an important factor in inducing the original inventive effort in the first place.

Theory II becomes distinctively different from the standard version of Theory I in circumstances where not only is the organization that does the early inventing work not in a position to do the development work, but also, the invention itself would have been made without any patent in prospect. Thus consider the case where the original 'inventor' is a university or a government lab, and the research has been financed by Government. This is basically the context assumed in the discussions that led to the Bayh–Dole Act. Bayh–Dole does not make any sense under Theory I, which presumes that while patents may be needed to induce inventing, they should not be granted if inventing would go on in any case. The argument for the bill was basically Theory II.

While the 'inventions' under discussion had been achieved using public monies, it was argued that they served no economic purpose unless and until they were developed to a point where they were commercial. Only companies had the capabilities to undertake such development and, under the version of Theory II most clearly articulated in these discussions, it was argued that a company would be unlikely to engage in development of a university invention unless it had proprietary rights. If the universities held strong patent rights they would be in a position to sell such licenses. In contrast, if there were no patents, or if the government held them with a commitment to non-exclusive licensing, companies would be unlikely to invest in the necessary development work (see the analysis of the legislative history by Eisenberg, 1996).

This particular argument for the Bayh–Dole Act seems to presume that firms have weak incentives to invest in the development work unless an exclusive license on a university patent provides assurance that the returns from such investment can be appropriated. The presumption clearly is that patents cannot be taken out on the further 'inventing' that is involved in development work, and that the results of such development cannot be made proprietary in other ways. Thus a controlling patent on the original invention is seen as the only way to prevent competitors from sharing in the returns through imitation.

However, in many areas, patents do in fact emanate from development. Further, the Levin et al., Mansfield and Cohen et al. studies indicate that in

many industries patents are not needed to induce development: a simple head start on commercialization can yield large profits on a new product, and secrecy often can effectively protect new process technology used by the developer.

Of course these findings were from the responses of large established firms. Where the licensee is a small firm, who must marshal outside funds, and who may be swamped by quick imitation from a large firm, the case for Theory II might well be stronger. Also, another justification for patenting already paid-for inventions is that the possession of a patent gives the original patent holding organization incentive to push out its inventions to firms that can develop and commercialize them. There is evidence that Bayh–Dole has significantly increased the extent to which American universities, given research results that have potentially commercial aspects, advertise and push these (see Gelijns et al., 1996, 1998; Crow et al., 1998).

On the other hand, a case can certainly be made that, for many university 'inventions' that were funded with public monies, the policy implications of Theory I—that if one does not need to grant a patent to get an invention one should not grant a patent—are basically correct. The results of research would be published in any case. Firms, in many instances, would have ample incentive to work with and 'develop' what comes out of university research. They usually can patent the developments, or gain the advantage of a head start on the market, or both. No ex-ante grant of an exclusive license is needed to motivate this work, and the presence of a patent and the requirement to get a license to do further work on the original idea may restrict the number of parties who will do that work. The Cohen–Boyer basic technology in biotechnology was patented if very broadly; the Kohler–Millstein technology was not. Firms certainly were not reserved bout using the latter.

On the other hand, it is clear that Bayh–Dole has led universities to advertise their 'inventions' more actively. In some instances at least the effort to achieve a patent, and the information regarding both the nature of that invention and of what its uses might be, provide potential users with more and different information than would a simple scientific publication alone. This leads us to Theory III.

2.3. Theory III—patents induce disclosure of inventions

Theory III also has been part of the conventional wisdom of the patent policy community for a long time (Machlup, 1958). Under theories I and II patents are necessary to induce the inputs needed to advance technology, but at the cost of restricting use. Under Theory III patents are not necessarily required to induce innovation. However, patents encourage and provide a vehicle for disclosure and, more generally, generate quick and wide diffusion of the technical information underlying new inventions.

The conventional version of Theory III focuses on commercially oriented inventors, and assumes that they can appropriate some returns from a new process or product simply by using or producing it, while keeping the relevant information secret to prevent rapid imitation. The possibility of patenting the invention, however, lures the inventor into making the relevant information public. In earlier years, the argument was often couched in terms of society's access to the technology after the inventor had died (Machlup, 1958). However, in the modern world where companies, rather than individuals, are largely the custodians of invention-specific technological knowledge, the issue clearly must be posed more generally in terms of the speed, breadth, and completeness of information disclosure or leakage.

In our view, Theory III, like Theory II, becomes interesting when it is assumed that the inventor, by him or herself, cannot exploit all possible uses of the invention. Then, to the extent that the publication of a patent attracts the attention of parties who can make use of the invention, patenting can increase use. This argument obviously is kin to versions of Theories I and II where the lure or holding of a patent facilitates technology transfer, but the focus here is in the 'advertising' value of patents.

In this light, one can see one of the positive effects of Bayh–Dole to the advertising of potentially commercial university research results through the publication of patents. We noted above that since Bayh–Dole American universities have invested much more effort in advertising their wares. At present we know very little about whether, or the extent to which, this advertising has facilitated technology transfer.

In any case, while the thrust of the Theory II arguments for Bayh–Dole is towards exclusive licensing of university inventions, the thrust of the Theory III arguments would appear to be towards widespread licensing. This gets us into the range of issues that are associated with Theory IV—the prospect control theory.

2.4. Theory IV—patents enable orderly development of broad prospects

An implicit feature of most versions of Theory II is that, while significant resources and risk taking may be needed to develop an invention, there is basically one commercial product at the end of the rainbow. The prospect theory—Theory IV—differs from Theory II in that an initial discovery or invention is seen as opening up a whole range of follow-on developments or inventions (Kitch, 1977). We note that many university 'inventions' are of this sort. So also, more generally, are many of the new patents being granted on rDNA techniques, and on gene fragment codes.

Under Theory IV the holding of a broad patent on a prospect opening invention permits the development of the full range of possibilities to proceed in an orderly fashion. Under the articulation of Kitch (1977), unless there is a broad patent on a prospect opening invention, development of the prospect is likely to proceed in a wasteful way. He proposes that, unless there is a controlling patent, a lot of people will see the same opportunities and know that their competitors also see them, and the consequence will be races for specific targets of opportunity, and general overfishing in the prospect-pond (Barzel, 1968; Loury, 1979; Dasgupta and Stiglitz, 1980a,b). Thus a broad patent on the initial invention is necessary if 'wasteful mining of the prospect' or 'over fishing of the pool' is to be avoided. [1]

A combination of Theories II and IV, we would argue, lies behind much of the present belief in the desirability of granting strong and broad patents on 'inventions' that potentially can be fruitfully developed in a wide number of possible directions, but still are a long distance from anything of real practical utility. We frankly are amazed by the range of recent patents of this sort. Some come from universities, some from private for-profit firms that have gone into business to create such 'inventions,' and get such patents, and which aim to make their profit by licensing rather than development and commercialization in-house. The most obvious, and perhaps the most important, examples are the rash of firms that have set themselves up in the business of identifying parts of the genetic code, with the objective of licensing their patented findings to companies who then will try to make commercial hay out of those findings. Many contemporary analysts see the rise of specialized research firms as a triumph of a policy of granting strong, broad patents on embryonic inventions.

As one of us has argued in another place (Merges and Nelson, 1990) one can come to a very different view of the benefits and costs of giving a wide patent on a 'prospect opening' invention if one assumes that different inventors see very different things in the prospect, and would do different things. Indeed, under this version of the 'prospect theory' there might be very high social costs to granting a broad initial patent which gives monopoly rights on the exploration of the prospect. This would cut down on the number of diverse inventors who would be induced to work in the prospect in anticipation of a profitable invention down the road, since their ability to work that invention would be constrained by their ability to negotiate a license with the holder of the original prospect defining patent.

This argument suggests that an important issue on which the analysis of the benefits and costs of granting patents on broad prospects turns is what one understands about the market for patent licenses. If one assumes that, in general, potential licensees and patent holders have little difficulty in reaching a license agreement (that is, that the transaction costs of patent licensing are small), then one may take a relatively relaxed view of the costs of granting a large prospect controlling patent, even when one

[1] A variant of this normative proposition results also from the rent dissipation theory advanced by Grady and Alexander (1992), who indicate the existence of a trade-off between rent dissipation at the stage of the prospect opening invention and rent dissipation at the improvement or application stage. However, their argument does not avoid the sorts of problems that we raised with respect to Kitch's prospect theory (Merges, 1992).

believes that potential explorers of the prospect are diverse in terms of what they would do. On the other hand, if one believes that transaction costs often are high, and patent holders are prone to litigation, one is less sanguine about this. [2]

The issues raised by Theory IV are particularly salient, we believe, in two kinds of contexts. One of these is when technological advances within a prospect are strongly connected, as they are in what Merges and Nelson (1990) call cumulative systems technologies. In such contexts advancing a technology often requires ability to use a number of already developed components, and hence either the ability to negotiate a license, or an environment where litigation is not a serious threat. In the past, a number of systems technologies have been held up by cross-licensing difficulties. Aircraft and radio are interesting cases, in which the impasse ultimately was resolved only through Government action. (See Merges and Nelson, 1990.)

The principal new area 'systems' area where many parties see patents as posing such troubles is in the patenting of software, particularly software that controls or defines systems interfaces (Samuelson et al., 1994). But there are good reasons to believe that research on genes and gene expression is also running into systems problems, particularly insofar as patents are being granted piecemeal on various parts of the puzzle (Ko, 1992; National Research Council, 1997).

The other setting in which Theory IV issues are important is when an initial invention or discovery is a far distance from practical application, and its principal value is in providing clues as to how to proceed. In such cases we would argue that technological progress is likely to be furthered if a number of different parties follow the leads as they see them. At the same time it may be virtually impossible for any party to estimate with any confidence the expected value of taking out a license to follow those clues.

In any case, note that whenever an invention is understood as contributing to further invention potential as well as creating a new or improved product or process of immediately final use, a question can be raised as to whether strong patents enhance or hinder technical advances in the long run. The question of how strong a patent should be, or whether a patent should be granted at all, no longer turns on analysis of a trade-off between the positive effects on inventing of stronger patents, and the restrictions in use of technology associated with a regime of strong patents, as in Theories I and II. Rather, a good part of the argument is about whether the long run net effect on inventing of strong broad patents is positive or negative.

[2] The (admittedly limited) evidence on the transaction costs of technology transfer and licensing suggests that the latter is likely the case (see Caves et al., 1983; Contractor, 1981).

3. Is the case for stronger, broader patents persuasive?

The range of arguments about the positive social value of patents is obviously much wider than the area that strong empirical studies have explored to date. An analyst, citing the earlier empirical studies that appear to have shown only limited social value, obviously is vulnerable to the argument that those studies do not provide evidence on some of the possibly most important functions patents serve. Do these considerations warrant the current enthusiasm for stronger, broader patents? Or do good grounds remain for being quite cautious about the social welfare consequences of broadening and strengthening intellectual property rights?

We cannot present here an empirically supported and intellectually persuasive argument on this broad question. The important empirical research that needs to be done in order to map out the basic facts simply has not been done yet, and in any case the conclusions drawn from such empirical research would still be somewhat controversial. We can, however, lay out a point of view that is consistent with what is presently known, and see two important reasons for doing so.

First, it is important to raise a warning flag about the apparent rapid march of national public policies in the direction of stronger, broader patent rights. We would like to call attention to the possibility that in that direction lies a lot of future trouble. Second, by

making our assertions, we hope to stimulate, and focus, empirical research to try to support, or refute them. Such research is sorely needed.

We want to articulate here, therefore, the following position. The world economy will not benefit from a general broadening and strengthening of patent rights. In some areas, patent rights certainly are economically and socially productive in generating invention, spreading technological knowledge, inducing innovation and commercialization, and providing some degree of order in the development of broad technological prospects. However, in many areas of technology this is not the case. In a number of these, strong broad patents rights entail major economic costs while generating insufficient additional social benefits. And in some strong broad patents are simply counterproductive. One needs to be discriminating and cautious on this front.

In the first place, the across-the-board strengthening of intellectual property rights courts the danger of increasing litigational conflicts and costs in what we have called 'cumulative systems technologies.' Such technologies comprise a significant fraction of the technological landscape. In the past, in industries like aircraft, automobiles, computers, semiconductors, and telecommunications, the holding of intellectual property rights on different parts of the system by different parties tended to cause serious trouble, except insofar as the industries in question were able to work out relatively quick, low transaction cost mechanisms for cross-licensing. In each of these industries arrangements ultimately did get worked out to facilitate such cross-licensing, and to cut down on the extent of mutual blockage. (See the various cases described by Merges and Nelson, 1990.)

However, the new thrust toward defining and enforcing broad intellectual property rights already is causing some of the earlier arrangements to either become unglued or to be renegotiated on very different terms. The current situation in the semiconductors and computer industries is a good example (Scheier, 1992; Zipper, 1990). A common practice until not long ago was to negotiate blanket licenses among companies according to which the licensees were allowed to invent and develop products performing the same functions as those of the licensor without facing the threat of an infringement suit. After the strengthening of patent protection following the decisions of the CAFC, and with increased competition from (often foreign) newcomers to the industry, companies have changed their licensing and litigation strategy to better profit from their patent portfolio (Grindley and Teece, 1997). A case in point is Texas Instruments whose royalty earnings from semiconductor and electronics patents have grown roughly from US$200 million in 1987 to US$600 million in 1994.

As a general matter, in cumulative systems technologies there are strong reasons for keeping allowed patent claims relatively narrow, strongly enforcing the 'non-obviousness' criterion, and for encouraging the development of mechanisms for relatively broad and easy cross-licensing. In our view, current trends do not bode well. (For a more optimistic view, see Merges, 1994, unpublished.)

An important consequence of the trend toward broader and stronger protection of patents, particularly in these kinds of technologies, is higher barriers to entry for new firms. This is bad news for companies in the developing countries. The Japanese manufacturing sector, and more recently the manufacturing sectors in Korea and Taiwan, have grown up under a regime in which patent rights held by companies in advanced countries have not been strictly enforced. Had they been, the development of particularly the electronics industries in these countries would have been much more difficult. The strengthening of intellectual property rights regimes, and in particular the move toward enforcing these in developing countries, is not a happy development for those that had hoped for the development of indigenous manufacturing industry in these countries.

We are also concerned about the increasing tendency of intellectual property rights to be granted on discoveries or procedures that are a long way from practical application, and in particular the establishment of intellectual property rights on what used to be considered as 'science' and introduced to the public domain. We think that the basic argument behind Bayh–Dole—that companies need to have an exclusive license on an embryonic invention in order to try to develop and commercialize it—is for the most part empirically wrong. Much of inventive activity, in fact, involves exactly companies trying to develop something useful and patentable out of ideas in the public domain. Traditionally the award of the

patent has come after something useful has been achieved, rather than well before that stage.

Furthermore, the usefulness of an invention traditionally has been defined in terms of its potential practical use, as opposed to its ability to stimulate a broadly promising research agenda (Eisenberg and Merges, 1995). However, the trend in areas like biotechnology is toward considering as patentable research discoveries for which usefulness can only be defined by reference to their value in performing further research. This is likely to foster the growth of markets based on patent licenses on research tools and ideas that would have otherwise been in the public domain (National Research Council, 1997). As we have noted, whether the establishment of markets for information and techniques that were previously the domain of public science is a plus or not for society depends also on how well these markets work. Our understanding of the (admittedly non-systematic) evidence is that transaction and litigation costs are considerable.

Thus, while the granting of patents on findings and techniques that still are a long way from practical application has helped spawn research specialist firms in biotechnology, and perhaps in a few other areas, we are not sure that this phenomenon unambiguously represents a net benefit for society. There are reasons to ponder whether granting strong broad patents on gene fragments, and thereby inducing a whole new industry of for-profit firms to do research to identify the coding, is completely a positive development. There are very good reasons for keeping 'science' in the public domain, and publicly funding it. And where patents are granted they should be kept narrow.

The increased entrepreneurial activity of American universities (Henderson et al., 1995), which clearly has been induced, in part at least, by the above practice regarding intellectual property rights, has been looked at by many observers as an unmitigated plus, and something to be imitated by other countries. We suggest that a more cautious and balanced view is called for, and are especially uncomfortable with the notion that, as a general rule, university inventions ought to be licensed exclusively. In the limited set of cases where new or small firms are the entrepreneurial vehicle, such patent control may be important in getting outside funding, but this is a relatively small part of the nexus of connections between university research, and industrial development and commercialization. In fact, some of the inventions that have generated the greatest royalty income for the universities that have licensed them have been widely, not exclusively, licensed. One prominent example is the Cohen–Boyer patent held by Stanford University and the University of California (see also Gelijns et al., 1996 on Columbia University patents and licensing practices). Widespread licensing has avoided most of the problems that monopoly control of these 'prospect opening' inventions could have entailed. But the problem potentially is there.

We believe that the advocates of Bayh–Dole underestimate, or simply have not been concerned about, the extent to which Bayh–Dole in conjunction with broader changes in attitudes regarding intellectual property rights would lead to universities patenting research results whose principal input is into further research. We are not advocating here a repeal of Bayh–Dole. But we very much are urging the managers of the patents held by American universities to adopt a policy of non-exclusive and liberal licensing of university patents that hold the promise of being used in a wide variety of ways, and in further scientific research. And we very much believe that the public, and the policy-making community, should be aware of the problem.

To repeat our earlier statement, we recognize fully that we do not have powerful documentation to support the case we have developed here. However, we think the questions need to be raised simply to get more balance in the current discussion about intellectual property rights. And we think they provide extremely interesting and important challenges for scholars doing research on technological advance.

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