The Logic of Open Innovation: Managing Intellectual Property

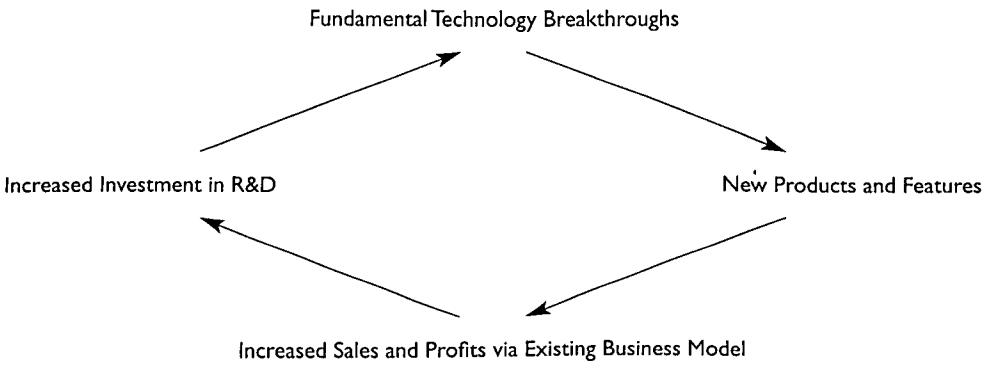
Henry Chesbrough

What accounts for the apparent decline in the innovation capabilities of so many leading companies, at a time when so many promising ideas abound? My research suggests that the way we innovate new ideas and bring them to market is undergoing a fundamental change. In the words of the historian of science Thomas Kuhn, I believe that we are witnessing a "paradigm shift" in how companies commercialize industrial knowledge.[1] I call the old paradigm Closed Innovation. It is a view that *says successful innovation requires control.* Companies must generate their own ideas and then develop them, build them, market them, distribute them, service them, finance them, and support them on their own. This paradigm counsels firms to be strongly self-reliant, because one cannot be sure of the quality, availability, and capability of others' ideas: "If you want something done right, you've got to do it yourself."

The logic that informed Closed Innovation thinking was an internally focused logic. This logic wasn't necessarily written down in any single place, but it was tacitly held to be self-evident as the "right way" to innovate. Here are some of the implicit rules of Closed Innovation:

- We should hire the best and the brightest people, so that the smartest people in our industry work for us.
- In order to bring new products and services to the market, we must discover and develop them ourselves.
- If we discover it ourselves, we will get it to market first.

FIGURE 1. The Virtuous Circle



- The company that gets an innovation to market first will usually win.
- If we lead the industry in making investments in R&D, we will discover the best and the most ideas and will come to lead the market as well.
- We should control our intellectual property, so that our competitors don't profit from our ideas.

The logic of Closed Innovation created a virtuous circle (Figure 1). Companies invested in internal R&D, which led to many breakthrough discoveries. These discoveries enabled those companies to bring new products and services to market, to realize more sales and higher margins because of these products, and then to reinvest in more internal R&D, which led to further breakthroughs. And because the intellectual property (IP) that arises from this internal R&D is closely guarded, others could not exploit these ideas for their own profit.

For most of the twentieth century, this paradigm worked, and worked well. The German chemicals industry created the central research laboratory, which it used to identify and commercialize a tremendous variety of new products. Thomas Edison created a U.S. version of this laboratory, used it to develop and perfect a number of important breakthroughs, and founded General Electric's famed laboratory. Bell Laboratories discovered amazing physical phenomena and harnessed its discoveries to create the transistor, among its many important achievements. Moreover, the U.S. government created an ad hoc central research laboratory to conduct a crash project on nuclear fission, which led to the development of the atomic bomb.

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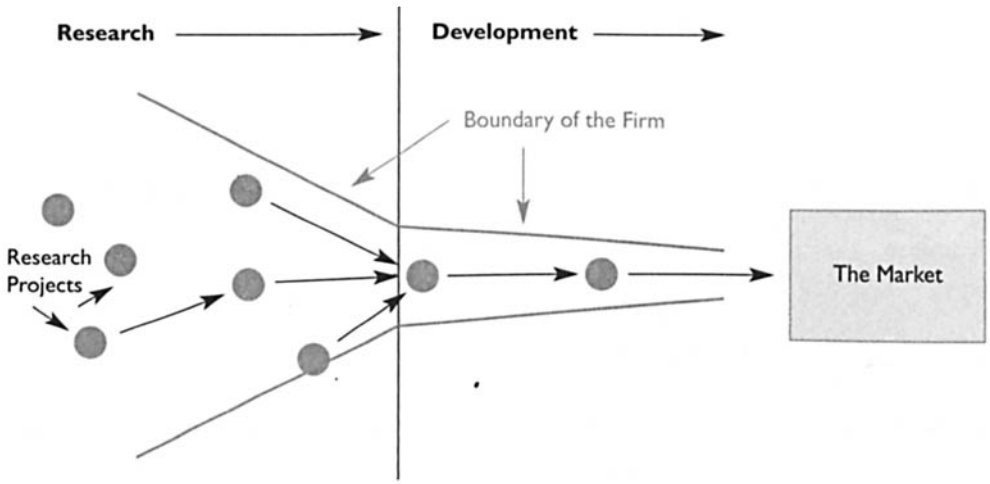
Figure 2 depicts this Closed Innovation paradigm for managing R&D. The heavy solid lines show the boundary of the firm. Ideas flow into the firm on the left and flow out to the market on the right. They are screened and filtered during the research process, and the surviving ideas are transferred into development and then taken to market.

FIGURE 2. The Closed Paradigm for Managing Industrial R&D

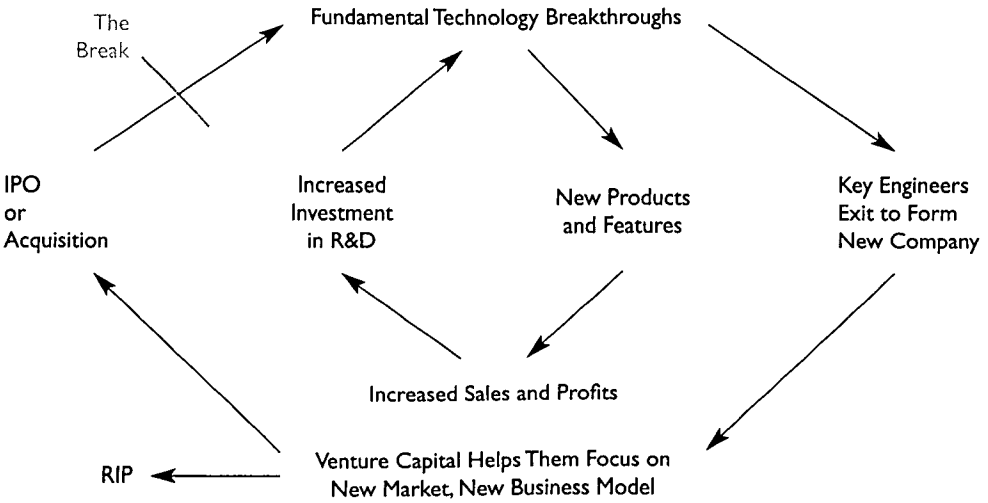


In Figure 2, the linkage between research and development is tightly coupled and internally focused. Our extant theories of managing R&D are built on this conception. Examples of this thinking are the stage gate process, the chain link model, and the product development funnel or pipeline found in most texts on managing R&D.[2] Projects enter on the left at the beginning, and proceed within the firm until they are shipped to customers on the right of the figure. The process is designed to weed out false positives, projects that look initially appealing, but later turn out to be disappointing. The surviving projects, having survived a series of internal screens, hopefully have a greater chance of success in the market.

Erosion Factors That Undermined the Logic of Closed Innovation

In the last years of the twentieth century, though, several factors combined to erode the underpinnings of Closed Innovation. One factor was the growing mobility of highly experienced and skilled people. When people left a company after working there for many years, they took a good deal of that hard-won knowledge with them to their new employer. (The new employer, though, neglected to pay any compensation to the previous employer for that training.) A related erosion factor was the burgeoning amount of college and post-college training that many people obtained. The growing number of such people allowed knowledge to spill out of the knowledge silos of corporate central research labs to companies of all sizes in many industries. A further factor was the growing presence of private venture capital (VC), which specialized in creating new firms that commercialized external research and converting these firms into growing, valuable companies. Often, these highly capable start-up

FIGURE 3. The Virtuous Circle Broken



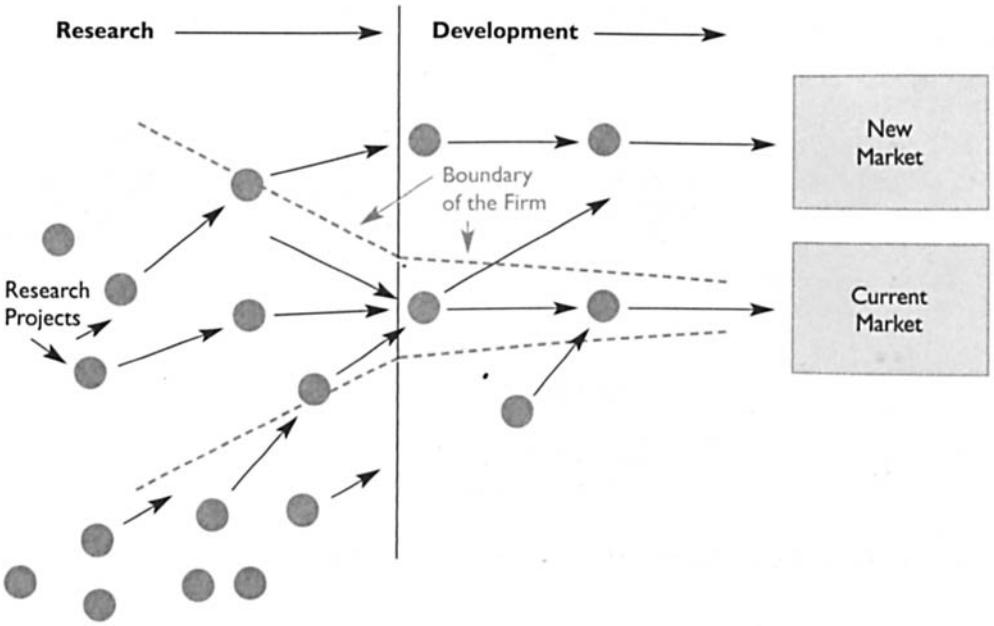
firms became formidable competitors for the large, established firms that had formerly financed most of the R&D in the industry—the very ideas these new companies fed off of as they competed for industry leadership.

The logic of Closed Innovation was further challenged by the increasingly fast time to market for many products and services, making the shelf life of a particular technology ever shorter. Moreover, increasingly knowledgeable customers and suppliers further challenged the firm's ability to profit from their knowledge silos. And non-U.S. firms became more and more effective competitors as well.

When these erosion factors have impacted an industry, the assumptions and logic that once made Closed Innovation an effective approach no longer applied (Figure 3). When fundamental technology breakthroughs occurred, the scientists and engineers who made these breakthroughs were aware of an outside option that they formerly lacked. If the company that funded these discoveries didn't pursue them in a timely fashion, the scientists and engineers could pursue these breakthroughs on their own—in a new start-up firm. The start-up company would commercialize the breakthroughs. Most often, the company failed (shown in Figure 3 as Rest in Peace [RIP]). But if it became successful, it might achieve an initial public offering (IPO) or be acquired at an attractive price. The successful start-up would generally *not* reinvest in new fundamental discoveries. Like Cisco, it would instead look outside for another external technology to commercialize.

The presence of this outside path broke the virtuous circle. The company that originally funded the breakthrough did not profit from its investment in the R&D that led to the breakthrough. And the company that did profit from the breakthrough generally did not reinvest its proceeds to finance the next genera-

FIGURE 4. The Open Innovation Paradigm for Managing Industrial R&D



tion of discovery-oriented research. This severed link between research and development meant that there would not be another round of investment in basic research to fuel another round of advances.

In situations in which these erosion factors have taken root, Closed Innovation is no longer sustainable. For these situations, a new approach, which I call Open Innovation, is emerging in place of Closed Innovation. Open Innovation is a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology. Open Innovation combines internal and external ideas into architectures and systems whose requirements are defined by a business model. The business model utilizes both external and internal ideas to create value, while defining internal mechanisms to claim some portion of that value. Open Innovation assumes that internal ideas can also be taken to market through external channels, outside the current businesses of the firm, to generate additional value. Figure 4 illustrates this Open Innovation process.

In Figure 4, ideas can still originate from inside the firm's research process, but some of those ideas may seep out of the firm, either in the research stage or later in the development stage. A leading vehicle for this leakage is a start-up company, often staffed with some of the company's own personnel. Other leakage mechanisms include external licensing and departing employees. Ideas can also start outside the firm's own labs and can move inside. As Figure 4 shows, there are a great many potential ideas outside the firm. In Figure 2, the solid lines of the funnel represented the boundary of the firm. In Figure 4, the

TABLE 1. Contrasting Principles of Closed and Open Innovation

Closed Innovation Principles	Open Innovation Principles
The smart people in our field work for us.	Not all the smart people work for us. We need to work with smart people inside and outside our company.
To profit from R&D, we must discover it, develop it, and ship it ourselves.	External R&D can create significant value; internal R&D is needed to claim some portion of that value.
If we discover it ourselves, we will get it to market first.	We don't have to originate the research to profit from it.
The company that gets an innovation to market first will win.	Building a better business model is better than getting to market first.
If we create the most and the best ideas in the industry, we will win.	If we make the best use of internal and external ideas, we will win.
We should control our IP, so that our competitors don't profit from our ideas.	We should profit from others' use of our IP, and we should buy others' IP whenever it advances our own business model.T

same lines are now dotted, reflecting the more porous boundary of the firm, the interface between what is done inside the firm and what is accessed from outside the firm.

Although the Open Innovation process still weeds out false positives (now from external as well as internal sources), it also enables the recovery of false negatives, that is, projects that initially seem almost worthless, but turn out to be surprisingly valuable. Often these projects find value in a new market, rather than in the current market. Or they may be worthwhile if they can be combined with other projects. These opportunities were frequently overlooked by the earlier Closed Innovation process.

At root, the logic of Open Innovation is based on a landscape of abundant knowledge, which must be used readily if it is to provide value to the company that created it. The knowledge that a company uncovers in its research cannot be restricted to its internal pathways to market. Similarly, its internal pathways to market cannot necessarily be restricted to using the company's internal knowledge. This perspective suggests some very different organizing principles for research and for innovation.

Table 1 shows some of the principles of this new paradigm and contrasts them with the earlier logic of the Closed Innovation approach.

Assessing the Prevalence of Open Innovation

This is not to argue that all industries now operate in an Open Innovation regime. Some industries have not been severely impacted by the erosion factors noted previously, and they continue to operate in a Closed Innovation regime. Nuclear reactors and aircraft engines are two industries in which reliance on one's own ideas, and internal commercialization paths to market, appear to remain the dominant innovation mode. (The innovation process of designing

and assembling aircraft using those engines, however, is undergoing important changes.)

Other industries have been in an Open Innovation mode for many years: The Hollywood film industry, for example, has innovated for decades through a network of partnerships and alliances between production studios, directors, talent agencies, actors, scriptwriters, specialized subcontractors (e.g., suppliers of special effects), and independent producers. Modern-day investment banking has been using external ideas for its innovations for many years as well. Newly minted Ph.D.s and even university finance professors develop new, exotic varieties of investment instruments to hedge against risks that could not have been financed a generation ago.

These different industries can be located on a continuum, one end of which includes industries in which entirely Closed Innovation conditions prevail, the other end containing industries with fully Open Innovation conditions:[3]

Closed Innovation	Open Innovation
• Examples of industries: nuclear reactors, mainframe computers	• Examples of industries: PCs, movies
• Largely internal ideas	• Many external ideas
• Low labor mobility	• High labor mobility
• Little VC	• Active VC
• Few, weak start-ups	• Numerous start-ups
• Universities unimportant	• Universities important

Many industries are in transition between the two paradigms: Automotive, biotechnology, pharmaceuticals, health care, computers, software, communications, banking, insurance, consumer packaged goods, and even military weapons and communications systems are examples. It is within these transition areas that the book's concepts will be the most important. In these industries, many critically important innovations have emerged from what seemed like unlikely places. The locus of innovation in these industries is moving beyond the confines of the central R&D laboratories of the largest companies and is spreading to start-ups, to universities, and to other outsiders.

Business Models and Managing Intellectual Property

Licensing technology is an important part of managing intellectual property (IP). How companies manage IP depends critically on whether they operate in a Closed Innovation paradigm or an Open Innovation paradigm. The Closed Innovation paradigm assumes that you must "make" your ideas and monetize them through your own products. A company manages IP to create and maintain control over its ideas and to exclude others from using them. The Open Innovation paradigm assumes that there is a bountiful supply of potentially

useful ideas outside the firm and that the firm should be an active buyer and seller of IP. A company manages IP not only to leverage its own business, but also to profit from others' use of the company's ideas.

The link between IP and a company's business model is overlooked by many proponents of managing IP. Consider the following claim: "[C]orporate America is wasting a staggering $1 trillion in underutilized patent assets. Given the pressures on companies these days to maximize shareholder return, this underutilization of technology assets represents either a stinging myopia regarding intellectual property or the greatest opportunity to be handed to chief financial officers in a generation."[4]

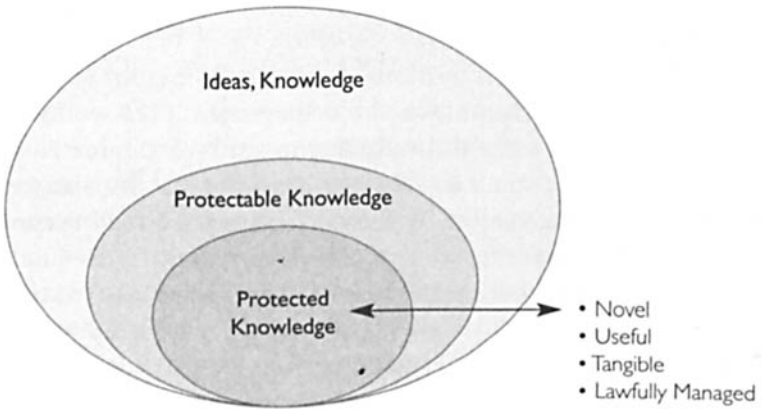
This claim is typical of many made by enthusiasts of IP. They claim that IP has enormous potential value, if only companies would pay proper attention to managing it. These proponents have half a point. There is indeed latent economic value in companies' IP, and some of that value has not been realized. Yet as I will discuss on the following pages, most patents are worth very little, and it is hard to know in advance which patents are valuable and which are not. Moreover, the claim as it stands is incomplete, because it assumes that technology assets have some inherent value, independent of any business model used to employ them. Technology by itself has no inherent value; that value only arises when it is commercialized through a business model. As with xerography and some other PARC spin-off technologies, the same technology commercialized through two different business models will yield two different economic outcomes. An awareness of the business-dependent value of technology is a crucial insight here, because much of the work on managing IP *assumes that there is some objective value* for a technology, separate from how it is commercialized.[5] As a result, the enthusiasm for more proactive IP management, such as that noted in the preceding quote, misses some key issues—and opportunities—in managing IP.

We will start by exploring the market for ideas in general and then will discuss how a company's business model can motivate the company to be a seller as well as a buyer in this market. Once we understand the overall market for ideas, we will discuss how companies can manage IP in this environment. A great deal of the conventional wisdom on this topic fits with the logic of control and exclusion that characterized the Closed Innovation paradigm. Using the logic of Open Innovation, we will sketch out a very different approach to managing IP. To create value from a technology, companies must create a business model for it, or else allow someone else's business model to govern the value realizable from the innovation. Alternatively, a company's business model might dictate that the company would be better served by publishing its knowledge, whereas at other times, a company would be better off protecting it instead.

The Market for Intellectual Property

We need to start by defining our terms and clarifying what IP is and is not. Not all ideas are protectable as IP, and many ideas that might be protectable are not protected (Figure 5). Intellectual property refers to the subset of ideas

FIGURE 5. Ideas and Intellectual Property



that are novel, are useful, have been reduced to practice in a tangible form, and have been managed according to the law.[6] Although IP encompasses patents, copyrights, trade secrets, and trademarks, this article focuses primarily on patents. Patents are the leading source of trade in IP, and many of the issues in managing patents will also apply to the management of other types of IP.

By some measures, the market for patents and licenses is enormous. The dominant players in the worldwide patent and licensing markets, the United States, Japan, and the European Union (EU), accounted for more than 90 percent of the $142 billion global royalty receipts in 2000, according to the Bureau of Economic Analysis in the U.S. Department of Commerce.[7] The United States was the largest net exporter of royalties, with royalties and fees received from foreign firms in 1998 amounting to $36 billion, which was three times the $11.3 billion spent by U.S. firms on offshore technology. This surplus was driven by trade with Asia, where Japan, the single largest consumer of U.S. IP, accounted for 45 percent of all royalties and licenses, with South Korea, in second place, making up 18 percent.[8]

While the overall market for this exchange is huge, the majority of exchange occurs between affiliates of the same firm operating in different countries, rather than in the open market. In the United States, 73 percent of all international licensing volume in 1998 was due to these transactions between affiliated firms.[9] This exchange is driven by many considerations outside the scope of this article, such as tax rates and where firms wish to take profits in their activities.

Nonetheless, the amount of arm's-length transactions in patents and licenses is also substantial and growing. The estimated $66 billion in 1996 in U.S. corporate royalty receipts from unaffiliated entities both foreign and domestic has been growing at an estimated 12 percent each year. Individual corporations profited significantly from these receipts. The IBM Corporation reported

receiving more than $1.9 billion in royalty payments in 2001. Lucent also received $400 million that same year. Texas Instruments received more than half its net income in such payments during the late 1980s.[10] As the overall market size suggests, and as individual companies have found, there can be big money in licensing one's IP.

Although big money is at stake, the management of IP seems to have substantial room for improvement. According to a survey conducted in 1998, only about 60 percent of patents held by the top patenting firms around the world were utilized in mainstream businesses.[11] Many responding companies had hundreds of nonperforming patents, which were neither used in their own business nor licensed to any other business. As companies learn of the profits of the exemplars just noted and survey their own patent portfolios, they sense that they can do more with their IP than they are currently doing. As will be discussed in the following paragraphs, however, most patents are not worth much. Consequently, there may not be as many valuable patents among the 40 percent of nonperforming patents as IP management proponents think.

In addition, companies are paying more attention to selling their own IP to others than they are to buying more IP from outsiders. This is a serious oversight. Companies can realize a great deal of value by accessing an external technology, instead of inadvertently reinventing it internally. Both the buying and the selling perspectives are necessary to improve the management of IP.

Strategies for Managing Patents

Patents traditionally played a protective role in business strategy through their legal ability to exclude rivals from using a company's own technology. Other strategies such as vertical integration—the dominant mode of organizing innovation assets in the twentieth century during the Closed Innovation era—had also defended a company's business by allowing safe, efficient transfer of specialized knowledge within a close-knit group.[12] In this era, patents were valued primarily as a barrier to entry, not as a source of revenue and profit in their own right.

By the 1990s, CEOs and CFOs began viewing patents and other IP as revenue-generating assets that could directly increase a company's market value. Licensing out one's own IP during this era elevated patents and other IP assets to the domain of corporate strategy. Businesses with underutilized patent portfolios began taking their IP off the shelf and using it to generate profits. Companies such as Dow Chemical also sorted through their patent portfolio and donated a sizable portion of it to reduce portfolio maintenance costs (primarily filing fees, language translation, and annual renewal fees to cover administrative costs), which could be quite high, and received a tax benefit for doing so.[13]

However, these maintenance costs are only the tip of the iceberg in the costs of managing IP. The darker side of creating additional value from one's IP is the cost of enforcement: In the United States, 6 percent of patents incurred some form of legal challenge, leading at times to costly judgments.[14] In the 1990s, awards were often in the $10 million range, although several passed the $100

million mark.[15] The costs of litigation can truly add up: In the United States, they were estimated to be as much as 25 percent of aggregate R&D costs of U.S. industries.[16]

Companies would prefer not to pay royalties for IP if they don't have to, and the thicket of competing claims of dozens or hundreds of patents can create genuine confusion about exactly who owns what. Moreover, the validity of a patent's claims is not truly known until after it has been tested in court in an infringement suit. For this reason, companies that might be infringing on another company's patents understandably do not volunteer their money. Indeed, if the IP owner is not engaged in a business activity that uses the IP, the owner may not even become aware of the infringing activities of other firms.

Litigation is only the last step in the process of monitoring, detection, enforcement, and value realization. Preferable outcomes for IP owners usually include reaching a settlement through cross-licensing, alliances, or retroactive royalty fee payments with or from the infringing partner. According to Jeff George, VP of AT&T's Intellectual Property Management Organization, "when someone infringes on one of our patents, we take action—but that doesn't necessarily mean litigation. Usually it means negotiating royalties, cross-licensing or even strategic alliances."[17]

Where Patents Come From

Most analyses of managing IP start with the patent-issuance process, that is, the stage at which the company has already received a legal patent. Unfortunately, scholars often pay little attention to the process that most R&D organizations go through prior to obtaining an eventual patent. Yet this is where any useful approach to managing IP must start.

Here is a simplified view of the process that results in a patent. The first step is the report of a discovery or an invention by one or more employees in the organization. In some organizations, these reports are termed *invention disclosures*. Once a discovery or an invention is reported, the organization in which the invention took place (which is the legal owner of the discovery) must decide whether to file a patent on the idea. Sometimes, the idea may be kept as a trade secret, or it may not be protected at all. As discussed in the later section on Intel, publication even may be the best path for the discovery to follow in some cases.

If a decision is made to file a patent, then the inventor must spend time with a patent attorney, who will file the patent claim with the U.S. Patent and Trademark Office. The USPTO reviews the claim and often asks for additional information, such as other relevant prior art, or how the claims of the patent application differ from the claims of prior patents. If the invention is determined to be novel, useful, nonobvious, and adequately explained, the USPTO may then issue the patent. The USPTO estimates that it takes an average of twenty-five months for a patent application to wind its way through to issuance, and the process costs $15,000 to $50,000 per patent, on average, to complete.[18]

To understand the process of managing patents once they are issued, we must start with a point often overlooked in discussions of managing IP: Most

patents are worth very little financially. For example, in studies of patents from six leading U.S. universities, the top 10 percent of those patents accounted for 92 percent of the royalty payments those universities received. Put the other way, 90 percent of patents from these universities accounted for only 8 percent of royalty payments. These results are consistent with other studies of the distribution of payments for patents in universities and from society at large.[19] These studies also conclude that most patents are worth very little.

Another related, also overlooked point is that it is very, very difficult to know the value of a patent beforehand. Since filing patents is expensive, companies would doubtless prefer to save the costs of filing the worthless ones—but they have no way of knowing which are worthless.

Technologies acquire economic value when they are taken to market with an effective business model. When research discoveries are driven by scientific inquiry and are not connected to any business purpose, the commercial value of the resulting discoveries will be serendipitous and unforeseeable. Unsurprisingly, most of these discoveries will be worth very little, although a few may be worth a great deal—once they are connected to the market through some viable business model.

The implication from this is that companies should manage IP to enhance and extend their business models and should seek out new business models for discoveries that don't fit their present models. Research discoveries from within the company should be evaluated not only on their scientific and technical merit, but also on their ability to strengthen the company's ability to create and capture value in its business. This in turn suggests that companies should educate their R&D personnel on their business model, so that the researchers can understand the potential connections early on in the research process.

In an informal survey of a number of high-technology companies, I found that companies generally do not educate their researchers about the business side of their innovations.[20] They do little to share their business model with their researchers, and usually locate their R&D personnel away from the people who plan and execute the business strategy.

A more specific finding in the same vein is the way rewards are given to employees who discover patentable ideas within the company. In a company I used to work for, Quantum Corporation, any employee who came up with an idea that the company decided to submit for a patent received $500. He or she got another $1,000 if the patent was subsequently granted by the patent office. The employee also got a plaque, which replicated the cover page of the patent in bronze, if the patent was granted. That was it. There was no assessment of whether or how the invention helped Quantum advance its own business, and all patents were rewarded in the same way.

Nor was this a unique case. At the time of my survey at Xerox, an employee who came up with a patentable idea received $500—period. And if the Xerox employee came up with ten such ideas, he or she not only received ten $500 payments, but also was invited to a dinner with other Xerox inventors who had ten or more patents. Again, there was no discrimination between

TABLE 2. Informal Survey of Patent Rewards to Inventors by Selected High-Technology Companies

Company	Award for Patent Filing	Award for Patent Issuance	Other Rewards	Other Rewards Comment
HP	$1,000	None	NA	
IBM	$1,500	$500	$25,000	Exceptional patents (in hindsight)
Lucent/Bell Labs	$500	None	$10,000	Strategically important patents (in hindsight)
Microsoft	$500	$500	NA	
Quantum	$500	$1,000	$5,000 $10,000	Plateau awards at 5th, 10th, 15th, and 20th patents
Seagate	$500	$1,000	$5,000	Hall of fame for 10th patent
Sun	$500	$2,000	NA	
Stanford University	None	None	33% net royalties	1/3 to inventor 1/3 to department 1/3 to school

patents that directly applied to Xerox's businesses versus those that had no applicability to Xerox. Other companies have similar symbolic observances for a person's receiving patents, such as hall-of-fame awards. These companies also make no distinction between patents that have direct connection to the business model and those that do not. Only in the cases of IBM and Lucent did companies take any note of the strategic effect of a patent, and this was only recognized in a few cases long after the patent was received. Table 2 shows the rewards that other leading technology companies in my survey provided to their inventors.

For comparison, I have included Stanford University's policy on rewards for its inventors.[21] The difference in incentives is striking: Stanford pays no reward for a patent filing, nor does it pay any award for a patent's being issued. However, Stanford shares with its inventors a sizable percentage of the royalty stream that its patents generate. Interestingly, Stanford also shares a similarly sizable percentage with the academic department that housed the inventor, and the school retains a final third for its own purposes. (The amounts paid by Stanford are net of Stanford's costs of obtaining the patent and a charge for its costs of operating its technology licensing office.)

These incentives inside the companies in Table 2 (excluding Stanford) are not very large, to say the least. If the enthusiasts of IP are correct in saying that IP is a critical source of value for companies in the twenty-first century, then one might expect these incentives for inventors to be much larger, to spur them to create more IP. If, on the other hand, the value of a patent depends primarily on its being commercialized through a business model, then the weak incentives

make more sense: The value comes from the party that has a business model to create and capture value from the patent, *not* from the invention of the patentable technology itself.

This also implies that companies should find ways to search for, and reward, the creation of effective business models that leverage technologies they seek to license. Absent an effective business model, a technology may be worth little indeed. With an identified business model, the owner of IP has a better idea of where to look for potential buyers and some idea of the value of the idea to those buyers. The importance of the business model in managing IP will be illustrated further with Millennium Pharmaceuticals in the next section.

Notice that something else is missing in these reward policies. Nowhere in these companies' reward policies is there any incentive for employees to identify and access useful *external* IP. This omission would be perfectly understandable if owning the IP were the key to generating value in today's economy. Then the external technology would be of little importance to a company's value and so would not warrant any particular incentive to find it.

If, however, accessing external knowledge is also critical to creating and capturing value, then the omission is a mistake. If external technologies can also support and extend a company's business model, then companies ought to encourage their R&D staff to survey the landscape to identify potential outside technologies. They could even provide a "bounty" to their staff when a promising external technology is identified and brought into the firm. And they should do this survey *before* launching next year's internal R&D projects.

Intellectual Property Strategies in Action: Millennium Pharmaceuticals

A few leading companies discussed in this section exemplify Open Innovation principles in action for the management of IP. Each company has a logic behind its approach, which is not a logic of control and exclusion, but instead a logic that connects IP to business models and leverages internal and external IP through those models.[22]

Millennium is a very young company that has catapulted itself into a surprisingly strong position in the pharmaceutical industry. Founded in 1993, the company achieved a market value of more than $11 billion by the end of 2000 and split its stock twice that year.[23] Moreover, Millennium achieved this valuation without selling a single product or pharmaceutical compound; all the company's activities through 2000 involved delivering information and analysis of potential biological compounds and licensing its technologies for doing this analysis.

Millennium is an instructive example of how IP takes on exciting new possibilities when managed in an Open Innovation mind-set. Many companies act as contract research organizations (CROs) that supply information and analysis of biological compounds to pharmaceutical manufacturers. Prior to Millennium, though, most of these CROs lived from research contract to research contract and essentially charged their customers for the time and expenses of their employees. As small organizations with no control over their IP, these

CROs had no way to grow out of what is a low-margin business that lacks economies of scale.

One crucial limit for most CROs is that the knowledge generated from their work belongs contractually to the company paying for the research. This is a typical control mentality over IP that characterizes so much of the Closed Innovation paradigm. Because of the prevalence of this contractual provision, CROs cannot themselves build on or otherwise use the knowledge that they generate from their work.

Millennium started out doing contract research as well.[24] How did it escape from the CRO rut of living from contract to contract, with no control over the knowledge that it generated? It did so by creating a powerful technology platform that allowed it to rapidly discover and validate biological targets and chemical compounds, and by using some highly astute deal making with its pharmaceutical customers. I will discuss the technology platform later, but will analyze the deal making here.

Millennium recognized that its customers would use the results of the contract research within the confines of their business models. Millennium exploited the fact that their customers placed little value on knowledge that did not fit these business models. This was the pattern the company established from its first major deal, with Hoffman-LaRoche (now called Roche) in 1994. Millennium agreed to provide Roche with a number of *targets* (genes or proteins linked to diseases through various tests that both companies agree on in advance) for obesity and Type II diabetes. Roche had strong interests in both areas and was developing a variety of initiatives to treat these health conditions.

However, Roche was *not* particularly interested in other possible uses of the targets in diseases outside its chosen focus, such as cardiovascular disease. Because of the capabilities Millennium had established with its technology platform, it convinced Roche that it could identify and screen potential targets more effectively and more quickly than rival CROs. Millennium then assigned Roche the rights to those targets within the domains of obesity and Type II diabetes, but *retained* the residual rights to those targets for other possible diseases.

This arrangement was a good deal for Roche. The company needed additional targets to feed into its business model, and it had decided to focus on obesity and Type II diabetes. Roche had the scientific expertise to convert the most promising targets into drugs. The company had the clinical and regulatory expertise to manage the Food and Drug Administration (FDA) testing and approval process for these drugs. And it had the sales and marketing assets needed to call doctors' attention to its drugs when they were approved for use. As we saw earlier with Xerox, Roche assigned little value for a technology (here, a specific target) outside the scope of its business model. And giving away the residual rights to these targets in areas of little interest to it, Roche may have gotten a better deal from Millennium than it would have had it insisted on complete control over all possible uses of the targets. Indeed, Millennium probably accepted less money from Roche than it ideally would have liked. Steven

Holtzman, Millennium's chief business officer, commented after the deal, "We gave a little more to Roche because we were younger."[25]

Nonetheless, the Roche deal enabled Millennium to break out of the CRO mold and established two vital parameters for what would become Millennium's business model: First, Millennium's technology platform was a valuable asset, even for large pharmaceutical companies. And second, companies could access this platform profitably for their particular business needs, but would not obtain complete ownership over the resulting IP.[26]

Over time, Millennium has established a variety of research partnerships like the one it established with Roche. Millennium advances its technology platform through some up-front funding from the partner and retains residual IP rights to targets, leads, and compounds beyond the areas of interest to its partner. In addition to the Roche deal, Millennium has signed similar agreements with Eli Lilly, Astra AB, Wyeth-Ayerst, Monsanto, and Bayer.

In deciding how to structure and price these deals, Millennium thinks hard about the partner's business model, Holtzman said: "We spend a lot of time thinking about how the poor man or woman on the other side of the table is going to have to go sell this deal to his or her boss. We spend a lot of time trying to understand how they are modeling it, so that we know whether we can fall within their window."[27]

This awareness of, and empathy for, the customer's business model enables Millennium to identify where value will be realized for its partner. That understanding, in turn, helps it capture residual value from the deal outside the partner's business model.

Another important deal was reached with Bayer in 1998. In that deal, Millennium agreed to deliver 225 targets over a five-year period for Bayer, which amounted to the responsibility for nearly half of Bayer's drug development pipeline. In return, Bayer gave Millennium $33 million up front, committed to another $219 million in licensing fees and research funding, and promised another $116 million in performance incentives. In addition, Bayer committed to returning to Millennium almost 90 percent of the 225 targets after selecting those that fit their business model. As these deals have accumulated, Millennium has developed a growing base of IP built from the "leftovers" that its customers didn't particularly value or had no clear way to use.

Millennium has also taken an Open Innovation approach to the management of its technology platform. As discussed, the company's ability to develop processes, equipment, and software to enable it to rapidly evaluate potential targets was a powerful selling tool for its research partnerships. In a Closed Innovation mentality, Millennium might have chosen to keep this platform exclusively to itself, since its capability was winning it new research partnerships.

But it took a different, more farsighted approach instead. Eli Lilly approached Millennium in 1995 with an interest in licensing the high-throughput DNA sequencing technology that Millennium had developed. Eli Lilly also wanted to license Millennium's technology for rapid analysis of differential

expression, which shows which genes are expressed in different tissues and organs in the body. Millennium knew that these technology areas were evolving rapidly and that it would have to make major investments to keep up with the leading edge. The company also knew that it lacked the resources of many larger companies to do this. A deal with Eli Lilly would compromise Millennium's exclusive control over its current technology and processes, but the proceeds from a deal could support Millennium's continued investment in building its future technology and processes. Thus, Millennium made the deal, licensing two key technologies to Eli Lilly. According to Holtzman, who also championed this transaction, Millennium looked at its competitive advantage when considering the deal: "We sat down internally and said, 'Wherein lies our competitive advantage?' And what we concluded was that our success would lie in the application of our technology, not in the technology itself. In order to stay ahead of the curve technologically, we needed to find a reliable source of funding. So . . . we said we would be willing to license the technology.[28]

A related philosophy governed the arrangement that Millennium reached with Monsanto in agricultural products. Millennium realized that its own business model was not going to exploit its technological prowess in the agricultural domain in the foreseeable future. Although its technology doubtless had potential value in that area, Millennium itself had no practicable way to exploit that opportunity. When Monsanto approached it about licensing its platform in 1997, Millennium saw another opportunity to trade its technology platform for additional funds to advance that platform. The companies agreed to a deal that delivered $38 million up front to Millennium and promised a potential additional $180 million over five years. This gave Millennium additional resources to build out its platform and to keep up with the rapidly advancing technology. Millennium's ability to advance its platform, in turn, would enable it to enter future partnerships on attractive terms.

Do these deals work not only for Millennium, but also for its partners? One way to answer is to evaluate whether the objectives of the partner are achieved. In the case of Bayer, the objective can be measured by the delivery of the expected number of targets. By 2002, Millennium had delivered more than 180 targets. From these targets, Bayer has found six promising leads and has taken one into clinical development.[29] The Monsanto partnership has been set up to "pay for performance," with payments of $20 million per year for Millennium's reaching predetermined milestones. To date, Monsanto has made every milestone payment to Millennium. The results suggest that at least these partners are reasonably satisfied with the relationship.

By 2000, Millennium judged that it had accumulated enough of these rights to shift its business model. No longer would Millennium simply act as a sophisticated CRO with a state-of-the-art set of screening processes; it would now become a full-fledged drug development company that would operate from "gene to patient," in the words of its CEO, Mark Levin.[30] This new business model escalates the capital needs of the company and entails significant new

risks. But the company could never have gotten this far without its deep understanding of the uses and limits of business models in managing its IP.

Intellectual Property Strategies in Action: IBM

Because IBM was the leading U.S. patent recipient from 1995 through 2001, it is not surprising that it may have learned a thing or two about how to leverage its IP. IBM received an estimated $1.9 billion in licensing revenues in 2001, which was about 17 percent of its pretax income that year. To put this amount in perspective, consider that IBM would have had to generate an addition $15 billion in revenue (at its 2001 operating margins) to generate the same amount of pretax income.[31]

Although IBM receives the most U.S. patents of any company in the world, IBM uses its IP not to exclude rival firms, but instead to grow its own business. What I will focus on here is how some of IBM's strategies map so well into the Open Innovation paradigm. I will start with how IBM manages the actual patents it receives.

U.S. patents are granted by the U.S. Patent and Trademark Office. The office has begun electronically publishing all the patents that it issues; anyone wishing to search for a patent can now find it online at www.uspto.gov. Since this material is maintained and published by the government each year, you might conclude that there is nothing of value to be done by a profit-seeking business in this area at least. Yet anyone looking for a patent online would soon realize that the search process is incomplete at best, and frustrating or even hopeless at worst. As a result of this difficulty, one initiative IBM undertook early on was to offer its own patent database for online searches. Although the core data are the same U.S. patents that are located in the USPTO database, IBM added additional search features to make the patents easier to locate.

Why would IBM seek to add value to a public database? Consider that IBM receives more patents than anyone else and that it receives substantial licensing and royalty patents for its patents. A better search process may create more such receipts for IBM. More subtly, better search processes may help patent examiners and attorneys identify the relevant prior art, including IBM's own prior patents. Such knowledge may increase the impact of IBM's patent portfolio on the issuance of new patents. This is akin to Intel's use of its capital to grow its Pentium ecosystem. Here, IBM is using internal resources to grow the ecosystem for IP management.

More recently, IBM realized that a Web service with enhanced search features for patent data could become a stand-alone business in its own right. It has chosen to team with the Internet Capital Group, which invested $35 million to spin off its patent database into a new company, Delphion. Delphion believes that its Intellectual Property Network is "the world's most popular online destination for researching patents." IBM continues to be a customer of the service, but no longer has to fund it with its own internal resources.

IBM does a thriving business in selling technology and technology components to the computer and communications industries. For example, IBM

utilizes some of its semiconductor fabrication capacity to serve as a foundry, where it manufactures chips for other companies to their stated specifications. This increases the capacity utilization of IBM's fabs, which spreads the enormously high fixed capital costs over a larger production volume, improving the economics of IBM's own products.

IBM is also able to charge a healthy margin for the external use of its fab capacity, and part of that margin is earned by IBM's IP portfolio. When a start-up company like Tensilica, for example, wishes to compete with a powerhouse like Intel in the low-power microprocessor market, it has to worry a great deal about Intel's ability to impair its business.through the threat of patent infringement litigation. Given the complexity of microprocessors and the complexity of their manufacture, it is difficult at best to assure a young start-up's investors and prospective customers that the start-up's activities will not infringe another company's IP rights. What's more, Intel is known to be aggressive about litigating any perceived infringement of its IP.

This is where IBM's IP enters in. IBM has a wonderful portfolio of semiconductor patents, earned over many years of R&D in the industry. IBM has leveraged this portfolio to enter into cross-licensing agreements with virtually all the major industry players (including Intel), often receiving payments in addition to access to other companies' IP in return for access to its own. This network of agreements and strong internal IP makes IBM a safe foundry for younger companies seeking to enter the industry. IBM signed an agreement to make Tensilica's chips, and likely earns a healthy margin doing so. Tensilica is not merely buying foundry capacity, or even the supply of high-quality chips in the volumes it requires. By using IBM as its foundry, Tensilica is also buying an IP insurance policy.

IBM has used its IP portfolio to sign up long-term contracts with large companies as well, such as Cisco Systems and Dell Computer. IBM agrees to supply important component parts to these customers over a long period, and these long-term customers receive both the parts and an IP assurance that these parts are free from potential infringement actions of other companies. While IBM must compete with other companies to supply Cisco and Dell, those companies competing with IBM do not have the same depth of IP that IBM enjoys. This ownership of extensive IP gives IBM an edge in the competition to supply complex products, where the possibility of IP infringement is real and hard to discern in advance. Put differently, companies that do not buy from IBM are taking some amount of risk in their IP. They may find that they infringe on IBM's rights and will have to pay some amount of money to IBM anyway.

Intellectual Property Strategies in Action: Intel

Intel has not traditionally invested in internal research in the way that IBM or AT&T used to do. Nonetheless, it too has a significant patent portfolio (though nothing as extensive as IBM's), and it has innovated some creative ways to make use of its IP as well. Part of Intel's approach to IP is to aggressively defend its rights against direct competitors, as its decade-long battles with rival

AMD attest. Intel seeks every opportunity to slow down AMD in AMD's attempts to copy Intel's Pentium architecture, and Intel has also gone after departing employees when those employees have joined start-up companies that sought to compete with Intel.[32]

But Intel's approach to managing IP goes far beyond the Closed Innovation approach of playing hardball with its direct competitors and its departing employees. Intel has been able to leverage external IP in its business quite effectively as well. It is this latter aspect of Intel's approach to managing IP that I will focus on here.

One important example of leveraging external IP comes from Intel's approach to university research. Intel underwrites a substantial amount of university research, but not by handing universities a blank check. Instead, Intel insists on making up-front agreements that govern its access to technologies that emerge out of university research that Intel funds. These agreements stipulate that, should an Intel-funded project later be patented by the university, the university agrees to give Intel royalty-free access to that technology.

Note the logic of this approach from Intel's perspective. Intel does not own or control the outcome of university research that it funds. However, it does assure itself of the ability to use the research output of projects it funds, whatever the eventual IP protection of that output. As noted previously, Intel also benefits from this approach in gaining access to the research agendas of leading university researchers. By reviewing research proposals that seek to obtain Intel funding, Intel learns about the "technology frontier" in a variety of academic domains *before* it spends a dime. And Intel's funding also allows the company to monitor the progress of the university research, giving it early access to any promising results arising from that research.

This access isn't free for Intel. Not only must it put up the funding for this work, but the company must spend additional funds on Intel staff that manage the relationships Intel has with leading universities. Then Intel spends more money on its internal labs, trying to transfer the most promising results into its own processes. But Intel's investments give it the knowledge and the connections to become an enlightened sponsor of university research and an intelligent user of promising results emanating from the universities.

Intel's strengths as a manufacturer of semiconductors and its control (with Microsoft) over the Wintel PC architecture position the company well to continue to leverage external knowledge in its business. Intel is so strong in these areas that it can win in its business by playing for a tie in the IP domain. That is, Intel can win if it can continue to access leading knowledge from whatever sources are available, provided that it can gain access to that knowledge on reasonable terms.

Intel's strengths enable it to influence the knowledge landscape that it relies on to advance its business. One mechanism it uses to shape the landscape is to publish research discoveries, rather than patent and protect them internally. Intel maintains a technical publication, the *Intel Technical Journal* (web site: www.intel.com/technology/itj/index.htm), whose primary purpose is to

document Intel discoveries that the company would prefer to put into the public domain, rather than to patent for itself.

The logic of the publish-versus-patent approach here is a wonderful example of Open Innovation thinking. In a Closed Innovation regime, firms that make new discoveries would think first about how to own and protect this knowledge, so that they could exclude rivals from this knowledge. They would prefer to patent the knowledge to gain the legal entitlement granted by the U.S. government in excluding their rivals from this knowledge. These patents might also allow Intel to entice rivals into cross-licensing agreements that prevent them from holding up Intel's business by threatening IP infringement litigation.

In an Open Innovation world, though, this logic is but one of many considerations. Sometimes, firms will choose to patent core knowledge, but carefully consider the "publish" alternative as well. Companies ask themselves, If knowledge in this area is abundant, can we really hope to exclude our rivals for very long? Can they invent around whatever protections we can claim? Is our own business better served by protecting this knowledge, or would it be better for our business to propagate the knowledge widely? Is it in our interests *to make sure that no one can fence this knowledge in*—that this knowledge will be available to everyone without cost? After all, if it is firmly in the public domain, then a rival cannot threaten us with some version of it later on.

When should the firm patent its knowledge, and when should it publish it instead? This issue hearkens back to the business model being used by the firm. The model helps the firm create value throughout the value chain and then positions the firm to capture some portion of that value.

These twin roles of the business model inform the patent-versus-publish decision. Knowledge that grows the value chain, which enhances the ability of firms in the ecosystem to advance the complementary products and services they make, is exactly the kind of knowledge that the Open Innovation firm wants to make public. Knowledge that helps the firm position itself to capture a portion of the value within that chain, by contrast, is the kind of knowledge that the firm wants to claim for itself. The firm's own complementary assets also help the firm claim a portion of the value in the ecosystem for itself. In Intel's case, its manufacturing prowess, its Pentium brand, and its Wintel architecture all help Intel profit from advances in its ecosystem, even from advances that it does not own or control.

Intel incurs some risks when it publishes its knowledge instead of patenting it. For one, rivals such as AMD also benefit when Intel's knowledge expands the Wintel ecosystem. If Intel fails to maintain a lead over AMD in its business, its knowledge could help AMD overtake Intel. And Intel certainly forgoes any opportunity to collect licensing and royalty payments from its knowledge when it chooses to publish it.

But there are risks on the other side facing Intel as well. Perhaps the biggest issue is what happens to Intel's business model if Moore's Law "slows down," that is, if the industry fails to make the technical advances predicted by Moore's Law at the same pace in the future. Intel's advantages in manufactur-

ing, marketing, and architecture are worth much less when the technology base advances only slowly. Then, the high-quality chips that Intel made last year, and the year before, become increasingly effective competitors to Intel's sales of chips in the current year. Users would have less and less reason to replace their old systems, because these systems would become obsolete much more slowly. And competitors would have an easier time competing against Intel, since they would enjoy more time to catch up to Intel in producing high volumes of chips with the latest technology. As the PC market shows signs of maturing, Intel likely thinks that the risks of its technology slowing down greatly outweigh the risks of publishing its knowledge.

Incidentally, other companies can also benefit from the publish-versus-patent approach without incurring the costs of creating their own journal. Recall that it costs tens of thousands of dollars to file a patent application and takes an average of twenty-five months to see it through to issuance. That's a lot of time and money for small companies, particularly when they operate in industries with accelerating product cycles and shorter time-to-market pressures. Companies may prefer a mechanism that allows them to make immediate use of their knowledge and protects them from some other company's investing the time and money to stake a claim to that knowledge later on. The "publish" option allows companies to do this, and third parties now provide various means to do this at a very low cost.

One such mechanism is IP.com (web site: www.ip.com). For as little as $155, a company can post a document on the company's web site and effectively ensure that the document becomes part of the public domain of prior art. Since IP.com maintains links with the U.S., European, German, and Hungarian patent offices, subsequent applications for patents to these offices will be searched against any documents of prior art on IP.com. This greatly reduces the chance of another company's patenting this knowledge later on, and it provides an inventing company with an affirmative defense in the event that another company does receive such a patent and then tries to sue for infringement.

Valuing Intellectual Property: It Takes a Business Model

Companies that have invested significant R&D resources and have received a number of patents along the way understandably would like to know what the patents are worth. They rightly sense that most patents are worth very little—so little that the companies would actually save money if they donated the patents (and their subsequent maintenance costs) to some worthy institution. But these companies also hear the stories of how much money an IBM or a Texas Instruments or a Lucent is making from its patents, and think, What about us? How much could we make from our own patents?

A thriving cottage industry of IP valuation consultants has arisen to respond to this demand. For a fee, they will evaluate the entire portfolio of patents that a company holds and tell the company what this combined portfolio is worth. One such exercise occurred at Xerox PARC, where an external IP valuation in 1997 determined that the PARC patent portfolio was worth more than

$1 billion. This valuation made intuitive sense to PARC research management, because Xerox had invested more than $1 billion cumulatively in funding PARC since its founding in 1970.

But valuing IP is more problematic than this assessment would imply. The ideal measure of IP is what a willing buyer would pay a willing seller in a market of many buyers and sellers, where all parties are well informed about what is being transacted. Calculating what a technology costs to be produced is only one means of valuing IP, and not usually the most appropriate means. Another measure is what it would cost a potential buyer to invent around the technology, since this is the opportunity cost of not purchasing the IP. A third measure would be to gauge comparable sales of IP—what "similar" buyers have paid for "similar" technologies in the recent past.[33] There is no reason to think that these measures would yield the same valuation, and in practice, most IP consultants triangulate on a final Figure by employing analyses of all three. Moreover, none of these methods takes any account of the business model into which the technology will be placed.

In fact, Xerox found that when it came time to actually engage in IP transactions the consultants' assessments of its patent portfolio were overly optimistic. In one case that I have documented, Xerox had some patents in the area of interactive collaboration using shared public electronic domains.[34] It sought to obtain value from this IP by spinning off the research team that developed the concepts within PARC into a company called PlaceWare. It did this because Xerox had determined that its own business model had no further use for the technology, and Xerox wanted to stop any additional funding of the project. The company also wanted to get some financial return on the IP it had created.

The core issue for obtaining value for this IP, though, was the business model that would be used to commercialize the technology. The generic ideas had commercial potential, but the company was uncertain where and how to use the technology. Many alternatives were considered, but none seemed a clear winner. When the PlaceWare project sought external capital, these considerations became crucial to its *premoney* valuation (i.e., the value of the company before any additional external capital was invested into the company).

At that point, Xerox had invested at least $5 or $6 million into the technology, having funded a team of five or six people for the previous four or five years. Xerox initially hoped to receive $8 to $10 million for it. This is fairly typical of most IP sellers' perspectives: We have done all this work for years now, and we'd like to make some return on the investment we have made in the IP.

To the IP buyers, though, who in this case were venture capitalists, this perspective seemed ludicrous. There was no proven business model for the IP to create value, nor was there even a potential business model in view. The IP itself was fairly general, and the specific software that had been written over the past four or five years would have to be entirely rewritten before it would be useful. This perspective is fairly typical of that of IP buyers: How much more do I have to invest in this IP to get something of commercial value?

The actual valuation that resulted from the bargaining between Xerox and the venture capitalists who eventually financed the spin-off of PlaceWare was far lower than Xerox had hoped. The premoney valuation of the enterprise was put at $3 million. Xerox received a 10 percent equity stake in the firm in return for a nonexclusive license to the IP in the venture. Xerox also received a promissory note for $1 million, due in four years' time. This note was valuable—if the company remained viable four years down the road. Thus, Xerox received somewhere between $300,000 and $1.3 million for its IP in PlaceWare, depending on how one valued the note.

This valuation is far below what any IP valuation firm would have judged to be the value of Xerox's IP. Yet it proved to be the value that a buyer was willing to pay Xerox for the IP in question, which is the only true measure of what IP is worth. This is a cautionary tale for firms that seek to capitalize on the treasure hidden in their patent portfolios, and a sobering reminder that conceptual valuation exercises can stray far from a technology's actual value in the market. Licensing a technology outside is essentially hiring an external business model to create value for that technology. Unless and until a business model can be identified for a technology that is available for sale, you are likely to receive a surprisingly small amount for that technology. For this reason, companies seeking to leverage their IP will need to work hard to identify prospective business models that could profitably employ their technology, even if the company has no plans to use that business model itself.

Notes

1. I use the term paradigm to refer to a widely accepted model for how a group of professionals pursue a complex activity, here industrial R&D. Kuhn's notion of a paradigm can be found in Thomas Kuhn, *Structure of Scientific Revolutions* (Chicago, IL: University of Chicago Press, 1962).
2. See Richard Schonberger and Edward Knod, *Operations Management* (Boston, MA: Irwin, 1994), pp. 59–61, for an example of this view.
3. The maxim that "not all the smart people in the world work for us" first came to my attention from a talk given by Bill Joy of Sun Microsystems in the early 1990s. See, for example, Alex Lash, "The Joy of Sun: The Most Important Person Building the Software That Makes the Internet Tick," The Industry Standard, June 21, 1999, <http://thestandard.com/article/0,1902,5171,00.html> (accessed 27 September 2002).
4. Kevin Rivette and David Kline, "Discovering New Value in Intellectual Property," *Harvard Business Review*, 78/1 (January/February 2000): 59.
5. The value need not come only from the company's own business model. There can be value in IP beyond a company's current business model if, for example, a patent happens to block a critical pathway in another company's business model. If the patent is critical to another company's model, then the owner of that patent may be able to extract a healthy portion of that value for herself or himself—thanks, of course, to the presence of the other's business model. Kevin Rivette and David Kline, *Rembrandts in the Attic: Unlocking the Hidden Value of Patents* (Boston, MA: Harvard Business School Press, 1999), provide some useful concepts on how to map the usage of patents and potentially identify such blocking patents.
6. There are many useful references that inform the management of IP. Two highly readable sources are notes authored by my colleagues at Harvard Business School: Myra Hart and Howard Zaharoff, "The Protection of Intellectual Property in the United States," note 9-897-046, Boston, MA, Harvard Business School, 1997), and Michael Roberts, "The Legal Protection of Intellectual Property," note 9-898-230, Boston, MA, Harvard Business School, 1998.

An influential managerial book that called attention to the latent value hidden in intellectual property is Rivette and Kline (1999), op. cit.

7. See the U.S. Department of Commerce, Bureau of Economic Analysis web site for the most recently available data on this topic, at <www.bea.doc.gov/bea/dn/nipaweb>.
8. National Science Foundation, National Science Board, "Science and Engineering Indicators: 1998," publication NSB 98-1. Arlington, VA, National Science Foundation, 1998, pp. 6–15.
9. Michael A. Mann and Laura L. Brokenbough, "Survey of Current Business: U.S. International Services," report prepared for U.S. Department of Commerce, Bureau of Economic Analysis, October 1999, pp. 72–75.
10. Peter Grindley and David Teece, "Managing Intellectual Capital: Licensing and Cross-Licensing in Semiconductors and Electronics," *California Management Review*. 39/2 (Winter 1997): 8–41.
11. Business Planning & Research International, "Intellectual Property Rights Benchmark Study," report prepared for BTG International, London, June 1998. The authors surveyed 133 corporations and 20 universities in Europe, North America, and Japan. Interestingly, approximately 25 percent of respondents replied "Don't Know," to the query of how many nonperforming patents they held.
12. For an excellent analysis of the relationship between the product market structure (e.g., whether it is vertically integrated) and the impact on the licensing of technology, see Ashish Arora, Andrea Fosfuri, and Alfonso Bambardella, *Markets for Technology: The Economics of Innovation and Corporate Strategy* (Cambridge, MA: MIT Press, 2001).
13. Dow's experience is recounted by the executive then in charge of Dow's IP management activity, Gordon Petrash, and his coauthor, Wendy Bukowitz, in "Visualizing, Measuring, and Managing Knowledge," *Research Technology Management*, 40 (July/August 1997): 67–74.
14. Josh Lerner, "Patenting in the Shadow of Competitors," *Journal of Law and Economics*, 38 (October 1995): 466–473.
15. In 1990, Eastman Kodak paid $909 million in damages (including interest) to Polaroid for infringement of several of its instant-camera patents. The fine included treble damages for "willful" infringement. And the $909 million excludes the costs that Kodak incurred to withdraw its inventory from its distribution channels, the write-off of its work-in-process inventory, and rebates paid to consumers. Including all these costs, the total cost to Kodak greatly exceeded $1 billion.
16. Samuel Kortum and Josh Lerner, "What Is Behind the Recent Surge in Patenting?" *Research Policy*, 28 (January 1999): 1–22.
17. Jeff George, "The Patent Pipeline," presentation to the Innovators' Breakfast Series, hosted by the MIT Technology Review, Cambridge, MA, April 13, 2000.
18. Sarah Milstein, "Protecting Intellectual Property," New York Times, February 18, 2002, <www.nytimes.com/2002/02/18/technology/ebusiness/18NECO.html>.
19. See F. Scherer and D. Harhoff, "Technology Policy for a World of Skew-Distributed Outcomes," *Research Policy*, 29 (April 2000): 560, table 1, for these data, and for a general discussion of the highly skewed distribution of value from patents. They report that 84 percent of the royalties from Harvard University's patents came from the top 10 percent of its patents, and that 84 percent of the value of all German patents granted in 1977 (including industry as well as university patents) came from the top 10 percent of patents granted.
20. My survey is decidedly informal and not statistically representative of all companies, or even high-technology companies. I contacted most companies mentioned here between 1997 and 2000; some of their practices may have changed since I spoke with them. Despite the individual changes that may have occurred since I interviewed these companies, the incentives inventors receive from their employers likely remain very weak, and there is likely still to be no corresponding reward for identifying external technology.
21. Stanford's policy is contained on its Stanford University, Office of Technology, web site, <http://otl.stanford.edu/inventors/policies.html#royalty>, accessed February 14, 2002.
22. This section draws heavily from Michael Watkins, "Strategic Deal-Making at Millennium Pharmaceuticals," case 9-800-032, Boston, MA, Harvard Business School, 2000. Other helpful materials on Millennium can be found in Stefan Thomke, "Millennium Pharmaceuticals (A)," case 9-600-038, Boston, MA Harvard Business School, 1999; David Champion, "Mastering the Value Chain: An Interview with Mark Levin of Millennium Pharmaceuticals," *Harvard Business Review*, 79/6 (June 2001): 108–115.

23. This market value had risen to more than $13 billion by the end of 2001. In 2002, however, Millennium's valuation has retreated significantly, as have other valuations in the biotechnology market.
24. Millennium would be horrified to be called a CRO, and there are important differences between what it was doing and what CROs typically do. Millennium was involved in more open-ended research far further upstream than are most CROs, which are typically involved in discrete tasks working on other people's IP (e.g., performing toxicity studies). In these studies, the discoveries are relatively binary (e.g., it's toxic or it's not). By contrast, Millennium's work focused on areas in which discoveries were much more informative—areas involving genomics, informatics, robotics, and so on—each of which created a strong base IP portfolio for the company. CROs typically are not able to develop such a strong IP portfolio from the research they perform. I am indebted to Cameron Peters of Millennium for clarifying these differences.
25. Watkins (2000), op. cit., p. 9.
26. Millennium also inserted a clause that stipulated that the IP would revert to Millennium if the partner did not proceed with developing the molecule in the specified field of use within a certain number of years. This is another kind of forcing function, prompting a customer to "use it, or lose it." The clause was similar in its effect to the stipulation that Lucent's NVG group had on Lucent's business units, or Procter & Gamble's commitment to out-license any technology not being used after a three-year period.
27. Watkins (2000), op. cit., p. 12.
28. Watkins (2000), op. cit., p. 10.
29. See Millennium Pharmaceuticals, 10-K form, March 7, 2002, p. 17, which includes the following statement:

> We formed the Bayer alliance in September 1998. This alliance is for a five-year term and covers several disease areas, including cardiovascular disease, cancer, pain, blood diseases, and viral infections. In September of 2001, we expanded this alliance to include the identification of important new drug targets relevant to thrombosis and urology. Under this alliance, we are eligible to receive up to $465 million from Bayer over the five-year term of the alliance. Bayer has already made a $96.6 million equity investment in us and paid substantial research and development funding to us. By the end of 2001, we had delivered to Bayer more than 180 disease-relevant qualified drug targets for assay configuration, of which 43 qualified drug targets had moved into high-throughput screening or lead identification. By the end of 2001, six projects had entered lead optimization with structurally attractive compounds, including four projects that have shown disease efficacy in animals. In January 2001, one of these projects moved forward to clinical development, and Bayer and we announced our discovery of the first genome-derived small-molecule drug candidate to emerge from our joint research alliance.

30. Levin's quote is taken from an interview by Champion (2001), op. cit., p. 111.
31. All of this data comes from the IBM web site, <www.ibm.com/annualreport/2001/financial_reports/fr_md_ops_results.html> (accessed 9 October 2002).
32. Intel's actions against AMD and departing employees are documented in an entertaining book by Tim Jackson, *Inside Intel: Andy Grove and the Rise of the World's Most Powerful Chip Company* (New York, NY: Dutton, 1997).
33. For a more elaborate treatment of these three means of valuation, see Gordon Smith and Russell Parr, *Valuation of Intellectual Property and Intangible Assets*, 2nd ed. (New York, NY: John Wiley & Sons, 1994). No mention is made of a company's business model anywhere in the book.
34. See Christina Darwall and Henry Chesbrough, "PlaceWare: Issues in Structuring a Xerox Technology Spinout," case 9-699-001, Boston, MA, Harvard Business School, 1999; as well as associated teaching note, 5-601-118, Boston, MA, Harvard Business School, 1999.