

# Scaling the Patent System

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*Forthcoming in the N.Y.U. Annual Survey of American Law*

## Abstract

Why do firms in some industries ignore patents when developing new products? This paper posits a simple but novel answer to this long-puzzling question: firms ignore patents because they are unable to discover the patents their activities might infringe. The costs of finding relevant patents, which we call discovery costs, are prohibitively high.

Not all industries face high patent discovery costs. Chemical patents are "indexable," meaning that relevant patents can be efficiently retrieved by chemical formula. As a result, discovery costs in the chemical and pharmaceutical industries are low, and inadvertent infringement by firms in these industries is rare. But many other patent categories are not indexable, and in some cases that makes avoiding infringement practically impossible. In software, for example, patent clearance by all firms would require many times more hours of legal research than all patent lawyers in the United States can bill in a year. The result has been an explosion of patent litigation.

This paper attacks two core premises of patent law — that parties are always *able* to respect each other's patent rights, and that firms should be punished for infringement even if they could not have avoided it. It concludes with several suggestions for how to change the patent system to alleviate the problems created by non-indexable patents.

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## I. Introduction

In 1945, Friedrich Hayek wrote a famous essay called "The Use of Knowledge in Society."<sup>1</sup> Responding to advocates for greater central planning of economic activity, Hayek pointed out that their theories assumed that knowledge about economic circumstances could be taken as "given" to economic decision-makers, an assumption he argued was unreasonable.<sup>2</sup> Knowledge about the state of the economy — about what resources exist and what goods and services consumers demand — is dispersed among millions of people. Gathering the information together in one place would be impractical, and even if it were done, no economic decision-maker could possibly absorb it all.<sup>3</sup>

The tendency to implicitly assume that economic actors are omniscient is a common pitfall of theoretical social science. By definition, the theorist knows everything there is to be known about the stylized model he has invented. Theorists often implicitly assume that economic actors automatically have the information they need to make decisions.<sup>4</sup> Indeed, this may be essential to building a tractable model of the world. But the failure to ponder the feasibility of acquiring and using information can lead to flawed conclusions.

The contemporary patent debate suffers from just this blind spot. Each patent is a demand that the world refrain from practicing a claimed art without the patent holder's permission. Potential infringers can only comply with this demand if they are aware of the patent's existence. On a blackboard or in the pages of a law review article, it's easy to implicitly assume that everyone knows about every patent.

But the real world isn't so simple. To avoid infringement, a firm must expend resources to learn

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1 Friedrich Hayek, *The Use of Knowledge in Society*, 35 AM. ECON. REV. 519 (1945).

2 *Id.* at 519.

3 *Id.* at 524.

4 *See id.* at 519.

about potentially relevant patents. Typically this means hiring patent lawyers to conduct patent searches, which may or may not be affordable or effective.<sup>5</sup> In this paper, we'll call the costs of such information-gathering activities the patent system's "discovery costs."<sup>6</sup> One criterion for a well-functioning patent system — or any system of property-like rights — is that discovery costs should be low enough that it's economically feasible for firms to obtain the information they need to comply with the law.<sup>7</sup>

Thinking explicitly about discovery costs is a powerful tool for understanding the dysfunctions of the patent system. As we will see, discovery costs are relatively low in pharmaceuticals and other chemical industries. As a consequence, the patent system serves these industries relatively well. In contrast, discovery costs in the software industry are so high that most firms don't even try to avoid

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5 For example, a recent Supreme Court case presumed that “simply asking an attorney to examine a product and compare it to the database of existing patents is not a dependable way to see if a product is likely to infringe a patent.” Stephen M. McJohn, *Top Tens in 2011: Patent, Trademark, Copyright and Trade Secret Cases 5* (Legal Studies Research Paper Series, Research Paper 11-56, Dec. 1, 2011), available at <http://ssrn.com/abstract=1968490> (discussing *Global-Tech Appliances, Inc., v. SEB S.A.*, 131 S.Ct. 2060 (2011)); see also *Global-Tech Appliances*, 131 S.Ct. at 2064 (describing how a patent attorney failed to locate a patent that a manufacturer’s deep fryer infringed on).

6 Discovery costs are one of the types of transaction costs identified by Ronald Coase in his seminal essay, *The Problem of Social Cost*. Coase explained,

In order to carry out a market transaction *it is necessary to discover who it is that one wishes to deal with*, to inform people that one wishes to deal and on what terms, to conduct negotiations leading up to a bargain, to draw up the contract, to undertake the inspection needed to make sure that the terms of the contract are being observed, and so on. These operations are often extremely costly, sufficiently costly at any rate to prevent many transactions that would be carried out in a world in which the pricing system worked without cost.

R. H. Coase, *The Problem of Social Cost*, 3 J.L. & ECON. 1, 15 (1960) (emphasis added); see also Paul J. Heald, *Optimal Remedies for Patent Infringement: A Transactional Model*, 45 HOUS. L. REV. 1165, 1167-68 (2008) (explaining Coase's description of transaction costs "in the context of contracting for inventions").

7 Clarisa Long has argued that “[p]atent law’s requirement of definition and registration of all patented goods lowers search costs.” *Information Costs in Patent and Copyright*, 90 VA. L. REV. 465, 532-33 (2004) (“[Specialized and knowledgeable practitioners] will be able to draw on their preexisting knowledge of goods and technologies in the relevant field and as a result search costs will be lower than if they were not knowledgeable. . . . Requiring a small set of people to search exhaustively is not as socially expensive [in patent law as searches by many are in copyright.]”); see also *id.* at 503 (“We would expect legal rules to force disclosure . . . , and . . . increase duties of avoidance, when the class of goods is small . . . , when the goods affect fewer observers, when the observers have greater tolerance for incurring costs of understanding the good, and when the disclosed information is objective and readily verifiable. This is indeed what we see with the patent form.”) Long does acknowledge that “[a] business patent that could be practiced by many individuals will often be harder to cognize, define, and avoid at low cost than a familiar and easily represented [copyrighted] figure like Mickey Mouse.” *Id.* at 524. “Nonetheless,” she argues, “for most paradigmatic patented goods, legal rules that consolidate entitlements in owners do not raise the information costs of searching and avoiding goods unduly.” *Id.* This paper disagrees with Long’s view in so far as it argues that the costs of discovering whether an independently-created invention has already been patented are actually unduly high.

infringement. Unsurprisingly, software is a major contributor to the recent spike in patent litigation.

We will argue that this disparity can be explained by the fact that pharmaceutical inventions can be organized by chemical formula, while no analogous organizational scheme exists for software inventions.

## II. Scale and Big-O Notation

Our subject is what software engineers call "scalability," the ability of a system to perform well as the "problem size" increases. A common experience for companies that build online services is to have a system that worked flawlessly with a limited number of test users grind to a halt when it's released to the public and used by millions of people. Often, a system's bottlenecks only become apparent when it is used at its full capacity.

He didn't put it in these terms, but Hayek was essentially arguing that central planning doesn't scale. Centralizing economic decision-making can work in a small tribe where the chief knows every tribe member personally. But in a modern economy with millions of households, a single, central decision-maker would become a bottleneck, causing the entire system to grind to a halt. So modern societies have developed other mechanisms, such as the price system, to coordinate economic decisions in a decentralized, scalable fashion.

Scalability is also an important issue for the patent system. In an island nation of, say, 100,000 people, the patent system's discovery costs wouldn't be a cause for concern. There might be a couple of patents granted each week, and it would be reasonable to simply expect every firm to read every patent. In contrast, the U.S. Patent & Trademark Office issues several *thousand* patents per week.<sup>8</sup> Clearly, it's not possible to expect every American firm to read and understand every issued patent. So a scalable

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<sup>8</sup> U.S. Patent Statistics Chart, Calendar Years 1963-2010, [http://www.uspto.gov/web/offices/ac/ido/oeip/taf/us\\_stat.pdf](http://www.uspto.gov/web/offices/ac/ido/oeip/taf/us_stat.pdf) (noting 219,614 utility patents were granted in 2010, averaging 4,223 utility patents granted per week).

patent system needs to offer firms efficient mechanisms to sort through those thousands of patents to find the ones that are relevant to them.

To think rigorously about this question, we're going to borrow the standard notation computer scientists use to talk about scalability, called "Big O" notation.<sup>9</sup> To illustrate this concept, imagine you're planning a chess tournament with  $n$  players. You have just one chess set, so games have to be played in sequence. You are deciding between two tournament styles: a round-robin tournament in which every player plays one game with every other player, or a single-elimination tournament in which players are paired off and the loser of each game is dropped from the tournament.

Suppose the tournament has  $n$  players. If we assume that each game takes one hour, and there are no breaks, the round-robin tournament will take  $n(n-1)/2$  hours. If  $n$  is large, the tournament will be intolerably long. For  $n=100$ , for example, the tournament will take more than six months!

Now consider the single-elimination tournament. If we again assume each game lasts an hour, then it can be shown that the entire tournament will take  $n-1$  hours. This is a much more manageable number; with  $n=100$  players the tournament will take about 4 days.

Big-O notation is a way to succinctly summarize how quickly a function grows relative to its input. To find the "Big-O" class of a function like  $n(n-1)/2$ , the function is expanded (in this case to  $\frac{1}{2}n^2 - \frac{1}{2}n$ ) and everything other than the fastest-growing exponent is dropped, leaving  $n^2$ . We can then say that the round robin tournament takes  $O(n^2)$  time to complete given  $n$  participants. In contrast, the single-elimination tournament takes just  $O(n)$  time to complete.

This means that round-robin tournaments scale poorly compared to single-elimination tournaments. Doubling the number of players roughly doubles the length of the single-elimination

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<sup>9</sup> See Paul E. Black, *big-O notation*, in *DICTIONARY OF ALGORITHMS AND DATA STRUCTURES [ONLINE]* (Paul E. Black, ed., U.S. Nat'l Institute of Standards and Technology Oct. 6, 2010), available at <http://www.nist.gov/dads/HTML/bigOnotation.html>; JON KLEINBERG & EVA TARDOS, *ALGORITHM DESIGN* 36-37, 47-56 (2006).

tournament, while it increases the length of the round-robin tournament by a factor of four.<sup>10</sup> For large tournaments, this effect will dwarf other considerations in choosing between the two options.

### III. Analyzing the Patent System's Scalability with Big-O Notation

#### A. A Simple Model of the Patent System

Now we use Big-O notation to evaluate the scalability of the patent system. We start by constructing a stylized model of the patent-eligible widget industry. There are  $n$  firms producing widgets and each firm produces just one type of widget and holds just one patent. We'll relax these assumptions later, but the simplicity of this model makes it a good starting point.

Each firm's widget may infringe multiple competitors' patents, and firms spend resources to learn which patents they must license or invent around. How large are these discovery costs? Suppose that the only known way to find the patents related to a particular widget is to examine all widget patents, and that lawyers can always correctly determine whether a widget violates a patent simply by reading the patent claims.<sup>11</sup> Suppose also that it takes a patent lawyer one hour to determine whether a given widget-related product infringes a given widget patent. Then each of the  $n$  widget firms will need to pay a patent lawyer to examine the patents held by each of the  $n-1$  other widget firms. That's  $n-1$

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<sup>10</sup> We can demonstrate this by plugging  $p$  players and  $2p$  players into the equations for determining the length of a single elimination and round robin tournament:  $n-1$  and  $\frac{1}{2}n^2-\frac{1}{2}n$ , respectively.  $P$  players could finish a single elimination tournament in  $p-1$  hours and could finish a round robin tournament in  $\frac{1}{2}p^2-\frac{1}{2}p$  hours. To determine how long it would take  $2p$  players to finish a tournament, we replace “ $n$ ” in the equation with “ $2p$ ”. Twice as many players would take almost twice as long to finish a single elimination tournament as  $p$  player —  $2p-1$  hours compared to  $p-1$  hours. In contrast, a round robin tournament of  $2p$  players would take  $\frac{1}{2}(2p)^2-\frac{1}{2}(2p)$  hours, which multiplies out to  $2p^2-p$  hours. Whereas the round robin tournament of  $p$  players took almost about  $\frac{1}{2}p^2$  hours, the tournament of  $2p$  players takes almost  $2p^2$  hours — quadrupling the time even though the players only doubled.

<sup>11</sup> In the real world, lawyers frequently cannot state for certain whether a given activity actually infringes a particular patent. In this paper, we will largely set this issue to the side and assume counterfactually that lawyers can always determine whether a particular activity infringes a particular patent in a reasonable amount of time. For further reading on the challenges of claim construction and determining the scope of patents, see Jeanne Fromer, *Claiming Intellectual Property*, 76 U. CHI. L. REV. 719 (2009), Michael Risch, *The Failure of Public Notice in Patent Prosecution*, 21 HARV. J. L. & TECH. 179 (2007); Christopher A. Cotropia, *Patent Claim Interpretation Methodologies and their Claim Scope Paradigms*, 47 WM. & MARY L. REV. 49 (2005); Christopher A. Cotropia, *Patent Claim Interpretation and Information Costs*, 9 LEWIS & CLARK L. REV. 57 (2005).

hours of work for each firm, leading to a total discovery cost of  $n(n-1)$ , or  $n^2 - n$ , billable hours. In other words, the discovery costs of the patent system are  $O(n)$  for each firm, and  $O(n^2)$  across the entire widget industry.

This means that the patent system scales poorly for widgets.<sup>12</sup> If the number of widget firms (and, with it, the number of patents) doubles, the industry's total legal bills increase by a factor of four. In an industry with many firms, the patent system's discovery costs would be a large burden; they could even dwarf some firms' revenues altogether. For example, in a widget industry in which 30,000 firms had one patent apiece and could review one patent per hour, each firm would need to hire around 15 full-time patent attorneys, for a total discovery cost of almost a billion billable hours.<sup>13</sup> That's a lot, even for deep-pocketed widget companies.

## **B. Indexing Lowers Discovery Costs**

The above analysis assumes that every firm must examine every patent in some detail, but this isn't practical in a world where there are hundreds of thousands of valid patents. Ideally, firms in real industries would have ways to quickly find the small minority of patents that relate to its own products and ignore the rest. The ability to do this depends on a good system of organization.

We can see the power of organization in the system of real property. Counties do not store real property records in a random order. Rather, they place them in a predictable order based on their geographic location. Filing them in a predictable order allows rapid record retrieval in the same way that alphabetization allows rapid lookup of words in a dictionary. In Big-O terms, retrieving one item

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12 Running time can get much worse for computer scientists, who sometimes must solve problems that can only be solved in non-polynomial time, such as  $O(k^n)$  for some constant  $k$  and number of inputs  $n$ .

13 Each of the 30,000 firms would need to hire a patent attorney to examine 29,999 other patents, which takes 1 hour per patent, so attorneys would spend a total of  $30,000 * 29,999 * 1 \text{ hour} = 899,970,000$  hours. Assuming a typical attorney bills 2000 hours of work per year, each firm would need just shy of 15 attorneys to examine 29,999 patents.

from a well-organized collection is a roughly  $O(1)$ , or constant-time, operation.<sup>14</sup> If a clerk needed to retrieve each record once during the year, he'd only spend  $O(n)$  time sorting through filing cabinets.

By way of contrast, we can imagine a county with an incompetent records clerk who placed property records in filing cabinets at random. In this county, the property system would have the same scaling problem as widget patents: as the number of parcels increased, looking up who owned any given parcel would become more and more time-consuming. The only way to find a particular record would be to examine records one at a time. That means retrieving all records related to a particular parcel would be an  $O(n)$  operation, where  $n$  was the total number of records. If a clerk needed to retrieve each record once during the year, he'd spend  $O(n^2)$  time sorting through filing cabinets. In a county with many parcels, the system would be completely unmanageable.

The ability to organize claims to real property depends on the existence of a standardized and predictable representation such as geographic coordinates. If a group of items has such a representation, we call that group "indexable," because the representation makes it possible to build an efficient index of the items. Dictionary words are indexable because they can be organized alphabetically. Real property claims are indexable because they can be organized by their geographic location.

### **C. Example: Chemical Patents are Indexable**

Are patents indexable? This is a difficult question to answer in general, since the answer varies by technology class. But at least one category of patents — chemical patents — is already being indexed.

The Food and Drug Administration produces a publication called the *Approved Drug Products*

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<sup>14</sup> Depending on the details of the filing method, lookup times might be a slow-growing function like  $O(\log_2 n)$ . The difference between  $O(1)$  and  $O(\log_2 n)$  is not large, and we're going to pretend they are the same to simplify the presentation.



*with Therapeutic Equivalence Evaluations*.<sup>15</sup> This publication, colloquially known as the "Orange Book,"<sup>16</sup> allows pharmaceutical patents to be looked up based on the chemical formula of the active ingredient. A German organization called FIZ Karlsruhe offers an electronic database called STN which allows researchers to pull up all literature on particular molecules, including patents.<sup>17</sup>

Chemical formula allows efficient retrieval of chemical patents, just as geographic coordinates allow efficient retrieval of real estate records. In other words, chemical patents are indexable. That means that finding a patent based on its chemical formula is approximately an  $O(1)$  operation, just as it is for real property records.

Recall that doubling the number of widget patents doubled every widget firm's discovery costs, since each firm is forced to look at twice as many patents to weed out the irrelevant ones. In contrast, doubling the number of chemical patents need not increase chemical firms' discovery costs because a database like STN can automatically filter out irrelevant patents, no matter how many of them there are. So the patent system scales well for chemicals.

#### **D. Example: Software Patents Are Disorganized**

Unfortunately, few if any non-chemical patents seem to be indexable. To be sure, there are searchable databases that include non-chemical patents. But few, if any, non-chemical categories of patentable inventions have a standardized and comprehensive scheme, like a chemical formula, for classifying patentable subject matter. And that means that there may not be a faster way to find all patents relevant to a particular product than to simply examine all patents in a particular technology

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15 See U.S. DEPT. OF HEALTH & HUMAN SERVS. ET AL., APPROVED DRUG PRODUCTS WITH THERAPEUTIC EQUIVALENCE EVALUATIONS (31st ed. 2011), *available at* <http://www.fda.gov/downloads/Drugs/DevelopmentApprovalProcess/UCM071436.pdf>.

16 Approved Drug Products with Therapeutic Equivalence Evaluations (Orange Book), <http://www.fda.gov/Drugs/InformationOnDrugs/ucm129662.htm> (last visited Dec. 10, 2011) (describing the origins of the nickname "Orange Book").

17 See STN International, <http://www.stn-international.de/index.php?id=123> (last visited Dec. 10, 2011).

class one at a time.

We'll focus on software patents, which provide a particularly good illustration of the problem.

As we have already noted, it would be completely impracticable for a firm to read every patent. So patent lawyers use a variety of methods to guess at what patents they should look at. These methods include searching by keyword, patent classification,<sup>18</sup> inventor or patent assignee, and searching for patents that cite to and are cited in similar patent applications.<sup>19</sup>

The keyword search is crucial, but searching by keyword hardly approaches the speed and certainty of searching an indexable system. A firm producing a new word processor might search for patents containing phrases like "word processor," "page layout," "printing," and so forth. But in the absence of a precise, standardized scheme for classifying software inventions, patent applicants are free to use any terms they like — or even make up new ones — to describe their software inventions. The scope of a patent's claims will not always be obvious from a patent's title or abstract. And a single software patent can claim multiple applications that are only loosely connected to each other.

One particularly illustrative example of the limits of keyword searching is U.S. Patent No. 4,528,643 — a “System for Reproducing Information in Material Objects at a Point of Sale Location.”<sup>20</sup> The invention that gave rise to the '643 patent was “a kiosk or vending machine to be used in retail locations for producing digital music tapes or other digital reproductions.”<sup>21</sup> The patent owner attempted to enforce the patent against several software and publishing companies, claiming that the

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18 The Patent and Trademark Office assigns classification numbers based only on the patent's claims, rather than the entire application. See U.S. Patent & Trademark Office, U.S. Department of Commerce Handbook of Classification 9, available at <http://www.uspto.gov/web/offices/opc/documents/handbook.pdf> (cited in Jeanne C. Fromer, *Patent Disclosure*, 94 IOWA L. REV. 539, 586 n. 212 (2009)). John R. Allison and Mark A. Lemley have discovered “numerous instances of what seem to be wrong or arbitrary classification decisions.” *The Growing Complexity of the United States Patent System*, 82 B.U. L. REV. 77, 92 (2002) (cited in Fromer, *supra*, at 586). They note, “This problem is compounded by the fact that some patents involve more than one type of technology, so that classifying them into only a single category will necessarily mischaracterize them to some extent.” Allison & Lemley, *supra*, at 92 n.49.

19 In addition to be able to search the USPTO website, numerous private companies provide searchable databases of patents and related information. See, e.g., Delphion, <http://www.delphion.com/> (last visited Jan. 18, 2012) (cited in Fromer, *supra* note 18, at 585 n. 208); PatBase, <http://www.patbase.com> (last visited Jan. 18, 2012).

20 U.S. Patent No. 4,528,643 (filed Jan. 10, 1983).

21 See JAMES BESSEN & MICHAEL J. MEURER, *PATENT FAILURE* 194 (2008).

sale and transfer of software and documents over the Internet infringed the patent.<sup>22</sup> The '643 patent was filed in 1983, long before “e-commerce” existed; indeed, the web page and browser were not created until 1990.<sup>23</sup> Nonetheless, litigation over the meaning of the '643 patent took over seven years to complete.<sup>24</sup>

The '643 patent illustrates the difficulty of relying on keywords to search patents. The “Background of the Invention” section of the patent discusses “retail outlets (point of sale locations)” and the difficulty in their deciding which recordings to stock.<sup>25</sup> The patent makes no mention of the Internet or personal computers. An attorney trying to determine *ex ante* whether selling and transferring software over the Internet had been patented would be unlikely to discover the '643 patent using keywords.<sup>26</sup>

This problem is exacerbated by the complexity of software products. Real software products often contain thousands — sometimes even millions — of lines of code. Given that a handful of lines of code can constitute a patent-eligible invention, the number of potentially patentable inventions in a 100,000-line computer program can be very large. The patent on raising a pop-up browser window

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22 See *Interactive Gift Exp., Inc., v. CompuServe Inc.*, 256 F.3d 1323, 1329 (Fed. Cir. 2001).

23 See TIM BERNERS-LEE, *WEAVING THE WEB* 28-30 (1999).

24 See Complaint, *Interactive Gift Exp., Inc., v. CompuServe Inc.*, No. 95-6871 (S.D.N.Y. Aug. 23, 1995) (E.C.F. No. 1); Order of Dismissal, *Interactive Gift Exp., Inc., v. CompuServe Inc.*, No. 95-6871 (S.D.N.Y. Jan. 21, 2003) (E.C.F. No. 224). The Federal Circuit had held the term “point of sale location” could include one’s home. See *Interactive Gift Exp.*, 256 F.3d at 1335. However, it also held that the “material objects” referenced in the patent had to be offered for sale, and thus excluded a buyer’s personal computer. *Id.* at 1338. Nonetheless, litigation following the Federal Circuit decision dragged on for a year and a half, concluding with voluntary dismissals and numerous settlement agreements. See Docket, *Interactive Gift Exp., Inc., v. CompuServe Inc.*, No. 95-6871 (S.D.N.Y. Nov. 7, 2001) (E.C.F. Nos. 184-86, 189, 201, 220-24 ) (dismissing parties, often after having reached a settlement).

25 U.S. Patent No. 4,528,643 cols. 1-2 (filed Jan. 10, 1983).

26 At first blush, one might suppose this problem could sometimes be averted by the reverse doctrine of equivalents. “The reverse doctrine of equivalents is an equitable doctrine designed to prevent unwarranted extension of the claims beyond a fair scope of the patentee’s invention.” *Roche Palo Alto LLC v. Apotex, Inc.*, 531 F.3d 1372, 1377 (Fed. Cir. 2008) (internal quotations omitted). “[W]here a device is so far changed in principle from a patented article that it performs the same or similar function in a substantially different way, but nevertheless falls within the literal words of the claim, the [reverse] doctrine of equivalents may be used to restrict the claim and defeat the patentee’s action for infringement.” *Graver Tank & Mfg. Co. v. Linde Air Prods. Co.*, 339 U.S. 605, 608-09 (1950). However, the reverse doctrine of equivalents is “all but defunct.” Long, *supra* note 7, at 519 (describing how the United States Court of Appeals for the Federal Circuit “proudly declare[d] that it has struck down every successful assertion of the reverse doctrine of equivalents.” (citing *Tate Access Floors, Inc., v. Interface Architectural Res.*, 279 F.3d 1357, 1368 (Fed. Cir. 2002)).

when one attempts to leave a webpage, for example, can be infringed by writing a mere three lines.<sup>27</sup>

Hence, it is extremely difficult to anticipate all the different aspects of a particular computer program that might be regarded as patent-eligible subject matter. It is even more difficult to anticipate all the terms patent applicants could use to describe those various patentable concepts. The effectiveness of keyword searching is further undermined by the doctrine of equivalents, which holds that a patent can cover subject matter "equivalent" to its claims even if it does not fall within their literal scope.<sup>28</sup> This means that in practice, a keyword-based patent search will only find a fraction of relevant patents or produce so many results that it would be of little help to the searcher.

Other search strategies, such as searching by inventor, assignee, or citations in related patents, are no more promising. If a firm knows of an existing patent similar to its product, these methods may be useful for finding closely-related patents. But as we've seen, many different aspects of a software product may be patent-eligible, and there's no reason to think all the patents relevant to a particular product will be linked together by citations, common inventors, or other similarities.

It's theoretically possible that future improvements in artificial intelligence will allow the creation of a search engine for software patents as powerful as conventional chemical patent databases.

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27 See BEN KLEMENS, MATH YOU CAN'T USE 1-2 (2006); U.S. Patent No. 6,389,458 (filed Oct. 30, 1998). The three lines of code necessary to create a pop up window when one attempts to leave a webpage in JavaScript are:

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function onExit() {  
    popup = window.open("pop.html", "Don't go!");  
    popup.focus();}
```

KLEMENS, *supra*, at 2.

28 A product or process may be found infringing under the doctrine of equivalents if it performs "substantially the same function in substantially the same way to obtain the same result" as the patented invention. *Graver Tank Mfg. Co.*, 339 U.S. at 608 (quoting *Sanitary Refrigerator Co. v. Winters*, 280 U.S. 30, 42 (1992)); see also *Warner Jenkinson Co. v. Hilton Davis Chem. Co.*, 520 U.S. 17, 40 (1997) (The essential inquiry under the doctrine of equivalents is whether "the accused product or process contain[s] elements identical or equivalent to each claimed element of the patented invention[.]"). John R. Allison and Mark A. Lemley argue, "[T]he doctrine of equivalents was . . . near death by the late 1990s.[, and] district courts are more likely to reject doctrine of equivalents claims today than ever before." *The (Unnoticed) Demise of the Doctrine of Equivalents*, 59 STAN. L. REV. 955, 958 (2007); see also David L. Schwartz, *Explaining the Demise of the Doctrine of Equivalents*, 26 BERKELEY TECH L.J. 1157 (2011); Lee Petherbridge, *On the Decline of the Doctrine of Equivalents*, 31 CARDOZO L. REV. 1371 (2010). Nonetheless, Samson Vermont points out that "one of every four or five cases in which a patentee wins a judgment of infringement is . . . a judgment of infringement under the doctrine of equivalents . . . [Doctrine of equivalents] scope is litigated frequently. One of every two decisions on infringement is a decision on [doctrine of equivalents] infringement." *Taming the Doctrine of Equivalents in Light of Patent Failure*, 16 J. INTELL. PROP. L. 83, 84 (2008).

This search engine would have to be sophisticated enough to analyze a real-world machine or process, make a comprehensive list of characteristics that could constitute patent-eligible subject matter, produce a list of all possible terms that could be used to describe this subject matter, and find all patents that use these terms in a way that indicates possible infringement. But that technology doesn't exist right now, and we are skeptical it will exist any time soon. In the meantime, the only reliable way to find all — not merely some — patents infringed by a particular software product is to have a human being look at all patents in software-related technology classes. So the discovery costs of software patents for a single firm is roughly  $O(n)$  in the number of software patents, not  $O(1)$  as with chemical patents.

Patent discovery costs that are  $O(n)$  in the number of patents would not be a problem if the number of firms and patents are both small. But the more firms and patents there are, the larger discovery costs will be.

Once again, the software industry is a good example of an industry where the patent system works poorly. The number of firms producing patentable software is massive — much larger than the number of firms in the software industry as it is conventionally defined. Almost every medium and large American firm has an IT department that performs backups, runs file and mail servers, runs the firm's website, and so forth. IT professionals routinely create software to automate such tasks, and this software is potentially patent-eligible. Many firms also develop custom software to automate common business processes, and some of it is quite complex. Hence, most medium and large American firms (as well as many non-profits, universities, and other organizations) are in the software industry as far as patent law is concerned.<sup>29</sup>

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<sup>29</sup> See KLEMENS, *supra* note 27, at 4-5 (“[A] patent on a piece of code is a restriction . . . on the information technology department of every company in America, not to mention every person who writes macros to facilitate his or her work . . .”).

And as a consequence, many kinds of firms are the targets of software patent lawsuits.<sup>30</sup> One complaint charged the Green Bay Packers, Caterpillar, Peapod, OfficeMax, and Kraft Foods with infringing a patent for a “remote query communications system”<sup>31</sup> — specifically for having JPEG images on their websites.<sup>32</sup> Another plaintiff filed lawsuits against firms such as J Crew and Linens 'n' Things for infringing its “Information Processing Methodology”<sup>33</sup> patents by transmitting data that costumers entered on the defendants’ websites.<sup>34</sup> Other firms facing allegations of software patent infringement include McDonalds, Barnes & Noble, Jamba Juice, Aeropostale, 7-Eleven, and Oprah Winfrey's Harpo Productions.<sup>35</sup>

Not only do firms outside of the conventional software industry frequently produce potentially

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- 30 Even frivolous allegations of patent infringement can be very expensive to dispel. In 2005, the average cost of an opinion letter assessing the validity of a patent and whether an accused party infringed was about \$24,000. AM. INTELLECTUAL PROP. LAW ASSOC., REPORT OF THE ECONOMIC SURVEY 102 (2005) (cited in Matthew Sag & Kurt Rohde, *Patent Reform & Differential Impact*, 8 MINN. J.L. SCI. & TECH. 1, 11 n. 41 (2007)). Getting a patent invalidated in court cost on average \$650,000. AM. INTELLECTUAL PROP. LAW ASSOC., *supra*, at 108 (cited in Sag & Rohde, *supra*, at 11 n. 44). It is thus often economically rational to pay high licensing fees for invalid patents that one did not even infringe rather than have to participate in a lawsuit. “This is the real perversity of the current patent system: rational actors will pay licensing fees for patents they strongly suspect are either invalid, or simply do not apply to them, because each of the alternatives is worse.” Sag & Rohde, *supra*, at 12.
- 31 U.S. Patent No. 5,253,341 (filed Apr. 11, 1991).
- 32 Am. Compl. at 1, *Global Patent Holdings LLC v. Green Bay Packers*, No. 00-4623 (N.D. Ill. Oct. 23, 2007) (E.C.F. No. 50). An attempt to enforce the ’341 patent in 2000 led to the invalidation of all sixteen claims, as well as to the addition of a seventeenth claim. *See* Motion to Reinstate at 1, *Techsearch LLC v. Internet Entm’t Group*, No. 00-4623 (N.D. Ill. Sept. 10, 2007) (E.C.F. No. 41); *see also id.* at Ex. A (Ex parte *Global Patent Holdings, LLC*, Appeal No. 2006-0698, Reexamination Control No. 90/005,742 (Dec. 26, 2006)). The amended complaint, *supra*, charged the Green Bay Packers and other parties with violating the new seventeenth claim, however an initial re-examination of the seventeenth claim found it invalid on nineteen grounds. *See* Initial Office Action in Ex Parte Reexamination of U.S. Patent No. 5,253, 341, at 3-5 (July 22, 2008), *available at* <http://www.scribd.com/doc/4328073/jpg-patent-reexam>. The case was dismissed without prejudice pending the reexamination on March 4, 2009. *See* Minute Entry, *Global Patent Holdings LLC v. Green Bay Packers*, No. 00-4623 (N.D. Ill. Mar. 4, 2009) (E.C.F. No. 154); Agreed Motion to Dismiss, *Global Patent Holdings LLC V. Green Bay Packers*, No. 00-4623 (N.D. Ill. Mar. 3, 2009) (E.C.F. No. 153).
- 33 U.S. Patent No. 7,075,673 (filed July 11, 2006); U.S. Patent No. 6,683,697 (filed Dec. 9, 1999); U.S. Patent No. 7,184,162 (filed Apr. 15, 2005).
- 34 *See* Complaint ¶¶ 14, 17, 20, *Eon-Net L.P. v. J. Crew*, No. 07-10488 (S.D.N.Y. Nov. 20, 2007) (E.C.F. No. 1); Am. Complaint ¶¶ 12, 15, *Eon-Net L.P. v. Linen & Things*, No. 06-315 (D.N.J. Aug. 2, 2006) (E.C.F. No. 15). The cases were dismissed or settled before the court rendered a final judgment. *See* Stipulation and Order of Dismissal with Prejudice, *Eon-Net L.P. v. J.Crew*, No. 07-10488 (S.D.N.Y. Aug. 4, 2008) (E.C.F. No. 11); Order of Dismissal, *Eon-Net L.P. v. Linen & Things*, No. 06-315 (D.N.J. Jan. 5, 2007) (E.C.F. No. 23); Stipulation of Dismissal, *Eon-Net L.P. v. Linen & Things*, No. 06-315 (D.N.J. Dec. 22, 2006) (E.C.F. No. 22).
- 35 *See* Complaint, *Card Activation Technologies, Inc. v. 7-Eleven Inc.*, No. 10-4984 (N.D. Ill. Aug. 9, 2010) (E.C.F. No. 1); Complaint, *Illinois Computer Research LLC v. Harpo Productions, Inc.*, No. 08-7322 (N.D. Ill. Dec. 23, 2008) (E.C.F. No. 1); Complaint, *Card Activation Technologies, Inc. v. Barnes & Noble, Inc.*, No. 07-1230 (N.D. Ill. Mar. 2, 2007) (E.C.F. No. 1) (also naming Jamba Juice Co. and Aeropostale Inc. as defendants); Complaint, *Card Activation Technologies, Inc. v. McDonald's Corp.*, No. 06-5578 (N.D. Ill. Oct. 13, 2006) (E.C.F. No. 1).

infringing software, they are also granted the lion's share of software patents. James Bessen has found that 83% of software patents granted to public firms in 2006 went to firms outside of the conventional software industry.<sup>36</sup>

In our discussion of the widget industry, we stipulated that each firm would hold exactly one patent and concluded that discovery costs of widget patents are  $O(n^2)$ . Obviously, real industries aren't like that. Some firms have many patents and others have none at all. So it's more precise to say that the patent system's discovery costs in non-indexable industries are  $O(n_f n_p)$ , where  $n_f$  is the number of firms and  $n_p$  is the number of patents. The widget industry is a special case where  $n=n_f=n_p$ , so that total discovery costs are  $O(n^2)$ .

In the software industry,  $n_f \neq n_p$ , but  $n_f$  and  $n_p$  are both large. As we've seen, most medium and large firms produce patent-eligible software. There are roughly  $n_f=634,000$  firms in the United States with 20 or more employees.<sup>37</sup> While not all of these firms produce software, many of the 1.7 million firms with 5 to 19 employees do, so we'll estimate the number of firms that create software at 600,000. And  $n_p$ , the number of software patents issued, is around 40,000 in a typical year (and growing).<sup>38</sup> That means that there are around 24 billion new patent-firm pairs each year that could produce accidental infringement. Even if a patent lawyer only needed to look at a patent for 10 minutes, on average, to determine whether *any* part of a particular firm's software infringed it,<sup>39</sup> it would require roughly 2

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36 James Bessen, *A Generation of Software Patents* 16, 25 (Boston University School of Law Working Paper No. 11-31, Berkman Center Research Publication No. 2011-04, June 21, 2011) (forthcoming in B.U. J. SCI. & TECH. L.) (showing only 17.2% of software patents granted to public firms were granted to firms in the computer services and software industries), available at [http://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=1868979](http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1868979).

37 According to the US Census Bureau, there were 634,000 businesses with 20 or more employees in 2008, and 1.7 million firms with 5 to 19 employees. See Statistics About Small Business from the Census Bureau, <http://www.census.gov/econ/smallbus.html> (last visited Dec. 9, 2011).

38 See Bessen, *supra* note 36, at 26 fig. 1.

39 Ten minutes is an unrealistically low amount of time. Patentable software can be written in only a few lines, see *supra* note 27; and many software programs consist of millions of lines of code. See, e.g., Stewart Brand, *The Physicist*, WIRED MAG. (Sept. 1995), available at <http://www.wired.com/wired/archive/3.09/myhrvold.html> (interview with Nathan Myhrvold, estimating Microsoft Word consisted of two million lines of code in 1995). It is plainly beyond human capacity for an attorney to be able to hold in his or her mind everything that a large software program does at all, let alone to be able to comprehend it and compare it all to the content of a patent in a matter of minutes.

million patent attorneys, working full-time, to compare every firm's products with every patent issued in a given year.<sup>40</sup> At a rate of \$100 per hour, that would cost \$400 billion. For comparison, the software industry was valued at \$225.5 billion in 2010.<sup>41</sup>

Obviously, \$400 billion is a highly speculative figure. But the exact number doesn't matter, because there are only around 40,000 registered patent attorneys and agents in the United States.<sup>42</sup> Even if the entire patent bar worked full-time on patent clearance for software firms, there wouldn't be nearly enough lawyers to go around.

### **E. Example: $n_p$ Is Small for Corkscrews**

We've argued that discovery costs are low for chemicals because chemical patents are indexable by chemical formula. But even non-indexable patent classes can have modest discovery costs if  $n_p$ , the number of potentially-relevant patents, is small enough.

For example, consider corkscrews. A search of corkscrew-related technology classes<sup>43</sup> reveals 301 utility patents awarded between 1992 and 2011. Just five of these were issued in 2011.

We've argued that it would be impossible for anyone to read and understand the hundreds of thousands of existing software patents, or even to keep up with the hundreds of software patents the patent office issues each week. But it would only take a few weeks to read and understand the 301 utility patents related to corkscrews.<sup>44</sup> And given that only about 15 patents are issued in corkscrew-related technology classes in a typical year, it would be fairly easy for an attorney who specialized in

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40 The math behind this is straightforward:  $40,000 \text{ patents} * 600,000 \text{ firms} * (10 \text{ minutes per patent-firm pair}) / (2000 * 60 \text{ minutes per attorney}) = 2 \text{ million attorneys}$ .

41 DATAMONITOR, GLOBAL SOFTWARE INDUSTRY GUIDE (2010) (abstract), *available at* [http://www.datamonitor.com/store/Product/software\\_global\\_industry\\_guide\\_2010?productid=4F026C5C-EBCC-4193-AD27-77260196E7F5](http://www.datamonitor.com/store/Product/software_global_industry_guide_2010?productid=4F026C5C-EBCC-4193-AD27-77260196E7F5).

42 *See* Patent Attorney/Agent Search, <https://oedci.uspto.gov/OEDCI/query.jsp> (last visited Dec. 11, 2011) (search for "US" in the country field).

43 We used patent classes 81/3.2, 81/3.4, 81/3.7, 81/3.9, 81/3.29, 81/3.36, 81/3.37, 81/3.45, 81/3.48.

44 For example, if we assume that it takes an hour, on average, to understand a corkscrew-related patent, then it would take approximately eight 40-hour workweeks to familiarize oneself with all 301 corkscrew-related utility patents.



corkscrew patents to keep abreast of new patents.

Amazon.com lists 4,551 corkscrews for sale in its "home and kitchen" section from 737 manufacturers. Not every firm manufacturing corkscrews is listed on Amazon.com, but it's reasonable to assume a majority of the commercially significant ones are. So we'll estimate that  $n_f$ , the number of firms in the corkscrew industry, is no more than 1500.

We've already estimated that  $n_p=301$  for corkscrews. If we again assume that each firm-patent comparison takes 10 minutes, then it would take approximately 75,250 hours to conduct patent clearance for all corkscrews currently on the market.<sup>45</sup> That would require the services of approximately 40 patent attorneys working full-time for a year.

And of course, this process wouldn't need to be repeated every year. In a typical year, firms would only need to clear their new products and compare their existing products with newly-issued patents. So in a typical year the corkscrew industry will require the services of significantly fewer than 40 full-time patent attorneys.

Moreover, the fact that there are few enough patents that a single person could read and understand all of them means that the vetting process is likely to be considerably more efficient for corkscrews than for software. A patent is much harder to understand the first time it's read than on the second, fifth, or 20th encounter. There are so many software patents that no one could possibly read more than a small fraction of them, so attorneys doing software patent clearance spend most of their time reading patents for the first time. In contrast, attorneys that specialized in corkscrews would be looking at the same 301 patents over and over again. Their familiarity with the corkscrew patents would allow them to quickly identify which were relevant to a particular client's products.

Hence, the fact that a patent class is non-indexable does not necessarily mean that discovery costs

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<sup>45</sup>  $301 * 75250 = 451,500$  comparisons. If each takes 10 minutes, this will take  $451,500 / 6 = 75,250$  hours of work. Obviously, 10 minutes per comparison is a rough estimate, but suffices to illustrate the point that corkscrew patent discovery costs are several orders of magnitude smaller than software patent discovery costs.

will be prohibitively high. If  $n_p$ , the total number of patents in the technology class, is small, then the "brute force" approach of examining every patent may be feasible.

#### **IV. Disorganized Patents Have Led to A Litigation Explosion**

In practice, firms don't — and can't — spend whatever it takes to avoid infringement. Rather, they spend only as much money on patent searches as they believe will "pay off" in lower future litigation and licensing costs.<sup>46</sup> In industries with low discovery costs, a rational firm is likely to spend enough money to find all patents relevant to its products. Inadvertent infringement in these industries is rare. On the other hand, in industries where discovery costs are high, the rational firm might not even try to avoid infringement, because a dollar spent on patent searches will produce much less than a dollar in savings due to reduced litigation.

Unsurprisingly, the software industry — and, indeed, the larger IT industry of which it is a part — is in the latter category. In a widely-cited paper, Mark Lemley documents the widespread IT industry practice of ignoring patents and tries to explain why IT firms behave as they do.<sup>47</sup> He suggests several explanations: patent negotiations take a long time, patent holders may not be willing to offer reasonable terms, many patents turn out to be invalid, and the number of patents a given firm must license would be large.<sup>48</sup> These are all plausible explanations, but there is a more important and fundamental one: firms have no cost-effective way of obtaining a complete list of relevant patents in the first place. Licensing the few they know about provides no protection against the many others they haven't yet discovered.

Lemley notes that the pharmaceutical industry is one of the few industries that do not ignore patents, and he attributes the difference to the fact that the FDA forces patent holders to disclose

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46 See Rebecca S. Eisenberg, *Patent Costs and Unlicensed Use of Patented Inventions*, 78 U. CHI. L. REV. 53, 55 (2011) (“Information costs and transaction costs may dwarf potential gains to users from identifying and clearing rights . . .”).

47 Mark A. Lemley, *Ignoring Patents*, 2008 MICH. ST. L. REV. 19, 21 (2008).

48 *Id.* at 25-29.

relevant patents.<sup>49</sup> But such disclosures can only be compiled into a useful form because chemical patents are indexable. Without chemical formula as an organizational scheme, it wouldn't be possible to create a publication like the Orange Book that allowed rapid retrieval of patents relevant to a particular real-world product.

The empirical evidence on litigation costs is consistent with our hypothesis about the importance of discovery costs. We should expect industries with high discovery costs to have high rates of inadvertent infringement and, as a consequence, high rates of litigation. In their 2008 book *Patent Failure*, James Bessen and Mike Meurer used stock market event studies to estimate the total costs of patent litigation for various industries during the 1980s and 1990s. They found that litigation costs for chemical patents are much lower than the profits from these patents.<sup>50</sup> This happy state of affairs can be explained by the low discovery costs of chemical patents — litigation is rare because infringement is rare.

Bessen and Meurer found litigation costs were much higher for non-chemical patents. From 1984 until 1994, the costs of litigation over non-chemical patents were roughly equal to the profits from those patents.<sup>51</sup> And from 1994 to until the end of their study period in 1999, the costs of litigation over non-chemical patents increased dramatically.<sup>52</sup>

Why was there a spike starting in the mid-1990s? Between 1989 and 1998, the courts made it dramatically easier to get patents on software and "business methods." And Bessen and Meurer find that these patents contributed a disproportionate share of patent litigation. Software patents were more than twice as likely to be involved in patent litigation as other kinds of patents.<sup>53</sup> The closely-related

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49 *Id.* at 29-30.

50 See BESSEN & MEURER, *supra* note 21, at 139 (Fig. 6.5).

51 *Id.* at 138-39.

52 *Id.*

53 *Id.* at 22,153.

category of business method patents was nearly seven times as likely to be involved in litigation.<sup>54</sup> This is not surprising. We've already seen that software patents have particularly high discovery costs, and business method patents have high discovery costs for similar reasons.

## **V. Policy Suggestions: Beyond Patent Quality**

We've argued that for technology classes with high discovery costs, the patent system is unlikely to ever work like a traditional property system. Rampant infringement is inevitable because firms have no way to discover which patents they are infringing. Because of this, firms have little incentive to even attempt to clear patent rights before introducing new products into the market.

No one would claim this state of affairs is ideal, but is this system the best we can do?

We don't think so. The patent system is supposed to be a mechanism for promoting the progress of the useful arts by transferring resources from the users of technologies to their inventors. But in industries where discovery costs are high, it does so in an erratic, wasteful, and unjust fashion. The system resembles a lottery more than system of property rights — an unlucky minority of infringers are the target of ruinous lawsuits, and only a minority of patent owners "win" by catching infringers who pay up.

Not only is this unfair to the targets of these lawsuits, but it creates a generalized disincentive to innovate. Developing new products comes with the risk of incurring crippling liability and having one's business enjoined — precisely the opposite of the effect patents are supposed to have. And, of course, many of the resources consumed by the patent system flow not to inventors, but to pay patent attorneys and cover the patent system's other deadweight costs.

Many observers have argued that patent law reforms should focus on increasing patent

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<sup>54</sup> *Id.*

“quality.”<sup>55</sup> They usually mean that more patents should be invalidated for obviousness or non-novelty and that patents should have narrower and clearer claims. These are worthwhile goals to be sure. But they do not directly address the discovery cost problem.

There's no reason to think obvious or non-novel patents cost more to discover than "high quality" patents. So reforms that invalidate "low quality" patents reduce discovery costs only because they reduce the total number of patents being issued. That's valuable, of course, but really dramatic changes would be needed to invalidate enough patents to bring discovery costs under control in large non-indexable industries like software. Nor are high discovery costs primarily due to unclear patent boundaries. Unclear boundaries do raise discovery costs, since they require patent attorneys to spend more time examining each patent. But recall that we began our analysis with the counterfactual assumption that widget patents have perfectly clear boundaries. So discovery cost problems will crop up even where patent boundaries are crystal clear. Problems related to unclear patent boundaries exist in addition to the basic discovery cost problems that are the focus of this article.

There are several strategies the government could take to reduce discovery costs, ranging from making small changes to radically restructuring the patent system. Here we look at a few categories of policy changes that would lessen discovery costs to various degrees.

### **A. Subject Matter Restriction**

The preceding analysis suggests that the patent system will work well when there's a clear and comprehensive way to index patents — reducing the entire industry's patent discovery time to  $O(n_f)$  rather than  $O(n_f n_p)$ . And the patent system will also work better when  $n_f$  or  $n_p$  is very small — e.g. in

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55 See, e.g., U.S. PATENT & TRADEMARK OFFICE, 2010-2015 STRATEGIC PLAN 10-25 (2010), available at [http://www.uspto.gov/about/stratplan/USPTO\\_2010-2015\\_Strategic\\_Plan.pdf](http://www.uspto.gov/about/stratplan/USPTO_2010-2015_Strategic_Plan.pdf) (describing initiatives to improve patent examination timelines and patent quality); ADAM B. JAFFE & JOSH LERNER, INNOVATION AND ITS DISCONTENTS 171, 178-81 (2004) (discussing ways to improve patent quality); John R. Allison & Starling D. Hunter, *On The Feasibility of Improving Patent Quality One Technology At A Time: The Case of Business Methods*, 21 BERKELEY TECH. L.J. 729 (2006).

industries with a small number of firms or inventions.

Together, these criteria arrange technologies on a spectrum. At one end of the spectrum are pharmaceuticals, an industry that is highly concentrated, has relatively few inventions, and can use chemical formulas to organize its patents. At the other end of the spectrum is software, an industry that's highly decentralized, produces many patents, and has no standardized classification system.

Notice that the factors that make software patents work poorly are characteristics of the software *industry*, not the patent system. This suggests that it is probably not possible to make the patent system work well for software. The basic problem is that there is a massive number of firms producing potentially-infringing software, they are producing many inventions, and there's no systematic way to organize them all. That is, discovery costs grow as  $O(n_f n_p)$ ,<sup>56</sup> and  $n_f$  and  $n_p$  are both large numbers. Changes to patent law probably can't make software inventions indexable, and policymakers certainly shouldn't try to reduce the number of firms.

The fact that some categories of patentable subject matter have much higher discovery costs than others suggests an obvious policy response: exclude subject matter with high discovery costs from patent eligibility. The strongest version of this reform would be to exclude all non-indexable technology classes from patent eligibility.<sup>57</sup> Or policymakers might exclude only those non-indexable categories for which litigation costs are highest.

The problem of high discovery costs provides a strong rationale for the courts' traditional

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56 If we let  $n$  be the lesser of  $n_f$  and  $n_p$ , then discovery costs will grow faster than  $O(n^2)$ .

57 The patent system is often described as a "bargain with the public in which the inventor gives information about the invention in exchange for an exclusive right." Mark A. Lemley, *The Myth of the Sole Inventor* 74 (Stanford Public Law Working Paper No. 1856610, July 21, 2011), available at <http://ssrn.com/abstract=1856610> (citing *Eldred v. Ashcroft*, 537 U.S. 186, 225 (2003) (referring to a patent as a "quid pro quo" for disclosure); *Aronson v. Quick Point Pencil Co.*, 440 U.S. 257, 262 (1979) (identifying "promotes disclosure of inventions" as a key function of the patent system); Fromer, *supra* note 18, at 542; Lisa Larrimore Ouellette, *Do Patents Disclose Useful Information?*, 25 HARV. J.L. & TECH. \_\_ (forthcoming 2012), available at <http://ssrn.com/abstract=1762793>). If nonindexable patents are, in practice, undiscoverable, then the justification behind this "bargain" is significantly diminished because even fully disclosed patents would be relatively obscured among the many other nonindexable patents.

prohibition on patents on abstract ideas.<sup>58</sup> The more abstract an invention is, the more different parties are likely to use it for different purposes, and the more flexibility parties will have to describe it. All of these factors mean that more abstract patents will produce particularly high discovery costs and, as a consequence, particularly high rates of inadvertent infringement and litigation.

At one time, software and business method patents were considered too abstract to constitute patentable subject matter, but the United States Court of Appeals for the Federal Circuit took a more permissive stance towards software and business method patents during the 1990s.<sup>59</sup> The result has been an unprecedented explosion of litigation related to software and business method patents. The Federal Circuit's *de facto* legalization of software and business method patents was a mistake and should be reversed.

An enumeration of other technology classes with high discovery costs is beyond the scope of this paper, but would be a worthwhile subject for future study.

An alternative to exclusions based on subject matter would be to vary the application fee for patents based on the estimated discovery costs of each technology class. The patent office would take into account the indexability of the technology classes and the number of firms practicing in it. A party applying for a chemical patent would thus have to pay a very low fee, whereas the fee for patents in software-related technology classes would be drastically increased.<sup>60</sup> This would decrease  $n_p$  over time by discouraging applying for patents in areas with high discovery costs.

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58 See *Diamond v. Diehr*, 450 U.S. 175 (1981) ("Excluded from such patent protection are laws of nature, natural phenomena, and abstract ideas."); *Diamond v. Chakrabarty*, 447 U.S. 303, 309 (1980) ("The laws of nature, physical phenomena, and abstract ideas have been held not patentable."); *Parker v. Flook*, 437 U.S. 584, 589 (1978) ("Phenomena of nature, though just discovered, mental processes, and abstract intellectual concepts are not patentable . . .") (quoting *Gottschalk v. Benson*, 409 U.S. 63, 67 (1972)).

59 For a discussion of the changing status of software patents over time, see ROBERT PATRICK MERGES & JOHN FITZGERALD DUFFY, *PATENT LAW AND POLICY* 150-55 (4th ed. 2007). See also *State Street Bank & Trust Co. v. Signature Financial Group, Inc.*, 149 F.3d 1368 (Fed. Cir. 1998) (eliminating the common-law ban on business method patents).

60 In 2001, Mark A. Lemley estimated that the cost of prosecuting a patent was between \$10,000 and \$30,000. See Mark A. Lemley, *Rational Ignorance at the Patent Office*, 95 NW. U. L. REV. 1495, 1498 (2001). A change in patent application fees would have to be significant in relation to the already high costs of hiring attorneys to draft and prosecute the patent.

## B. Independent Invention

Another powerful reform would be to create an independent invention defense to patent infringement.<sup>61</sup> Between ninety and ninety-eight percent of modern patent lawsuits are filed against independent inventors, not copiers.<sup>62</sup> Independent inventors develop and commercialize inventions without use of the patent system. Patent owners who have patented the same invention and who identify an independent inventor can exact licensing fees or even stop the invention's use by the independently-inventing party entirely.<sup>63</sup> This system hurts independent inventors and the public by forcing independent inventors to negotiate licensing fees to keep their existing products on the market — or by removing otherwise-successful products from the market.

There is an extensive literature on proposed independent invention defenses,<sup>64</sup> and a full consideration of the arguments for and against such a defense is beyond the scope of this paper. Nonetheless, we note that in principle, an independent invention defense could reduce discovery costs to zero. With an independent invention defense on the books, patent holders would still have the

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61 Other authors have written about the possibility of creating an independent invention defense to patent infringement. *See, e.g.*, Mark A. Lemley, *Should Patent Infringement Require Proof of Copying?*, 105 MICH. L. REV. 1525 (2007); Samson Vermont, *Independent Invention as a Defense to Patent Infringement*, 105 MICH. L. REV. 475, 480 (2006); Elisabetta Ottoz & Franco Cugno, *The Independent Invention Defence in a Cournot Duopoly Model*, 12 ECON. BULL. 1 (2004), available at <http://www.accessecon.com/pubs/EB/2004/Volume12/EB-04L10005A.pdf>; Stephen M. Maurer & Suzanne Scotchmer, *The Independent Invention Defense in Intellectual Property*, 69 ECONOMICA 535 (2002) (arguing that independent creation defense would preserve incentives to invent, but also permit more efficient use of inventions), available at <http://www.dklevine.com/archive/scotchmer-independent-invention.pdf>; John S. Leibovitz, *Inventing a Nonexclusive Patent System*, 111 YALE L.J. 2251 (2002) (suggesting that it would be economically efficient for independent inventors to receive independent patents on the same invention).

62 Lemley, *supra* note 57, at 8 (citing Christopher A. Cotropia & Mark A. Lemley, *Copying in Patent Law*, 87 N.C. L. REV. 1421 (2009)). Notably, the prevalence of independent invention acts as evidence that the patent system is frequently unnecessary to spur invention. Independent inventors often develop and commercialize the very same inventions others have patented. The fact that a later party developed and commercialized a patented invention independently indicates that it was not necessary to award the original patentee a patent in order for society to benefit from the invention. *See* Lemley, *supra* note 57, at 57 (citing Vermont, *supra* note 61).

63 *See* 35 U.S.C. § 283; *see also* eBay Inc. v. MercExchange, L.L.C., 547 U.S. 388 (2006) (describing test for injunctive relief under the patent act).

64 *See* Roger Milgrim, *An Independent Invention Defense to Patent Infringement: The Academy Talking to Itself: Should Anyone Listen?*, 90 J. PAT. & TRADEMARK. OFF. SOC'Y 295 (2008); Lemley, *supra* note 61; Vermont, *supra* note 61; Long, *supra* note 7, at 525-33; Ottoz & Cugno, *supra* note 61; Maurer & Scotchmer, *supra* note 61; Leibovitz, *supra* note 61.



security of knowing that a competitor could not *copy* their work, but independent parties who happened to create something that infringed a patent would no longer fear retribution. Inventors would also have no obligation to search for patents they potentially were infringing because so long as they were not copying another's work, their inventions would be safe from patent lawsuits.

### **C. Limiting Injunctions and Multiplied Damages for Patent Infringement**

A final reform would be to limit patent remedies for infringement of non-indexable patents to actual damages, rather than permitting injunctive relief and multiplied damage awards.<sup>65</sup> In other words, remedies for patent infringement could be limited to those instantiating “liability rules” rather than “property rules.”

“Property rules” are designed to prevent parties from using another’s asset without permission. In the case of patent law, its property rule system “include[s] injunctions and supercompensatory damages that would make [patent infringement] less attractive than bargaining to a consensual price with the [patent] owner.”<sup>66</sup> In contrast, “liability rules” such as lost profits or a royalty, theoretically allow parties to infringe on another’s patent “so long as . . . officially determined damages are paid. The level of the damages is set to compensate the owner” rather than punish the infringer.<sup>67</sup>

Generally speaking, property-rule remedies are considered beneficial when transaction costs between property holders and those who want to acquire property are low.<sup>68</sup> As Stewart Sterk explains,

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65 Currently, patent infringers may be enjoined from future infringement and made to pay damages in the form of a reasonable royalty or lost profits. *See* 35 U.S.C. § 283 (Courts “may grant injunctions in accordance with the principles of equity to prevent the violation of any right secured by patent, on such terms as the court deems reasonable.”); 35 U.S.C. § 284 (Courts may award “damages adequate to compensate for the infringement, but in no event less than a reasonable royalty for the use made of the invention by the infringer, together with interest and costs as fixed by the court. . . . [T]he court may increase the damages up to three times the amount found or assessed.”).

66 Henry Smith, *Property and Property Rules*, 79 N.Y.U. L. REV. 1719, 1720 (2004).

67 *Id.*

68 Stewart E. Sterk, *Property Rules, Liability Rules, and Uncertainty About Property Rights*, 106 MICH. L. REV. 1285, 1290 (2008) (citing Guido Calabresi & A. Douglas Melamed, *Property Rules, Liability Rules, and Inalienability: One View of the Cathedral*, 85 HARV. L. REV. 1089, 1106-10, 1118 (1972)) (explaining Guido Calabresi and A. Douglas

“Because property rules require all potential users of a resource to buy rights from th[e resource] owner, property rules enable the owner to accumulate information about potential bidders and the values those bidders attach to those rights. As a result, property rules enable resource owners to channel those resources to the bidders who value them most — promoting efficient use of resources.”<sup>69</sup>

But property rules fail to promote the efficient use of resources when transaction costs are high. The combination of very high transaction costs (e.g., the costs of locating a patent holder to negotiate a license with) and punitive legal penalties (e.g., an injunction or multiplied damages for infringement) can prevent beneficial uses of property and waste resources.

Permitting property-rule remedies in patent law is harmful because the discovery costs of locating relevant patents render transaction costs too high for many non-indexable patents.<sup>70</sup> It is not merely costly for potential infringers of non-indexable patents to locate the patents they might infringe — it is completely impracticable. As a result, firms are faced with a *disincentive* to develop new products because of the liability that could result if those products infringed others’ patents. Firms cannot determine *ex ante* what is infringing, but an injunction *ex post* could be crippling. “Once a product or process has been designed in a way that incorporates a patented invention, redesigning the product might require shutdown for retooling. In addition, especially when the patented invention is a small component in the design of a complex product or process, a redesign around the patented invention may take substantial effort . . . .”<sup>71</sup> In this case, a patent owner may then exact enormous licensing fees from an accidental infringer that the infringer would not have agreed to if the infringed

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Melamed observed that “property rules are efficient in cases of low transaction costs, while liability rules are preferable in cases of high transaction costs.”).

<sup>69</sup> Sterk, *supra* note 68, at 1295.

<sup>70</sup> See *id.* at 1296 (“Only if potential resource users know that use of the resource would intrude on someone else’s property right, and can readily identify the owner of that right, will they approach the owner to act as an information clearing-house.”); *id.* at 1304 (“[C]ompared to a liability-rule regime, a property-rule regime creates excessive incentives to search [to determine the scope of one’s legal rights] even when the search costs are high, [and] the probability of encroachment [on another’s right] is relatively low . . . .”); see also *id.* at 1311 (“Because the consequences of using without search are so draconian [in a property-rule regime], the user will often be willing to undertake an expensive search even when the probability of liability is very low.”).

<sup>71</sup> *Id.* at 1333.

patent had been identified in the product development stage.

Eliminating property-rule remedies — specifically eliminating injunctions and multiplied damages — would lessen the disincentives to producers created by the high discovery costs of the patent system.<sup>72</sup> This proposal does not constitute a complete solution: litigation costs would still be high, and potential infringers and patent holders would still dispute the existence of liability and the size of damages. But, it would be a step in the right direction.

A more modest proposal would combine this proposal and the previous one: limit injunctions and multiplied damages to cases where the plaintiff can demonstrate actual copying took place. Under this approach, independent inventors would still be subject to liability for infringement, but their products could not be enjoined and their damages would be limited to a reasonable royalty rate determined by a judge. In contrast, a party caught copying another's invention would be subject to harsher remedies, including injunctions and heightened damages.

## **VI. Conclusion**

The patent system is supposed to promote the progress of science and the useful arts, but in some industries it seems to be doing just the opposite. The sheer number of patents and firms, and the lack of an effective organizational scheme for patents, can mean that patent clearance is practically impossible. In software, for example, patent clearance would require the services of many more patent attorneys than exist in the United States. In short, the patent system doesn't scale.

In practice, software firms don't even try to avoid infringement. Instead they ignore the patent system and hope that if lawsuits arrive, they'll have enough money to afford good patent lawyers.

The fundamental problem is that software inventions are not indexable as chemical inventions

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<sup>72</sup> For a more detailed discussion in favor of awarding non-punitive royalties, see Brian J. Love, *The Misuse of Reasonable Royalty Damages as a Patent Infringement Deterrent*, 74 MO. L. REV. 909 (2009).

are. This means that incremental changes to the patent rules, such as beefing up the novelty and obviousness requirements, are not going to fix the problem. Only dramatic reforms — such as excluding industries with high discovery costs from patent protection, establishing an independent invention defense, or eliminating injunctions — can return the patent system to its proper role of promoting innovation.