

TRADABLE PATENT RIGHTS

Ian Ayres* & Gideon Parchomovsky**

Patent thickets may inefficiently retard cumulative innovation. This Article explores two alternative mechanisms that may be used to weed out patent thickets. Both mechanisms are intended to reduce the number of patents in our society. The first mechanism we discuss is price-based regulation of patents through a system of increasing renewal fees. The second and more innovative mechanism is quantity-based regulation through the establishment of a system of Tradable Patent Rights. The formalization of tradable patent rights would essentially create a secondary market for patent permits in which patent protection will be bought and sold. The Article then discusses how price and quantity regulation can be combined to effect superior weeding.

INTRODUCTION.....	863
I. PATENT THICKETS AND THEIR COSTS.....	867
A. Patent Thickets.....	867
B. The Cost of Patent Thickets.....	869
C. Extant Academic Responses.....	876
II. PRICES V. QUANTITIES.....	877
A. Using Renewal Fees to Weed the Thicket.....	877
B. Should Government Choose the Quantity Instead of the Price?.....	881
C. Regulating Both Price and Quantity.....	889
III. HOW MIGHT A TRADABLE LICENSE SCHEME BE IMPLEMENTED?.....	890
CONCLUSION.....	893

INTRODUCTION

According to a famous academic anecdote, in the 1960s Ronald Coase was invited to participate in a panel discussion on pollution. His copanelists (who since that time have fallen into oblivion) were a radical environmentalist who

* Townsend Professor, Yale Law School.

** Professor, University of Pennsylvania Law School; Visiting Professor, Bar Ilan University, Ramat Gan, Israel.

This Article greatly benefited from comments and criticisms by Avi Bell, Bob Cooter, Adi Eyal, Gery Faulhaber, Jesse Fried, Zohar Goshen, Assaf Hamdani, Mark Lemley, Doug Lichtman, Jacob Nussim, Peter Siegelman, Endre Stevang, Eric Talley, and Polk Wagner. Steven Wu, Anthony Vitarelli, Geoffrey Bauer, Adam Goldfarb, and Adam Banks provided excellent research assistance.

passionately argued that pollution is the worst problem to ever face humanity and an equally extreme conservative who vehemently denied that pollution even exists. When it was Coase's turn to speak, he reportedly slowly turned his head and said, "I am sure that pollution exists, I know that much; what I do not know is whether we have enough of it."¹

A substantially identical question to that which bothered Coase about four decades ago now preoccupies patent theorists. But, unlike Coase, who did not know whether we had *enough* pollution—or, more precisely, enough of the underlying activities from which pollution results—patent scholars seem to believe that we have *too* many patents. Patents are supposed to promote innovation, and virtually all economists agree that "innovation is the main driver of economic growth."² But there is a growing concern that the modern patent system actually chills, not promotes, innovation. In recent years, aggressive filing patterns by private firms and excessively loose standards of review at the United States Patent and Trademark Office (USPTO)³ have combined to produce an unprecedented proliferation of patents.⁴ A particularly disconcerting result of the increase in the number of patents is the emergence of patent thickets: multiple patents that cover a single product or technology.⁵ Patent thickets can be found in several key industries, such as semiconductors, biotechnology, computer software, and the Internet.⁶

Patent thickets are especially harmful in cumulative innovation settings. In such settings, the need to secure licenses from multiple patentees, each

1. One of us heard the story from Bruce Lehmann, a former student of Ronald Coase and currently a professor at the University of California, San Diego, in a presentation he gave at the Business Method Patents and Financial Services conference that was organized by the Federal Reserve Bank of Atlanta in April 2003. The conference program with a link to an outline of Professor Lehmann's presentation is available at <http://www.frbatlanta.org/invoke.cfm?objectid=A6BDAC9C-384A-4C59-9096A079D324A9B7&method=display>.

2. See, e.g., DAVID WARSH, KNOWLEDGE AND THE WEALTH OF NATIONS: A STORY OF ECONOMIC DISCOVERY (2006) (discussing the importance of innovation to economic growth).

3. See, e.g., Robert P. Merges, *As Many as Six Impossible Patents Before Breakfast: Property Rights for Business Concepts and Patent System Reform*, 14 BERKELEY TECH. L.J. 577, 589-90 (1999) (discussing the poor quality of patent applications in terms of the number and nature of prior art references).

4. See U.S. PATENT AND TRADEMARK OFFICE, PERFORMANCE AND ACCOUNTABILITY REPORT: FISCAL YEAR 2003, at 107 (2003); Gideon Parchomovsky & R. Polk Wagner, *Patent Portfolios*, 154 U. PA. L. REV. 1, 17 (2005) ("Notwithstanding the high private cost of patent protection and the relatively low expected value of individual patents, the number of filings in the U.S. (and worldwide) continues to increase."). For more specific discussion that includes figures, see *infra* Part I.

5. The term "patent thicket" probably originated in the 1970s in a series of cases involving Xerox's patents. See Gavin Clarkson, *Objective Identification of Patent Thickets: A Network Analytic Approach* (2004) (unpublished Ph.D. dissertation, Harvard Business School) (on file with author).

6. See Carl Shapiro, *Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard Setting*, in 1 INNOVATION POLICY AND THE ECONOMY 119 (Adam B. Jaffe et al. eds., 2001), available at <http://faculty.haas.berkeley.edu/shapiro/thicket.pdf>.

possessing a veto power over the production of new innovation (1) dramatically increases bargaining costs between patentees and subsequent innovators; (2) creates a potential for hold-ups; and (3) lowers the profits of the original patentees. Patent thickets also harm regular users of patented products and technology by making it more expensive for users to gain access to the relevant product or technology.

Economists and legal scholars have advanced various mechanisms to mitigate the harmful effects of patent thickets. Carl Shapiro has suggested that cross licensing and patent pools can be effective in reducing patent thickets and has called for the relaxation of various antitrust doctrines to accommodate those arrangements.⁷ Other economists, such as Adam Jaffe and Josh Lerner, and legal scholars have focused their search on solutions for the USPTO and recommended various reforms in the standards of patent examination in order to better screen for valid patents.⁸ Finally, Dan Burk and Mark Lemley have called for different application of equitable rules in different industries.⁹ This proposal would lead to a dramatic shortening of patent terms in various industries, which in turn, would reduce the overall number of valid patents.

In this Article, we seek to explore two alternative mechanisms that may be used to weed out patent thickets. Both mechanisms are intended to reduce the number of patents in our society. The first mechanism we discuss is price-based regulation of patents through a system of renewal fees. Renewal fees are already being used in the United States and foreign countries.¹⁰ Empirical studies show that even very modest renewal fees have prompted patentees to abandon patents,¹¹ thereby reducing the number of patents with which subsequent innovators need to contend. The discussion of renewal fees will therefore focus on ways to improve the workings of the existing system.

The second and more innovative mechanism is quantity-based regulation through the establishment of a system of tradable patent rights. The formalization of tradable patent rights will essentially create a secondary market for patent permits in which patent protection will be bought and sold. While this proposal may seem at first radical and far-fetched, it should be borne in mind that a similar system has been implemented in the context of industrial pollution.¹² The introduction of tradable emission permits for sulfur dioxide

7. *Id.*

8. *E.g.*, ADAM B. JAFFE & JOSH LERNER, *INNOVATION AND ITS DISCONTENTS: HOW OUR BROKEN PATENT SYSTEM IS ENDANGERING INNOVATION AND PROGRESS, AND WHAT TO DO ABOUT IT* 171-72, 178 (2004).

9. Dan L. Burk & Mark A. Lemley, *Policy Levers in Patent Law*, 89 VA. L. REV. 1575, 1631-32 (2003); *see id.* at 1578-79 (suggesting that patent law should be tailored to the needs of specific industries).

10. *See* 37 C.F.R. § 2.6 (2007); European Patent Convention art. 86, Oct. 5, 1973, 1065 U.N.T.S. 199.

11. Parchomovsky & Wagner, *supra* note 4, at 14.

12. *See* Bruce A. Ackerman & Richard B. Stewart, *Reforming Environmental Law*, 37 STAN. L. REV. 1333, 1341-42 (1985) (proposing tradable emissions permits as an alternative

(SO₂) in the 1990 Amendments to Title VI of the Clean Air Act resulted in a dramatic improvement in air quality and is viewed by economists and environmentalists alike as a success story. Furthermore, it is widely believed that the use of tradable permits can solve other environmental problems such as depletion of ocean fisheries.¹³ Tradable rights systems induce actors to behave in a more socially desirable fashion by imposing quantity limits and inducing voluntary rights transfers from less efficient to more efficient users.

A similar mechanism may be adopted to reduce the “informational haze” produced by patent thickets. Policymakers can set a cap on the overall number of patents¹⁴—or, more precisely, the overall number of years of patent protection—and institute a system of tradable patent rights. Doing so will induce holders of low-value patents to sell their rights to higher value inventors, thereby improving the efficiency of the entire patent system. Likewise, such a system will prompt new patentees to purchase the right amount of protection. Patentees will be able to acquire one, five, or fifteen years of protection depending on the commercial success of their inventions. Valueless patents will be abandoned, clearing the path for newer, more valuable inventions. Over time, this process will weed out patent thickets, as valueless and low-value patents are relinquished.

Implementation of the proposed solution will effect a dramatic shift in the existing patent system. While patentees will continue to submit their applications to the review of the USPTO, approval will no longer mean an automatic fixed term of twenty years. Instead, successful applicants will need to purchase tradable patent licenses either from the USPTO or on the secondary market and will be able to tailor the protection term to their specific needs.¹⁵ The price of the protection will be determined by the forces of supply and demand, not by administrative fiat.

The remainder of the Article consists of three parts. Part I discusses the burgeoning phenomenon of patent thickets and its adverse effect on innovation. Part II explains how price- and quantity-based regulation may arrest the development of patent thickets. We first assess each of the mechanisms on a stand-alone basis and then consider the possibility of combining them in order to achieve optimal weeding. Part III addresses the issue of implementation by

to command-and-control regulation).

13. See discussion *infra* Part II.B.

14. Admittedly, determining what the cap should be is a difficult task. In this sense, the analogy between industrial pollution and patents is imperfect. In the context of industrial pollution, the cap was set based on careful environmental research. There is no analogous way to determine the desirable quantity of patents. We have not yet figured out a way to measure the optimal level of innovation in our society. In this Article, we use the current level of patent protection, i.e., the total number of patent years, as the baseline cap. Of course, this number might prove too high or too low but over time it may be adjusted through a process of trial and error.

15. See discussion *infra* Part III.

proposing a way to introduce a tradable patent rights regime. A short conclusion follows.

I. PATENT THICKETS AND THEIR COSTS

This Part explores the burgeoning phenomenon of patent thickets and its adverse effect on innovation. It then surveys the academic responses to the problem.

A. Patent Thickets

Recent years have seen a dramatic change in patent scholarship. Traditionally, patent scholarship focused, by and large, on the price effects of patent protection. The main problem theorists noted was that patent protection allowed patentees to engage in supracompetitive pricing, generating a social deadweight loss. This line of analysis suggested that patent protection involves a fundamental tradeoff between dynamic and static efficiency: patents spur innovation but only at the cost of distorted pricing. The normative challenge, therefore, was to design policy mechanisms that would minimize the market power of certain patentees without unduly diminishing research and development (R&D) incentives.¹⁶

Through time, patent theorists gradually turned their attention away from static to dynamic efficiency costs. That is, they adjusted their focus away from the deadweight loss generated by patent protection and shifted it to a different problem: the chilling effect of patents on innovation. The dramatic growth in the number of issued patents has prompted a concern that the modern patent system hinders technological progress, and hence retards dynamic efficiency. In particular, the desire of patentees to build strong patent portfolios, coupled with the poor quality of review by the USPTO and the laxity with which it

16. See, e.g., Michael Abramowicz, *Perfecting Patent Prizes*, 56 VAND. L. REV. 115, 122-24 (2003) (suggesting ways to improve the workings of patent prizes); Ian Ayres & Paul Klemperer, *Limiting Patentees' Market Power Without Reducing Innovation Incentives: The Perverse Benefits of Uncertainty and Non-Injunctive Remedies*, 97 MICH. L. REV. 985, 987 (1999) (proposing a system of probabilistic patents to limit patentees' market power); Michael Kremer, *Patent Buyouts: A Mechanism for Encouraging Innovation*, 113 Q.J. ECON. 1137, 1147-48 (1998) (describing an auction mechanism that allows for the compensation of inventors without creating deadweight loss); Douglas Gary Lichtman, *Pricing Prozac: Why the Government Should Subsidize the Purchase of Patented Pharmaceuticals*, 11 HARV. J.L. & TECH. 123, 124-25 (1997) (explaining how awarding subsidies to users of pharmaceutical drugs can reduce the deadweight loss associated with patent protection); Steven Shavell & Tanguy van Ypersele, *Rewards Versus Intellectual Property Rights*, 44 J.L. & ECON. 525, 525-29 (2001) (discussing the possibility of replacing intellectual property rights with a system of rewards).

grants patents, have dramatically increased the cost of follow-on innovation in our society.¹⁷

Between 1990 and 2003, the number of U.S. filings more than doubled from 176,264 to 366,043, and the number of issued patents grew from 99,077 to 187,015.¹⁸ Importantly, the dramatic rise in the number of filings and patent grants is not fully attributable to greater investments in R&D. Rather, it stems in large part from a conscious effort by firms to maximize the number of patents per R&D dollar.¹⁹ The case of IBM is illustrative. From 1994 to 2003, IBM received a total of 24,685 U.S. patents,²⁰ setting new records for the most U.S. patents received in a single year,²¹ despite the fact that over the same period IBM slashed its research budget.²² As befits an industry leader, IBM set

17. See generally Nancy T. Gallini, *The Economics of Patents: Lessons from Recent U.S. Patent Reform*, 16 J. ECON. PERSP. 131, 147 (2002) (reviewing the literature and suggesting that poorer review standards induce the creation of patent thickets).

18. U.S. PATENT & TRADEMARK OFFICE, U.S. PATENT AND STATISTICS CHART CALENDAR YEARS 1963-2006 (2007), http://www.uspto.gov/web/offices/ac/ido/oeip/taf/us_stat.htm.

19. To be sure, total R&D expenditures have grown even more dramatically in recent years. See SUMIYE OKUBO ET AL., BUREAU OF ECON. ANALYSIS, R&D SATELLITE ACCOUNT: PRELIMINARY ESTIMATES A-30 tbl.4.2 (2006), available at http://www.bea.gov/rd/xls/1959_2002_rd_data.xls (showing a 133% rise in real R&D investment over the period 1990 to 2002). The fact that R&D investment has outpaced growth in patent grants is not inconsistent with the proposition that firms are maximizing patents per dollar. Instead, these data likely also reflect an increase in the cost of R&D. See Joseph A. DiMasi et al., *The Price of Innovation: New Estimates of Drug Development Costs*, 22 J. HEALTH ECON. 151, 168 tbl.4 (2003) (finding an annual increase of 7.4% of drug development costs from 1980-1990). Our point here is that we would expect R&D expenditure growth to outpace growth in patent grants even more in the absence of patent thickets.

20. See Press Release, U.S. Patent & Trademark Office, USPTO Releases Annual List of Top 10 Organizations Receiving Most U.S. Patents (Jan. 12, 2004) (on file with authors); Press Release, U.S. Patent & Trademark Office, USPTO Releases Annual List of Top 10 Organizations Receiving Most U.S. Patents (Jan. 13, 2003) (on file with authors); Press Release, U.S. Patent & Trademark Office, USPTO Releases Annual List of Top 10 Organizations Receiving Most U.S. Patents (Jan. 10, 2002) (on file with authors); Press Release, U.S. Patent & Trademark Office, USPTO Releases Annual List of 10 Organizations Receiving Most Patents (Jan. 10, 2001) (on file with authors); Press Release, U.S. Patent & Trademark Office, IBM Repeats of PTO's Annual List of 10 Organizations Receiving Most Patents (Jan. 11, 2000) (on file with authors); Press Release, U.S. Patent & Trademark Office, IBM Repeats at Top of PTO's Annual List of 10 Organizations Receiving Most Patents (Jan. 8, 1999) (on file with authors); Press Release, U.S. Patent & Trademark Office, USPTO Announces Top Patent Earners (Jan. 12, 1998) (on file with authors); Press Release, U.S. Patent & Trademark Office, USPTO Announces Last Year's Top Patent Earners (Jan. 21, 1997) (on file with authors); Press Release, U.S. Patent & Trademark Office, USPTO Press Release on Top Patent Earners (Jan. 30, 1996) (on file with authors); History of IBM, 1994, http://www-03.ibm.com/ibm/history/history/year_1994.html; see also Parchomovsky & Wagner, *supra* note 4, at 46 n.147.

21. Press Release, IBM, IBM Breaks U.S. Patent Record (Jan. 12, 2004), available at <http://www-03.ibm.com/industries/education/doc/content/news/pressrelease/992547110.html>.

22. See Robert Buder, *Into the Big Blue Yonder*, TECH. REV., July-Aug. 1999, at 48.

the standard for other companies. Realizing the importance of elaborate patent holdings, firms began to seek patents on various aspects of the same product or technology. For example, the technology underlying Adobe's Acrobat Reader 6.0 is protected by as many as forty-one different patents (which you can see scroll by each time the software loads). Worse yet, some companies adopted the practice of "patent flooding," which entails filing dozens, sometimes hundreds, of applications on every conceivable improvement on a broad basic invention patented by a rival company.²³

Responsibility for the explosion of patents does not fall exclusively on patentees; the USPTO also shoulders part of the blame. A careful examination process might have curbed the filing frenzy. Unfortunately, the USPTO's review of patent applications is anything but comprehensive; scholars who studied the USPTO expressed great concern about the quality of review of patent applications by the USPTO. The main findings were that the USPTO is both underfunded and understaffed. On average, patent examiners spend only eighteen hours on each application. Moreover, due to the reward structure in the USPTO, examiners have a clear financial incentive to approve applications they review. As a result, dubious applications that should have been rejected often pass muster with the USPTO.²⁴ Overwhelmed by the rising tide of filings, the USPTO has failed to perform adequately its gatekeeping duties and thereby contributed to the proliferation of patents.

B. *The Cost of Patent Thickets*

The proliferation of patents is not without a cost. The aggressive pursuit of patents over any innovation, large or small, has given rise to the phenomenon of "patent thickets." A patent thicket occurs when a technology or a product is covered by multiple patents that are often held by numerous patentees.²⁵ To see why patent thickets chill innovation, it is first necessary to understand the nature of technological progress. Innovation in most technological sectors is a cumulative process. As Joseph Stiglitz observed, "[W]e have an innovation system in which one innovation builds on another."²⁶ In our system, new inventors have the benefit of the insights made by their predecessors. But

23. This practice was common in Japan. Sri Krishna Sankaran, *Patent Flooding in the United States and Japan*, 40 IDEA 393, 393-94 (2000).

24. See, e.g., U.S. Patent No. 5,960,411 (filed Sept. 12, 1997) (claiming one-click online shopping); U.S. Patent No. 6,289,319 (filed Nov. 30, 1994) (claiming online credit card payments); U.S. Patent No. 5,715,314 (filed Oct. 24, 1994) (claiming online shopping carts).

25. Shapiro, *supra* note 6, at 119. Shapiro defines a patent thicket as "a dense web of overlapping intellectual property rights that a company must hack its way through in order to actually commercialize new technology." *Id.* at 120.

26. *Hearings on Global and Innovation-Based Competition Before Fed. Trade Comm'n*, Case No. P951201 (1995), available at <http://www.ftc.gov/opp/global/GC101295.shtm>.

enlightenment comes at a price. Patents confer on their holders property rule protection, namely, the power to exclude others from the underlying invention. Any person who wishes to improve upon a patented invention must either secure permission from the patentee or risk harsh consequences.

In a sense, the problems created by patent thickets are not completely new. The patent system grants property rights to patent holders, allowing them to prevent the use of their patent by future innovators. In the past, overbroad patents held by a single individual have had the effect of stifling innovation. For example, in 1895 George Selden was issued a patent for his "Road Engine,"²⁷ which included the already common concept of placing a gasoline engine on a chassis to create a car. Selden's patent was enforced against upstart automakers for sixteen years before being narrowed by a court, and the patent stifled the production and development of automobiles during that time.²⁸ Selden's vigorous enforcement strategy demonstrates the power that a single, well-situated patent holder can exercise over the development of an entire industry. The modern patent thicket phenomenon has the potential to grant that same power to many different patent holders, all of whom may control exclusive rights to integral pieces of innovation. Patent thickets already pervade several key industries in our economy, including biotechnology,²⁹ nanotechnology,³⁰ computer software, and the Internet.³¹

Computer software and the Internet have suffered the most so far. Computer programming has very low barriers to entry when compared to traditional businesses and especially high-tech fields like nanotechnology or biotechnology. Major developments in computer science often occur quickly and are spearheaded by heretofore unknown businesses with relatively little capital.³² The software industry also tends to progress on an incremental and cumulative basis;³³ it is rare and expensive to develop completely original software. Additionally, the USPTO has become more willing to grant patents

27. U.S. Patent No. 549,160 (filed May 8, 1879) (issued Nov. 5, 1895).

28. FED. TRADE COMM'N, TO PROMOTE INNOVATION: THE PROPER BALANCE OF COMPETITION AND PATENT LAW AND POLICY 3 (2003), available at <http://www.ftc.gov/os/2003/10/innovationrpt.pdf>.

29. See *id.*, ch. 3, at 29 (concluding that the proliferation of biotechnology patents may hinder future innovation).

30. Since most nanotechnology is not yet commercially viable, there has not been significant litigation regarding overlapping patents so far. However, the pattern of patenting in nanotechnology closely resembles other fields that are experiencing patent thickets, and some commentators fear that it is only a matter of time before the issue arises in nanotechnology. See, e.g., Liz Gannes, *Nanotech Patents Proliferate*, RED HERRING, Apr. 20, 2005, <http://www.redherring.com/Home/11866>.

31. See Shapiro, *supra* note 6, at 120-21.

32. The success stories of Microsoft and Google are two of many such examples in the software field.

33. FED. TRADE COMM'N, *supra* note 28, ch. 3, at 44-45.

for “business methods,” which often incorporate simple ideas already in widespread use and are difficult to invent around or otherwise avoid.³⁴

As a result, many software companies find it next to impossible to operate without some form of patent infringement. One member of the software industry undertook a search for existing patents relevant to his business and identified 120 that appeared to overlap and upon which his company was infringing.³⁵ Others have been reluctant to even undertake such a search, for fear that knowledge of the existing patents would leave them open to willfulness claims and significantly increased damages in the event of future litigation.³⁶

The situation in the semiconductor industry is not much better. As Jaffe and Lerner report: “The problem with patents in this industry is that there is so much overlap among the technologies developed by different companies that it is difficult to bring any product to market without potentially infringing patents held by other companies.”³⁷

When a technology is covered by multiple patents, the improver “must hack its way through [the patent thicket] in order to actually commercialize new technology.”³⁸ In this case, an improver must obtain permission from all relevant patentees. Alternatively, the improver can try to invent around all the relevant patents and thereby avoid the need to negotiate permissions. Finally, the improver can ignore all pre-existing patents, go ahead and commercialize her innovation, and expose herself, ex post, to multiple patent infringement suits.³⁹

Securing permission from all relevant right holders involves two types of costs: information costs and negotiation costs. To secure the licenses necessary to produce the improvement, an improver must first obtain information about all blocking patents and their holders. In other words, she must identify the relevant patents that comprise the thicket and determine who owns them. This would require the improver to pore over numerous patents, determine their validity, and assess their scope. Since the language of patent claims is often technical and vague, the foregoing tasks may require the hiring of one or more

34. See Shapiro, *supra* note 6, at 120-21. These “business method” patents have gone as far as to include a patent granted to Sightsound.com for the sale of downloadable music or video over the Internet. *Id.*

35. FED. TRADE COMM’N, *supra* note 28, ch. 3, at 52; cf. James Bessen & Robert M. Hunt, *An Empirical Look at Software Patents* 4 (Fed. Reserve Bank of Phila. Working Papers Research Dep’t, Working Paper No. 03-17/R, 2004) (reporting that the increase in patent filings in the software industry is positively correlated with a decline in investment in R&D). But see Ronald J. Mann, *Do Patents Facilitate Financing in the Software Industry?*, 83 TEX. L. REV. 961, 999-1009 (2005) (suggesting that intense patenting in the industry does not stifle research and that patents actually help small firms).

36. FED. TRADE COMM’N, *supra* note 28, ch. 3, at 49.

37. JAFFE & LERNER, *supra* note 8, at 59.

38. Shapiro, *supra* note 6, at 120.

39. *Id.* at 125.

legal or technical experts. Unfortunately, even a very careful review of all issued patents would not completely protect the intended innovator from the threat of infringement suits because many pending patent applications are not available to the public. The USPTO publishes patent applications eighteen months after their filing,⁴⁰ and until that time the public is kept in the dark about their content. As a result, regardless of their investment in information, follow-on innovators are always exposed to some risk of inadvertent infringements.

After reviewing all publicly available patents, the improver can either negotiate licenses from the owner or design around the pre-existing patents. Consider the negotiation option first. As Carl Shapiro has pointed out, patent thickets present a classic complements problem.⁴¹ Since each patent holder has a property right in a key input and the improver needs to produce her innovation, the improver must purchase licenses from all the patent holders. Each patent holder may thus be viewed as a monopolist who controls an input necessary for the production of the improvement.

Even if one sets aside for the moment the problem of strategic behavior, a simple numeric example can illustrate how the need to secure multiple licenses can stifle follow-on innovation. Suppose that a follow-on innovator contemplates a new product that is expected to yield a profit of \$500, net of R&D costs. To produce the product, the innovator must invest \$120 to search for pre-existing patents and then secure licenses from twenty different patentees. The cost of every negotiation process is \$5, and the license fee is \$15. Given that the cost of securing the necessary permissions (\$520) exceeds the expected return on the investment (\$500), the cumulative innovation will not be produced and society will be deprived of a valuable product.

Worse yet, when a manufacturer must purchase two key inputs from two different monopolists, the resulting price would be higher than the price that would prevail if the two inputs were controlled and sold by a single monopolist firm. Shapiro posits that this same double-markup problem applies “when multiple companies control *blocking patents* for a particular product, process, or business method.”⁴² Hence, cumulative innovators who face a patent thicket will pay higher license fees. On the margin, the higher fees may not leave enough profits to justify the investment in the innovation.

Finally, economic theory predicts that negotiations between cumulative innovators and patentees will be plagued by holdout problems. Each patent holder can block the new innovation by withholding consent and thus can ask for the entire expected value of the new innovation in exchange for her consent. Furthermore, due to information asymmetries, the asking price of patentees

40. See 35 U.S.C. § 122(b)(1)(A) (2000) (requiring the PTO, subject to a few narrow exceptions, to publish a patent application eighteen months after its filing date).

41. Shapiro, *supra* note 6, at 123.

42. *Id.* (emphasis added).

may be higher than the actual value of the innovation. If the cumulative innovator cannot invent around any of the relevant patents, even one holdout case is sufficient to stop the new innovation from being produced.

The holdout problem generated by patent thickets is a mere instance of a general problem in property theory. As Michael Heller pointed out, when multiple, dispersed property rights cover a resource, the resource will be underused.⁴³ In a subsequent contribution, Heller and Rebecca Eisenberg applied that basic insight to biotechnological research. They argued that the proliferation of blocking patents in that area causes underuse of basic research findings and generates “a tragedy of the anticommons.”⁴⁴

The problem of patent thickets also explains why the proliferation of even relatively low-value patents imposes social costs. One might initially suppose that the proliferation of patent grants is unproblematic because only a small fraction of patents have any significant social economic value.⁴⁵ Since most patents are worthless, you might think that no one would bother to infringe. But the patent thicket argument shows that even probabilistically worthless patents can do social harm. Low-value patents in the midst of a patent thicket can still stifle future innovation. An improver must innovate around a blocking patent or negotiate with its holder even if the patent, standing alone, has no economic value.⁴⁶ Moreover, the possibility of holdout creates incentives for inventors to obtain and maintain blocking patents that have low intrinsic value for the purpose of positioning themselves to take advantage of negotiations with future innovators. These blocking patents thus remain obstacles to future innovation and impose social costs despite their low economic value.

Renewal fees or the cost of acquiring tradable patent permits can usefully weed the thicket of blocking patents. Imagine in the foregoing example that the twenty patents were initially acquired solely for their blocking potential, and at the time of initial acquisition their blocking potential varied from five to ten percent. Renewal fees will not deter acquisition of patents with sufficiently high probability of blocking. If there is a 100% chance that patenting today will give rise to a subsequent licensing fee from a follow-on innovator, the initial inventor is still likely to patent even if the only profit is from a blocking license. But renewal or permit fees will deter the low-probability or marginal patents. An initial patentee with only a five or ten percent chance of being paid

43. Michael A. Heller, *The Tragedy of the Anticommons: Property in the Transition from Marx to Markets*, 111 HARV. L. REV. 621, 622-23 (1998).

44. Michael A. Heller & Rebecca S. Eisenberg, *Can Patents Deter Innovation? The Anticommons in Biomedical Research*, 280 SCIENCE 698, 698 (1998).

45. See Mark A. Lemley, *Rational Ignorance at the Patent Office*, 95 NW. U. L. REV. 1495, 1507 (2001) (estimating that only five percent of issued patents are licensed for a royalty); see also Steven C. Carlson, Note, *Patent Pools and the Antitrust Dilemma*, 16 YALE J. ON REG. 359, 385 (1999) (“Most infringed patents are not worth defending in court . . . Even in the pharmaceutical industry, where patents are most valuable, eight out of ten patents typically produce no value for their holders.”).

46. See Shapiro, *supra* note 6, at 120.

by a follow-on innovator will be much less likely to pay the price of the renewal or permit fee. The follow-on innovator (and society) wins because the costs of negotiation and failed holdouts are reduced.

While economists and legal scholars debate the prevalence of holdouts in actual cumulative innovation settings,⁴⁷ it should be noted that even if in the real world patentees rarely stop cumulative innovators dead in their tracks by withholding consent, the potential for holdouts increases transaction costs for cumulative innovators. Depending on the profit margin, this increase may cause the cumulative innovator to forego the new innovation. Furthermore, the potential for holdouts may deter innovators from assaying to produce the new innovation.

Instead of negotiating with multiple patentees, cumulative innovators can try to invent around the patent thicket. In many cases, however, inventing around may prove impossible or as costly as negotiating. First, while inventing around substitutes for negotiation, it does not lower information costs. Inventing around requires a careful study of the patents around which the new innovation is to be designed. Second and more importantly, it would often be impracticable or not cost-effective to invent around patent thickets. Inventing around a patent thicket would often require a new technological or conceptual breakthrough that most innovators are incapable of achieving.⁴⁸

Of course, cumulative innovators can adopt a mixed strategy of inventing around certain patents while licensing others. It is far from clear, however, that this mixed strategy would improve their lot. To begin with, the need to negotiate reintroduces the potential for holdouts. Moreover, the combined cost of inventing around and negotiating may render the new innovation unworthy of commercializing. Finally, in contrast to licensing, inventing around a patent leaves cumulative innovators exposed to the risk of litigation. Litigation may arise either because the effort to invent around was not completely successful

47. For articles suggesting that the problem is very real and acute, see, for example, Shapiro, *supra* note 6; Gregory J. Glover, *Patent Thickets and Innovation Markets Reviewed*, 26 NAT'L L.J., Oct. 14, 2002, at C10; Heller & Eisenberg, *supra* note 44; Bessen & Hunt, *supra* note 35; James Bessen, *Patent Thickets: Strategic Patenting of Complex Technologies* (Research on Innovation, Working Paper No. 0401, 2004); Robert Hunt, *When Do More Patents Reduce R&D?* (Fed. Reserve Bank of Phila. Working Papers Research Dep't, Working Paper No. 06-6, 2006). For the opposite view, see Richard A. Epstein, *Steady the Course: Property Rights in Genetic Material*, in PERSPECTIVES ON PROPERTIES OF THE HUMAN GENOME PROJECT 153, 166-68 (F. Scott Kieff ed., 2003); and John P. Walsh, Ashish Arora & Wesley M. Cohen, *Effects of Research Tool Patents and Licensing on Biomedical Innovation*, in PATENTS IN THE KNOWLEDGE-BASED ECONOMY 285, 285 (Wesley M. Cohen & Stephen A. Merrill eds., 2003).

48. *But see* Peter Lee, Note, *Patents, Paradigm Shifts, and Progress in Biomedical Science*, 114 YALE L.J. 659, 663 (2004) ("By raising the cost of 'doing science' within an established paradigm, however, patents encourage scientists to create alternate theories of how natural phenomena operate, theories whose investigation does not depend on using patented research tools.").

or because of strike suits by opportunistic patentees who enjoy relative cost advantages in litigation.

Kodak's attempt to invent around Polaroid's patent provides a striking example of the risk inherent in this strategy. For years, Polaroid controlled the instant camera market. In order to solidify its market position the firm acquired multiple patents on its inventions. In 1969 Kodak decided to enter the instant camera market. Kodak consciously decided that it would not infringe any of Polaroid's patents. To this end, Kodak worked closely with its patent attorney in order to develop a technology that gets around Polaroid's patents. After years of preparations, in 1986 Kodak entered the market. A week later it was sued by Polaroid for multiple patent infringements. The legal battle between the two companies took years and ended tragically for Kodak. Despite its best efforts, Kodak was held liable for seven patent infringements. The court issued an injunction against the company, forcing it to shut down its plant and lay off employees, which Kodak had argued would cause the company to lose hundreds of millions of dollars.⁴⁹

In principle, cumulative innovators have another option still: they can simply ignore all blocking patents, commercialize the new innovation, and deal with infringement suits after the fact. This option is the least desirable of all. By sinking money into the commercialization of an infringing product, the cumulative innovator only makes herself an easier prey for patent holders. After an innovation has been commercialized and put to a large-scale production, patentees can seek far greater royalty fees by threatening to shut down production.⁵⁰ Hence, only cumulative innovators who can fend off litigation may consider adopting this course of action. Most cumulative innovators, however, cannot afford to take the risk.⁵¹

The adverse effects of patent thickets are not limited to follow-on innovators. Patent thickets also lower the returns of the patentees whose patents compose the thickets. Complementary monopolies not only raise prices for downstream manufacturers but also lower the profits of the monopolists themselves.⁵² In cumulative innovation settings, this result is not surprising. Patentees' return on innovation depends in part on the licensing fees they collect from follow-on innovators and consumers. As we explained, when a technology or a product gets entangled in a patent thicket, the cost of using it goes up and licensing fees go down. Consequently, the emergence of a patent

49. JAFFE & LERNER, *supra* note 8, at 113-14.

50. The threat is credible in this case as injunctive relief is a standard remedy for patent infringement. *See id.* at 111 ("Perhaps the most dramatic way in which the [Federal Circuit] has strengthened the remedies available to patentees is the availability of preliminary injunctive relief.").

51. For an analysis of litigation trends in patent law, see Parchomovsky & Wagner, *supra* note 4, at 63-64.

52. Shapiro, *supra* note 6, at 123.

thicket might prevent original patentees from recouping their investment in innovation. Thus, patent thickets put a drag on all levels of innovation.

Finally, patent thickets also harm users of patented products and technologies. Not only do patent thickets raise the cost of certain patented products and technologies to consumers but they also create uncertainty as to the legal rights in such products and technologies. When a technology is covered by a single patent, the licensor is readily identifiable. When, on the other hand, a technology is covered by multiple patents that are held by multiple patentees, potential users find themselves in a bind. They can either try to navigate the patent thickets in an attempt to sort out which patentees should be contacted or simply obtain licenses from all the patentees who staked a claim to the technology. Per our earlier discussion, it should be clear that either option implicates a considerable cost.

C. Extant Academic Responses

The problem of patent thickets has not escaped the attention of theorists. Academics have proposed several ways to mitigate the harm occasioned by patent thickets. As always, these proposals may be divided into two broad categories: ex post solutions and ex ante solutions. Generally, the ex post solutions contemplate various transactional mechanisms that would induce more cooperative behavior and sharing of patent rights. In an influential article, Shapiro argued that cross licensing and patent pools are “natural and effective methods . . . to cut through the patent thicket.”⁵³ Accordingly, he recommended that our antitrust laws be relaxed to accommodate these currently illegal arrangements.⁵⁴

The ex ante solutions, by contrast, focus on the need to change the process and standards by which patents are granted. Perturbed by the ease with which patents are granted, some scholars have argued for a substantive reform of the USPTO and the introduction of a more rigid examination process. In a recent article, Dan Burk and Mark Lemley proposed a different mode of intervention that targets patent terms. In particular, they called for the abolition of the current uniform protection term and its replacement with a differential protection term that is tailored to specific industry needs. Accordingly, software patents will receive a relatively short protection term while pharmaceutical

53. *Id.* at 119.

54. *Id.*; see also Robert P. Merges, *Institutions for Intellectual Property Transactions: The Case of Patent Pools*, in EXPANDING THE BOUNDARIES OF INTELLECTUAL PROPERTY: INNOVATION POLICY FOR THE KNOWLEDGE SOCIETY 123 (Rochelle Cooper Dreyfus et al. eds., 2001); Peter C. Grindley & David J. Teece, *Managing Intellectual Capital: Licensing and Cross-Licensing in Semiconductors and Electronics*, CAL. MGMT. REV., Winter 1997, at 8; Josh Lerner, Jean Tirole & Marcin Strojwas, *Cooperative Market Agreements Between Competitors: Evidence from Patent Pools* (Nat'l Bureau of Econ. Research, Working Paper No. 9680, 2003).

patents will get a longer protection term. But while the protection term will vary among industries (or technological sectors), all patents in the same industry will receive the same protection term.⁵⁵

In the remainder of the Article, we wish to contribute to the burgeoning academic exchange by examining two alternative methods of intervention that can help thin patent thickets. The first is regulation of patent “prices” through a system of patent renewal fees; the second is quantity-based regulation that seeks to establish a market for patents through the introduction of tradable patent rights (TPRs).

II. PRICES V. QUANTITIES

Part I established the case for weeding out patent thickets. This Part asks: what is the best means of reducing the number of patents that are in effect? Perhaps the most obvious means of reducing the number of patents would be to heighten the requirements for patentability—for example, requiring more in the way of non-obvious improvement over the prior art.⁵⁶ But instead of relying on the judgments of patent examiners *ex ante* or judges *ex post*, it is possible to economize on the private information of the patentees to weed out the patents that are expected to have the least value. We first discuss how a system of renewal fees could accomplish such weeding. The current system of renewal fees that is in place in virtually all countries already accomplish some weeding by shortening the practical life of a majority of all issued patents. We then turn to the question of whether a system of tradable permits might accomplish the weeding in a more efficient manner.

A. Using Renewal Fees to Weed the Thicket

While many think of patents as having a fixed twenty-year term, the reality is that patentees have to repeatedly pay renewal fees to keep their patents effective over the full twenty years. These “maintenance” or “renewal” fees are required in virtually every country. The United States requires patentees to pay maintenance fees at three different points during the twenty-year term if they wish to preserve the validity of their patent:

Three and a half years after issuance, a patentee must pay \$900 or the patent will expire at the four year point. Seven and a half years after issuance, the patentee must pay \$2,300 or the patent will expire at the eight year point, and eleven and a half years after issuance, the patentee must pay \$3,800 or the

55. See Burk & Lemley, *supra* note 9, at 1634, 1638-40.

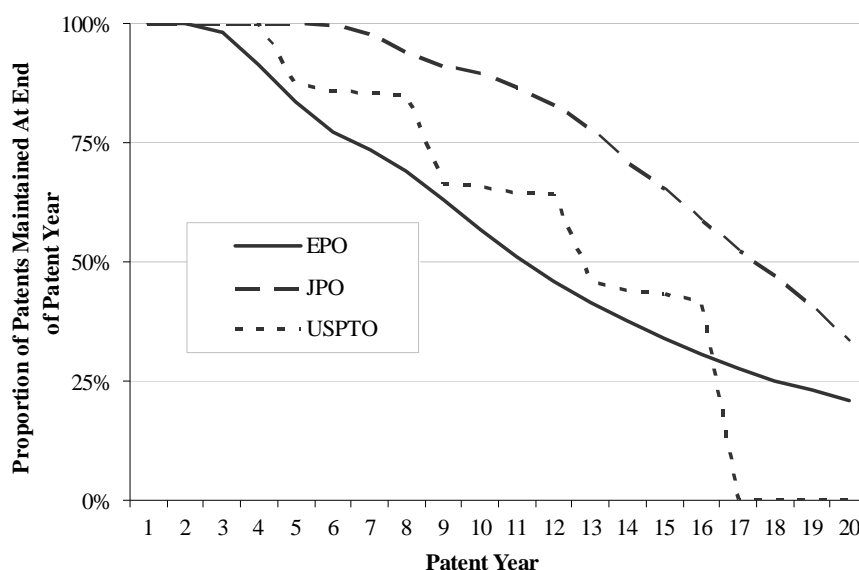
56. See, e.g., John H. Barton, *Non-Obviousness*, 43 IDEA 475, 492 (2003) (suggesting that the non-obviousness standard should be raised in certain industries); cf. Robert M. Hunt, *Nonobviousness and the Incentive to Innovate: An Economic Analysis of Intellectual Property Reform* 37-38 (Fed. Reserve Bank of Phila. Research Dep’t, Working Paper No. 99-3, 1999) (proposing different non-obviousness standards for different industries).

patent will expire at the twelve year point. Even though there is a uniform patent term for all patents (twenty years from the date of the application), renewal fees create a de facto differentiation in patent terms.⁵⁷

As economist Ariel Pakes long ago observed, a patentee can be seen as having an option to tailor the duration of the patent length.⁵⁸

In other countries, the payment of renewal fees tends to occur annually. For example, a twenty-year European patent has renewal fees that have to be paid from the third patent year onwards to maintain protection. A twenty-year Japanese patent has the first three year's renewal fees paid together, and for subsequent annual fees, "the applicant can pay either yearly or in advance."⁵⁹

Figure 1. Maintenance of Patents Granted by Trilateral Offices



The fees are relatively small and tend to be calibrated to covering some of the costs of operating the respective country's patent offices.⁶⁰ In Japan, for

57. Kimberly A. Moore, *Worthless Patents*, 20 BERKELEY TECH. L.J. 1521, 1525-26 (2005) (citations omitted); see 37 C.F.R. § 1.20(e)-(g) (2007). The maintenance fees for small entities are half these amounts. *Id.* If a patent expires due to non-payment of maintenance fees, it can be reissued within twenty-four months if the patentee pays a surcharge of \$700 or \$1640 and convinces the USPTO that the late payment was unavoidable or unintentional. See 37 C.F.R. § 1.378 (2003); *id.* § 1.20(h). The United States did not charge maintenance fees prior to 1982.

58. Ariel Pakes, *Patents as Options: Some Estimates of the Value of Holding European Patent Stocks*, 54 ECONOMETRICA 755, 756 (1986).

59. TRILATERAL CO-OPERATION, TRILATERAL STATISTICAL REPORT: 2005 EDITION 39 (2006), available at http://www.trilateral.net/tsr/tsr_2005/tsr2005.pdf.

60. See Joshua S. Gans, Stephen P. King & Ryan Lampe, 4 TOPICS IN THEORETICAL ECON. 1 (2004), available at <http://www.bepress.com/bejte/topics/vol4/iss1/art6>.

example, the renewal fees for the fourth to the sixth year are only \$74 plus \$5.48 per patent claim; for the seventh to ninth year, they are \$222 plus \$17.36 per claim. For the tenth to the twentieth year, they are \$742 and \$58.49 per claim.⁶¹

Nonetheless, these rather modest renewal fees have been quite successful in reducing the effective life of patents. Figure 1 shows that a large proportion of granted patents in the United States, Europe, and Japan are not maintained for their entire twenty-year life.⁶²

In the United States, more than 50% of all patents are not maintained after fourteen years. The median life of European patents is twelve years, and the median life for Japanese patents is just nine years. At the end of twenty years, less than 10% of European and Japanese patents and less than 40% of U.S. patents are still in effect.⁶³

The impact of the rather modest renewal fees on effective patent life has been exploited by economists in a number of ways. Empiricists have used the willingness of patentees to exercise (or not exercise) their continuation options to estimate the distribution of patent values—or more precisely, the distribution of values for patent protection.⁶⁴ Since, as noted previously, even these modest renewal fees cause most patentees to relinquish their patents, it is not surprising that the median value of patents (or more precisely, of patent protection) is often estimated to be less than \$10,000.⁶⁵ These numbers have also been used to produce better estimates of the number of patents that are in effect, as well as “value-weighted” patent counts.⁶⁶ An analysis of renewal rates can therefore

61. See Japan Patent Office: Schedule of Fees, http://www.jpo.go.jp/tetuzuki_e/index.htm. These prices derive from fees listed in Yen by the Japan Patent Office using the November 12, 2007, exchange rate of \$1 to ¥109.42.

62. This figure is reproduced from TRILATERAL CO-OPERATION, TRILATERAL STATISTICAL REPORT: 2006 EDITION 41 fig.4.8 (2007), available at http://www.trilateral.net/tsr/tsr_2006/tsr_2006.pdf. The underlying data is available at http://www.trilateral.net/tsr/tsr_2006/annex/2006_web_annex.xls.

63. *Id.*

64. See, e.g., Ariel Pakes & Mark Schankerman, *The Rate of Obsolescence of Patents, Research Gestation Lags, and the Private Rate of Return to Research Resources*, in R & D, PATENTS, AND PRODUCTIVITY 73, 73-74 (Zvi Griliches ed., 1984); Jean Olson Lanjouw, *Patent Protection in the Shadow of Infringement: Simulation Estimations of Patent Value*, 65 REV. ECON. STUD. 671, 671 (1998); Pakes, *supra* note 58, at 755; Mark Schankerman, *How Valuable Is Patent Protection? Estimates by Technology Field*, 29 RAND J. ECON. 77, 77 (1998); Mark Schankerman & Ariel Pakes, *Estimates of the Value of Patent Rights in European Countries During the Post-1950 Period*, 96 ECON. J. 1052, 1052 (1986); Jean O. Lanjouw, Ariel Pakes & Jonathan Putnam, *How to Count Patents and Value Intellectual Property: Uses of Patent Renewal and Application Data* (Nat'l Bureau of Econ. Research, Working Paper No. 5741, 1996).

65. Schankerman, *supra* note 64, at 93 (concluding that the median private value of patent rights, in 1980 dollars, amounted to only \$1631 in the pharmaceutical industry, \$1594 in the chemical field, \$2930 in the mechanical field, and \$3159 in electronics, excluding Japan).

66. See Lanjouw et al., *supra* note 64.

allow us to make progress on the problem that Mark Lemley and Kimberly Moore have noted:

While we can calculate the number of patents filed before June 8, 1995 which have yet to expire due to term end, and can therefore get an idea of the maximum number of potentially enforceable patents (1,300,000), we cannot calculate the exact number that are still enforceable or the number of potential submarine patents in that group.⁶⁷

Economic theorists in the last decade have also made progress modeling the potential beneficial uses of renewal fees as a policy tool. Articles by Suzanne Scotchmer and by Francesca Cornelli and Mark Schankerman have shown how a patent system with renewal fees can economize on the private information of patentees.⁶⁸ Cornelli and Schankerman, for example, have shown that a renewal fee system can give patentees with more productive opportunities the incentive to invest more in R&D.⁶⁹ Moreover, their model suggests how the current structure of patent renewal fees should be modified. The current structure imposes a regressive tax on patentee profits: low-value patentees who abandon their patents early, end up paying more than 50% of their profits as renewal fees, whereas high-value patentees who maintain their patents for the full term, end up paying less than 5% of their profits as renewal fees. Cornelli and Schankerman estimate that an optimal structure of patent renewal fees should have a progressive character: taxing less than 3% of profits for patents that are low value (and cancelled early), but taxing more than 8% of expected profits for high-value patents that are renewed to last the entire twenty-year term.⁷⁰

This first generation of articles models static innovation, in which only one person has a potential idea (no patent races), and there is no possibility of follow-on innovation. The latter point especially distinguishes their analyses from the prior Subpart's argument about the potential usefulness of weeding the patent thicket so that subsequent inventors retain some room to operate. But the fact that these articles see the possibility for more rapidly rising renewal fees in models without the "thicket" problem suggests to us that weeding strategies may be even more appropriate when we take into account the problems of follow-on investment.

67. Mark A. Lemley & Kimberly A. Moore, *Ending Abuse of Patent Continuations*, 84 B.U. L. REV. 63, 84 n.81 (2004).

68. Francesca Cornelli & Mark Schankerman, *Patent Renewals and R&D Incentives*, 30 RAND J. ECON. 197, 197-98 (1999); Suzanne Scotchmer, *On the Optimality of the Patent Renewal System*, 30 RAND J. ECON. 181, 181 (1999).

69. Cornelli & Schankerman, *supra* note 68, at 198 ("[D]ifferentiated patent lives can be welfare improving because of an 'incentive effect': allowing firms with high R&D capabilities to choose longer patent lives gives these firms an incentive to invest more R&D resources.").

70. *Id.* at 208 fig.3.

B. *Should Government Choose the Quantity Instead of the Price?*

While renewal fees certainly have reduced the number of patents that are in effect over time, this same effect could be accomplished by a license system in which the number of licenses that were in effect was limited and patentees had to acquire a patent as well as a license in order to have an effective patent.

The concept of tradable permits has long been a favorite of economists and has begun to gain traction with policy makers and academics. A tradable permit system can lead to the more efficient allocation of resources by allowing resources to flow to their highest value users. Such market-based systems have been implemented successfully in several arenas, most notably in air pollution control and in commercial fishing licenses.

Title IV of the the 1990 amendments to the Clean Air Act included a national tradable permit system for SO₂ emissions.⁷¹ Permits are granted to producers of SO₂ based on their prior production levels, and at the end of each year, each producer must hold enough permits to cover their emission of SO₂. Additional permits may be banked (or carried over) for the next year or sold to other producers or third parties.⁷² This tradable system allows for companies who can reduce their emissions at low cost to sell their excess SO₂ permits to companies who bear a higher cost of reduction. In the fifteen years since this system was put into place, there is evidence that it has been highly effective: SO₂ emissions were reduced by nearly thirty percent beyond the required level, and compliance with the program has been almost perfect.⁷³ Additionally, the tradable permits program has been estimated to create a cost saving of sixteen to twenty-five percent relative to a uniform emissions standard for SO₂.⁷⁴ These cost savings are less than some supporters hoped for when a market-based permit program was first proposed,⁷⁵ but the program has generally been considered a success.

Commercial fishing is a second industry that has benefited from the use of tradable permits. Commercial fishing is a textbook tragedy of the commons problem, in which every fisherman has the incentive to catch as many fish as possible, thereby leading to overfishing. This drives down prices in the marketplace and reduces the stock of fish in the wild, leading to endangerment or even extinction of certain species of fish. An estimated seventy percent of the world's fish species are now either fully exploited or depleted, and intense

71. EXECUTIVE OFFICE OF THE PRESIDENT, ECONOMIC REPORT OF THE PRESIDENT 122 (2005).

72. U.S. ENVTL. PROT. AGENCY, PROGRESS REPORT ON THE EPA ACID RAIN PROGRAM 3 (1999), available at <http://www.epa.gov/airmarkets/progress/docs/1999report.pdf>.

73. EXECUTIVE OFFICE OF THE PRESIDENT, *supra* note 71, at 122.

74. Nathaniel O. Keohane, *What Did the Market Buy? Cost Savings Under the U.S. Tradeable Permits Program for Sulfur Dioxide* 23 (Yale Ctr. for Envtl. Law and Policy, Working Paper No. ES-33, 2003), available at http://ssrn.com/abstract_id=465320.

75. *Id.* at 22-23 (noting that prior estimates anticipated even greater cost savings).

competition for the remaining fish creates economic waste.⁷⁶ The traditional government response to overfishing has been intense regulation of many aspects of the fishing industry, which has proven costly to enforce and still provides incentives for fishermen to search for loopholes and increase their own catch.⁷⁷

In response to these continuing problems, new programs of transferable fishing quotas granted to individual fishermen have been adopted by several countries, including New Zealand, Iceland, Australia, Canada, and Papua New Guinea.⁷⁸ Much like the pollution permits, these fishing licenses are fully tradable and ensure that fishing rights flow to those fishermen who can use them most effectively. Moreover, the programs allow the government to maintain a strict control on the quantity of fish being caught, thereby preventing overfishing. This program has been especially successful in New Zealand, where fish stocks are now healthier and there is evidence of increased profitability among fishermen.⁷⁹

The successes of tradable permit programs in air pollution control and commercial fishing have led to proposals for tradable permits in many other fields. Market-based permit concepts are available in fields as widely divergent as milk production in Canada,⁸⁰ red deer hunting in Scotland,⁸¹ and even wildlife conservation.⁸² As tradable permits become more common in different fields of government action, it is only natural to consider their extension into patent protection, which is the concern of this Article.

But would a system of tradable patent licenses be superior to a renewal-fee system? This is a classic “prices vs. quantities” question that has arisen in a variety of other contexts.⁸³ Martin Weitzman, in his classic article, *Prices vs. Quantities*, noted:

76. EXECUTIVE OFFICE OF THE PRESIDENT, *supra* note 71, at 123.

77. *Id.* at 124.

78. *Id.*

79. *Id.* at 124-25.

80. See Kevin Chen & Karl Meilke, *The Simple Analytics of Transferable Production Quota: Implications for the Marginal Cost of Ontario Milk Production*, 46 CAN. J. AGRIC. ECON. 37 (1998).

81. See Douglas MacMillan, *Tradeable Hunting Obligations—A New Approach to Regulating Red Deer Numbers in the Scottish Highlands?*, 71 J. ENVTL. MGMT. 261, 261 (2004).

82. See Ricardo Bayon, *A Bull Market in . . . Woodpeckers?*, MILKEN INST. REV., Mar. 2002, at 30, available at http://www.milkeninstitute.org/publications/review/2002_3/30_39.pdf.

83. See Robert Cooter, *Prices and Sanctions*, 84 COLUM. L. REV. 1523, 1523 (1984); William Poole, *Optimal Choice of Monetary Policy Instruments in a Simple Stochastic Macro Model*, 84 Q.J. ECON. 197, 197 (1970); Martin L. Weitzman, *Prices vs. Quantities*, 41 REV. ECON. STUD. 477, 477 (1974). Indeed, the analysis and figures of patenting in this Part closely parallel the analysis of affirmative action quotas and credits found in Ian Ayres, *Narrow Tailoring*, 43 UCLA L. REV. 1781 (1996).

From a strictly theoretical point of view there is really nothing to recommend one mode of control over the other. This notwithstanding, I think it is a fair generalization to say that the average economist in the Western marginalist tradition has at least a vague preference toward indirect control by prices, just as the typical non-economist leans toward the direct regulation of quantities.

...
A reason often cited for the theoretical superiority of prices as planning instruments is that their use allegedly *economizes on* information. . . . [I]t is neither easier nor harder to name the right prices than the right quantities because in principle exactly the *same* information is needed to correctly specify either.⁸⁴

Just as Weitzman questioned the “vague preference” that economists have toward effluent taxes, our purpose here is to show that the preference for renewal fees is overstated or possibly misplaced. To see why a regime with a limited number of patent licenses might be superior to a regime with renewal fees, imagine a one-period model in which a patentee would either have to pay a single fee in order to make her license active or would have to purchase one of a limited number of licenses. To implement these regimes, the government would have to set either a price (a renewal fee) or a quantity (the number of licenses to be issued).

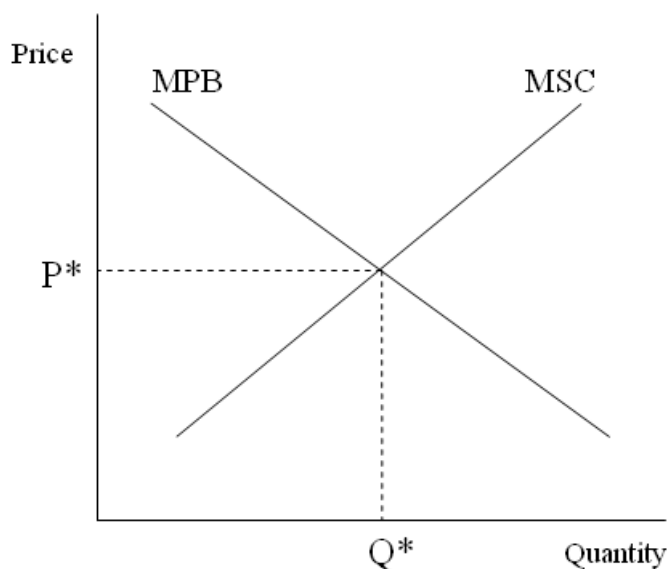
In a simple model with complete information, the optimal (price or quantity) regulation would turn on the marginal net private benefits and the marginal net social costs of patenting. The concept of net private benefits captures the expected profits from patent protection minus the costs of producing, prosecuting, and enforcing the patent. The concept of net social costs refers to all the social costs and benefits of patenting, excluding only the costs and benefits that accrue to the marginal patentee herself. Society enjoys many benefits from patenting—including, of course, the way that patent protection spurs innovation and then makes that innovation common knowledge. But for the reasons discussed in Part I, there are strong reasons to expect that a patent thicket that becomes too thick can produce net social costs that on the margin are higher than the net private benefits to the patentee.

These stylized assumptions are depicted in Figure 2. This figure assumes, following the logic of Part I, that the marginal net social costs of patenting (labeled MSC) rise as the quantity of enforceable patents increases. Further, because of diminishing marginal returns, the private net benefit of the marginal patent (labeled MPB) declines as the number of enforceable patents grows. This latter assumption does not mean that the last patent issued in a given time period is less valuable than the first, but simply that if we arrayed all the patents issued in, for instance, a year, the least valuable patent is worth less than the most valuable.

84. Weitzman, *supra* note 83, at 477-78 (first emphasis added). *But see* Louis Kaplow & Steven Shavell, *On the Superiority of Corrective Taxes to Quantity Regulation*, 4 AM. L. ECON. REV. 1, 1-2 (2002) (acknowledging that Weitzman’s view has been accepted by many economists but arguing that corrective taxes are a superior way of controlling externalities).

In simplistic “models” of this kind, social welfare is of course maximized at the point where the marginal costs equal the marginal benefits. Accordingly, the government would want to set either the price or the quantity at the point where the marginal net private benefit to patentees of an additional patent was set equal to the marginal net social cost of issuing more patents. These amounts are depicted in Figure 2 as P^* and Q^* , respectively.

Figure 2. Assessing the “Marginal Social Cost” (MSC) and the “Marginal Private Benefit” (MPB) of Patents



If the government had complete information about the marginal costs and benefits of patenting, then either price or quantity regulation would produce an identical equilibrium. Indeed, with this kind of complete information, the government could do even better by just offering patent protection to those ideas that produce a net social benefit and by paying these patentees a lump sum instead of granting them distortionary monopoly rights. But, as has long been known, all the important issues of developing optimal intellectual property rights turn on the government’s imperfect information—or possibly the question of how best the government might economize on the patentee’s (and others’) private information.⁸⁵

85. See Brian D. Wright, *The Economics of Invention Incentives: Patents, Prizes, and Research Contracts*, 73 AM. ECON. REV. 691, 691-92 (1983). Weitzman made a similar point:

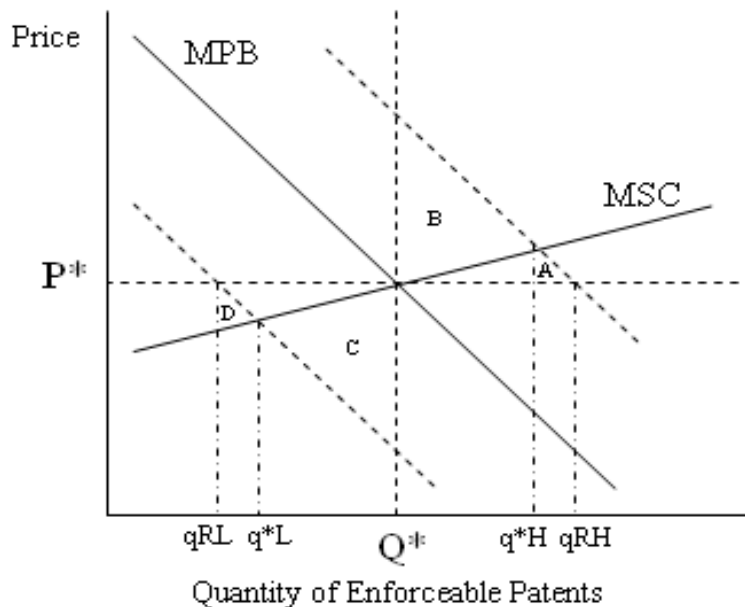
... In an environment of complete knowledge and perfect certainty there is a formal identity between the use of prices and quantities as planning instruments.

If there is any advantage to employing price or quantity control modes, therefore, it must be due to inadequate information or uncertainty.

Weitzman, *supra* note 83, at 480. For a parallel analysis in the affirmative action context, see

Therefore, to make the price vs. quantity question interesting, we need to introduce some uncertainty about how patentees will react to a renewal fee as opposed to a licensing scheme. A marginal net private benefit curve (MPB curve) can be thought of as the patentees' reaction function. Its position will determine, for example, how many patentees will find it worthwhile to pay a particular licensing fee. To make prices and quantities non-equivalent policy instruments, imagine that the government is uncertain about the position of the MPB curve. There are many types of uncertainty that the government might face, but for one stylized example, assume that the slope of the MPB curve is known but the intercept with MSC is not known. For stylized concreteness, imagine that half of the time the MPB curve is shifted up by epsilon and half the time it is shifted down by epsilon. This uncertainty is depicted in Figure 3 by the dotted lines that are parallel to, but lie above and below, the expected MPB curve (depicted by the solid line).

Figure 3. An Example in Which Patent Quotas Are Less Efficient than Renewal Fees



With these assumptions in place, it is possible to explore graphically whether price or quantity regulation is likely to be more efficient. A more tailored price or quantity rule would of course depend on the position of the MPB curve. The optimum patent quantity levels for the two possible states of the world are depicted in Figure 3 by q^*L and q^*H , which represent the quantities where the MSC curve intersects the two possible MPB curves. But

Ayres, *supra* note 83.

because of the government's limited information, simple price or quantity regulation cannot guarantee the optimum number of patents.

Figure 3 can help us assess how well simple price or quantity regulations will succeed in tailoring actual patent levels to these optimal benchmarks. The licensing scheme induces a fixed quantity of enforceable patents with an equilibrium market price of the license equal to the point where the MPB curve intersects with the fixed quantity Q^* . When the private benefit curve is unexpectedly low, the quantity regulation induces too much patenting ($Q^* > q^*L$). Under these circumstances, the marginal social cost of patenting at Q^* is epsilon greater than the marginal private benefit. The total inefficiency caused by this oversupply is represented in Figure 3 by a triangle drawn between the optimal and actual quantity (labeled B). Because, as Figure 3 indicates, the marginal social cost remains above the marginal private benefit at all points between q^*L and Q^* , the triangle area labeled B represents the total loss in welfare from the quantity regulation's failure to tailor a lower quantity when the net private benefits of patenting are unexpectedly low.

Tradable licenses create an analogous inefficiency by inducing too little patenting when the private benefits of patenting are unexpectedly high. When the private benefits of patenting are high, the optimum level of patenting (q^*H) is higher than the best level that an imperfectly informed government can identify (Q^*). When this is true, the private benefits of patenting on the margin at Q^* will be greater than the social cost. The inefficiency associated with this shortfall (between Q^* and q^*H) is depicted by an analogous triangle (labeled C).

Figure 3 also shows, however, that a simple price regulation fails to induce the optimal level of patenting. Quantity regulation is inefficient because the quantity of patenting does not vary with the strength of private benefits, but price regulation is inefficient because it causes the quantity of patenting to vary too much.

When private benefits are unexpectedly low, quantity regulation induces too much patenting ($Q^* > q^*L$), but Figure 3 shows that price regulation induces too little participation. Patentees responding to a renewal fee cost of P^* will only renew patents up to the point where the marginal private benefit equals the cost of the renewal. In Figure 3, this renewal point occurs at q^*RL . But at this level, the marginal net private benefits of patenting are larger than the marginal social costs. The inefficiency associated with this shortfall is represented by the smaller triangle between q^*RL and q^*L (labeled A). An analogous inefficiency is created when private benefits are unexpectedly high. The price regulation now induces too much minority participation ($q^*RH > Q^*$), which is depicted by an analogous small triangle between q^*H and q^*RH (labeled D).

Comparing the inefficiencies of price and quantity regulations, Figure 3 reveals the conventional result. The fixed-quantity regulation produces a less-nuanced outcome than the price regulation. The price regulation is better tailored because it produces enforceable patenting levels (q^*RL and q^*RH) that

are closer to the optimal levels (q^*L and q^*H , respectively).⁸⁶ Price regulation induces more variation in enforceable patenting. And for these assumed marginal cost and benefit curves, making the level of effective patenting sensitive to the size of private patent values is more efficient than having the patenting level be completely invariant.

The residual inefficiency of price regulation is caused by patentees ignoring the social costs of marginal increases in patenting; they instead only internalize the constant marginal cost of the renewal fee. But, as drawn in Figure 3, the externality caused by the flat pricing regulation is relatively small because the marginal cost curve is itself relatively flat—meaning that under a price regulation there are slight differences between the marginal costs to society and the marginal costs imposed by the simple (quantity invariant) renewal fee.

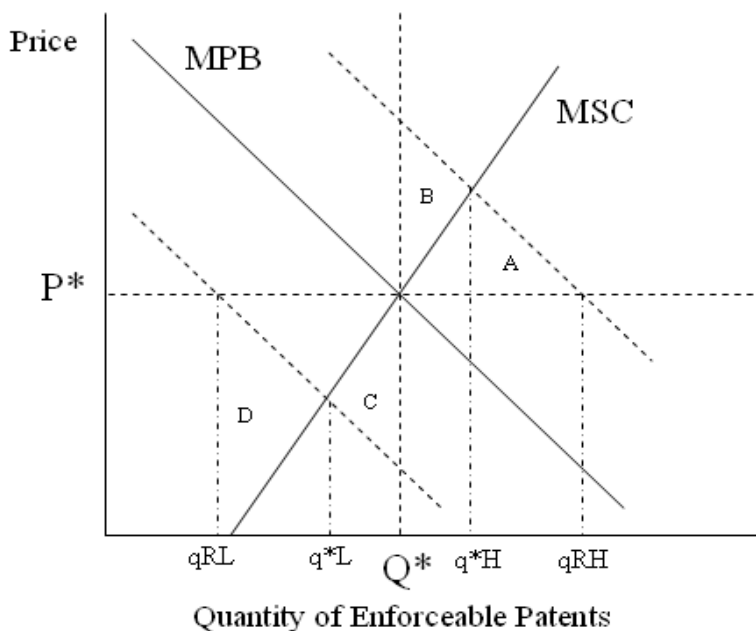
If the analysis stopped here, there would be little value added by this economic modeling. Consistent with the current legal embrace of renewal fees, Figure 3 shows that setting the quantity of tradable licenses is less efficient than having government set a renewal price. And even though this graph is for a single price and quantity, one might imagine the same type of graph showing that a renewal-fee system is clearly preferable to a quota on patent licenses for each year of a patent's potential life.

However, it turns out that it is easy to construct examples in which quantity regulation is more efficient than price regulation. Indeed, if we merely increase the slope of the social cost curve (MSC), setting the quantity becomes more efficient than setting the price. Figure 4 shows this possibility.

As before, a system of renewal fees makes the level of effective patenting more sensitive to the private benefits of patenting. But in this case, the swings in effective patenting are excessive compared to what optimally tailored (full-information) patenting levels would be. The fixed quantity (Q^*) is closer to the full-information optimal levels (q^*H and q^*L) than are the levels induced by a simple renewal fee (q_{RH} and q_{RL}). The deviations from the optimal level of effective patenting create analogous inefficiencies for price and quantity regulations, but in Figure 4, the inefficiency of renewal fees is greater than that for a fixed licensing quantity.

86. Graphically, $q^*L - q_{RL} < Q^* - q^*L$ and $q_{RH} - q^*H < q^*H - Q^*$.

Figure 4. An Example in Which Renewal Fees Are Less Efficient than Patent Quotas



This geometry suggests that quantity regulation will become more efficient than price regulation as the marginal social cost curve (MSC) becomes steeper relative to the marginal private benefit curve (MPB). Indeed, in this simple graph, quantity regulation will be more efficient than price regulation whenever the slope of the MSC curve is greater than (the absolute value of) the MPB slope. Why would this be so? As discussed above, the slopes of the MSC and MPB curves determine how sensitive effective patenting will be to shifts in private patent benefits. When the MSC curve is relatively flat, price regulation causes patentees to face a fee that, regardless of their private benefit, is approximately equal to the marginal social costs of enforceable patents. Flat MSC curves thus suggest that price regulation will be effective in inducing levels of patenting that are relatively close to the full-information optimum. When the MSC curve is steep, however, then shifts in the private benefits of patenting will cause the social cost curve to substantially diverge from a fixed renewal fee as the private benefit curve varies above or below its expected value. When the MSC curve is steep (relative to the MSB curve), pricing regulations will produce too great fluctuations in the level of effective patenting as patentees look to the size of the renewal fee in deciding whether to pay to make their patent enforceable instead of considering the diverging social costs of enforcements.

Economists tend to think of price regulations (effluent taxations and the like) as allowing the courts to economize on the information of private parties—in this case, allowing the patentees to choose the level of effective patenting

based on their privately-known valuations.⁸⁷ But the reactions of private parties in setting the level of effective patenting can, somewhat paradoxically, be less well-tailored than a fixed-quantity standard that does not allow patentees' action to vary the number of patents in effect. The fixed-pricing regulation causes patentees to systematically overshoot in their efforts to expand or contract the effective quantity of patents above or below the expected level. When this overshooting effect is large enough, the fixed effective quantity of tradable licenses can better emulate the full-information optimum than a simple, single-price-per-period renewal system.

The analysis of Part I gives us some reason to think that quantity regulation may in fact be more efficient than price regulation. The idea that patent systems become more socially costly as more "thickets" emerge suggests that the marginal social costs will likely be rising sharply. And as Figure 4 indicates, steep MSC curves tilt the efficiency analysis toward quantity regulation.

C. Regulating Both Price and Quantity

While the foregoing graphs are sufficient to show that fixed-quantity regulations can be more efficient than single-price regulations, it is important to realize that government might be able to do better by adopting a regime that is a mixture of price and quantity regulations. Specifically, the government might make the number of licenses issued be a function of the equilibrium bids. Instead of being a fixed vertical line, the supply of licenses might instead be an upward sloping curve that the government sets to coincide with the net social costs of patenting.

Graphically, the government's task would be to fit the quantity of licenses to the MSC curve of the previous Subparts. An upward-sloping license-supply curve would potentially reduce the information burdens on government. Instead of trying to assess the position of the MPB curve, the government would only need to assess the position of the MSC curve.⁸⁸ Making the license-supply curve equal to the external social costs of patenting would, in theory at least, cause patentees to internalize the total costs and benefits of creating an enforceable patent.⁸⁹ The patentees would receive the private benefits of an

87. See, e.g., Kaplow & Shavell, *supra* note 84, at 14 (noting that corrective taxes leave control decisions to individual firms); Louis Kaplow & Steven Shavell, *Property Rules Versus Liability Rules: An Economic Analysis*, 109 HARV. L. REV. 713, 725 (1996) (pointing out that liability rules allow the state to harness the information of private parties).

88. However, the government would need to assess a longer span of the MSC curve instead of just assessing the local point at which the MSC and MPB curves intersect. There may be circumstances in which the latter assessment might be easier. See Richard R.W. Brooks, *The Relative Burden of Determining Property Rules and Liability Rules: Broken Elevators in the Cathedral*, 97 NW. U. L. REV. 267, 284-99 (2002) (developing a framework for choosing between property rules and liability rules).

89. A similar point was made by Ryan Lampe and Anthony Niblett, *The Economics of Patent Design: A Selective Survey* 19 (Intellectual Prop. Research Inst. of Austl., Working

enforceable patent if they went forward, and they would have to pay a price to procure the license that would emulate what would otherwise be the external social costs of patenting. If the license-supply curve were simply the MSC curve, then the patentees would only purchase a license if the marginal benefit to themselves individually was greater than the marginal cost to society.

Of course, to assess the schedule of increasing social costs of additional patents is far from an easy task. But this Subpart suggests that relying simply on price regulations, to the exclusion of quantity and quantity/price regulations, artificially constrains the toolkit of intellectual-property policymakers.

III. HOW MIGHT A TRADABLE LICENSE SCHEME BE IMPLEMENTED?

This Part describes in a bit more detail how a system of tradable licenses might be implemented. For simplicity, imagine that the system would only apply to newly-issued patents, so that previously-issued patents would be governed by the pre-existing maintenance-fee system. Licenses would be described by two variables: a particular patent-issue year (e.g., 2010) and the time period of the patent's life that is covered (e.g., years 5 to 8). Thus, a 2010/years 5-8 license would cover only the years 5 to 8 of patents issued in 2010. To keep things similar to the current U.S. patent system, patentees will be required to purchase licenses every 4 years to preserve the effectiveness of their patents. The initial patent fees would make the patent in force for year 0 to 4. To keep a patent in force after the initial 4 years, a patentee would have to obtain ownership of a year 5 to 8 license for their particular patent issue-year. Afterward, a patentee who wants to keep a patent in force will need to obtain licenses for years 9 through 12, 13 through 16, and 17 through 20. (The current maintenance-fee system only requires patentees to purchase extended length in years 4, 8, and 12—but because of our concerns with the thicket problem, we would require relicensing in year 16 as well.) As with renewal fees, failure to acquire a license at the start of any particular four-year term would render the patent ineffective in all future years.

At the beginning of an issuance year, the USPTO would auction a predetermined number of licenses covering the various periods of patent life for all patents being issued that year. We imagine that the auction would be a sealed-bid auction, similar to the type used for the Environmental Protection Agency's annual SO₂ allowance auction.⁹⁰ For example, at the beginning of

Paper No. 06/03, 2003) (“This policy has been introduced (in part) to prevent inefficient use of the patent system. In order to ensure optimality, the patent renewal fee at time t should equal the marginal social cost at time t .”).

90. 42 U.S.C. § 7651o(d)(2) (2000). In order to comply with the cap on the level of air-polluting emissions established by the Clean Air Act Amendments of 1990, Pub. L. No. 101-549, 104 Stat. 2399 (1990), the EPA distributed allowances to certain industries that limited how much they could pollute; each allowance permitted the industry to emit a certain unit of air pollution. A small proportion of allowances were reserved by the EPA and sold at

2010, the USPTO would issue a certain number of 2010/5 licenses (granting protection for patents issued in 2010 for years 5 to 8 of the patent's life), a smaller number of 2010/9 licenses, an even smaller number of 2010/13 licenses, and a yet smaller number of 2010/17 licenses. The decreasing supply of licenses for each patent cohort suggests a kind of musical chairs in which some of the potentially enforceable patents will necessarily become unenforceable.

Anyone would be able to buy these licenses initially, and the licenses would be freely alienable in a secondary market. The official owner of record would be maintained by the USPTO. There would be no requirement that owners be patentees of patents issued in the relevant year. But if an owner wanted to use a license to make a particular patent enforceable for a particular time period, the owner would have to designate to the USPTO a particular license as applying to a particular patent.

In the last twenty years, the number of patents issued by the USPTO has been increasing at about a 4.6% rate. In 2000, the USPTO issued 157,495 utility patents. To replicate the same decay in enforceability that is occurring under the current system of maintenance fees, we might initially issue:

	2010/5	2010/9	2010/13	2010/17
No. of auctioned licenses	132,000	99,000	73,000	56,000

The first three figures are taken by looking at the rate of patent expiration that occurred in 1991⁹¹ and applying it (before rounding to the nearest thousand) to the initial level of patenting in 2000 (157,495 patents). The fourth figure for the number of 2010/17 licenses was calculated by continuing the same (geometric) average rate of decay.

Now that we have specified with a bit more particularity how a tradable licensing system would operate (at least) initially, we can say a bit more about the benefits that might accrue under such a system. As we said before, tradable licenses would offer more flexibility than the current system. Patentees could, at the time of patenting, secure all the licenses that they would need to keep

an annual sealed-bid auction. *See generally* Byron Swift, *How Environmental Laws Work: An Analysis of the Utility Sector's Response to Regulation of Nitrogen Oxides and Sulfur Dioxide Under the Clean Air Act*, 14 TUL. ENVTL. L.J. 309 (2001). The precise mechanism of the SO₂ auction has been described in the following way:

Interested parties submit bids indicating the number of allowances they seek to purchase and the price they are willing to pay. The Chicago Board of Trade [which the EPA has designated to run the auction] determines the price that would lead to the sale of all the available allowances. All bids at or above that price are then accepted, with each successful bidder paying the amount it bid.

Jonathan Remy Nash & Richard L. Revesz, *Markets and Geography: Designing Marketable Permit Schemes to Control Local and Regional Pollutants*, 28 ECOLOGY L.Q. 569, 658 (2001).

91. *See* Moore, *supra* note 57, at 1527-31.

their patent in force for the full twenty-year term. This could, in a small way, save on the current transaction cost of having to remember to pay your maintenance fee. Alternatively, patentees could wait and see if the value of their patent and the value of the licenses in the secondary market make continued enforcement worthwhile. Tradable licenses let assets flow to the highest valuers—in sharp contrast to maintenance fees, which are not tradable. Thus, a system that simply tried to replicate the rate of expiration under the current maintenance-fee system might be more efficient.

But we think that even more gains in efficiency can be achieved by gradually increasing the amount of weeding that takes place. And here the annual growth rate in issuing patents of about 5% comes to our aid. Simply maintaining any fixed level of issued licensing will gradually become more and more restrictive as the number of newly-issued patents increases. We need to consider how much more we should let the rate of licensing bind before it should adjust to accommodate the growing rate of patenting.

Quantitatively tailoring the patent system is the Herculean burden. Ever since Nordhaus,⁹² economists have been able to produce theories about, but precious few numbers on, the optimal length (or breadth) of patents. In theory, we know we want to weed until the marginal cost of a license equals the marginal social cost of patenting, but we do not yet know how to measure the marginal social cost.⁹³ A scheme of tradable licenses, however, gives us more information about the marginal patent. The USPTO will get to see the market price for the fifth, ninth, thirteenth, and seventeenth year licenses for each cohort. The license prices themselves (both in the auction and in the secondary market) will provide some information about what kinds of inventions are being deterred. For example, if the year five license price rises to seven figures, we are probably weeding too much because patentees will not find it

92. WILLIAM D. NORDHAUS, *INVENTION, GROWTH, AND WELFARE: A THEORETICAL TREATMENT OF TECHNOLOGICAL CHANGE* (1969) (discussing the optimal patent system). For subsequent studies of the issue of patent scope, see, for example, Howard F. Chang, *Patent Scope, Antitrust Policy, and Cumulative Innovation*, 26 *RAND J. ECON.* 34 (1995); Julie E. Cohen & Mark A. Lemley, *Patent Scope and Innovation in the Software Industry*, 89 *CAL. L. REV.* 1 (2001); Richard Gilbert & Carl Shapiro, *Optimal Patent Length and Breadth*, 21 *RAND J. ECON.* 106 (1990); Hugo A. Hopenhayn & Matthew F. Mitchell, *Innovation Variety and Patent Breadth*, 32 *RAND J. ECON.* 152 (2001); Paul Klemperer, *How Broad Should the Scope of Patent Protection Be?*, 21 *RAND J. ECON.* 113 (1990); Robert P. Merges & Richard R. Nelson, *On the Complex Economics of Patent Scope*, 90 *COLUM. L. REV.* 839 (1990).

93. See, e.g., FRITZ MACHLUP, *SUBCOMM. ON PATENTS, TRADEMARKS, AND COPYRIGHTS OF THE S. COMM. ON THE JUDICIARY, 85th CONG., AN ECONOMIC REVIEW OF THE PATENT SYSTEM* 80 (Comm. Print 1958) (“If we did not have a patent system, it would be irresponsible, on the basis of our present knowledge of its economic consequences, to recommend instituting one.”); George L. Priest, *What Economists Can Tell Lawyers About Intellectual Property: Comment on Cheung*, in 8 *RESEARCH IN LAW AND ECONOMICS: THE ECONOMICS OF PATENTS AND COPYRIGHTS* 19, 19 (John Palmer & Richard O. Zerbe, Jr. eds., 1986) (“The ratio of empirical demonstration to assumption in [the patent] literature must be very close to zero.”).

worthwhile to invent many useful things if they expect to pay more than a million dollars to keep their inventions alive after just four years. But beyond just the price information, the USPTO will be able to observe the identity of patents that are not extended. If the owners of socially valuable patents do not find it worthwhile to extend their patents' lives, policymakers should worry about whether similar future inventions will even come into being.

Finally, a word is in order about the possibility that non-patent owners will purchase the licenses solely for the purpose of reducing the number of patents that can be legally enforced. Remember that, under our scheme, the USPTO places no requirement that licenses purchasers be patent owners at the time of purchase or that they use the licenses to make actual patents enforceable. This means that Larry Lessig or the Free Software Foundation might purchase licenses just to expand the intellectual commons. Just as third graders and other environmentalists sometimes purchase SO₂ licenses to "park" them and reduce the amount of pollution, intellectual property communitarians would be free to purchase patent licenses so as to exacerbate the musical chairs shortage.

This is, all in all, a good thing. Such "parking" not only democratizes the effective supply of patent enforcement—it also increases efficiency. If a third grade class believes that it values a 2020/5 license more than the marginal patent owner, then efficiency is enhanced by letting the license flow to the highest valuer.

On the other hand, efficiency would not be enhanced if the end users of a patented product purchased a license only so that the particular patentee would not be able to enforce its patent, charge the end user, and thereby earn a return on its innovative effort. But it should be emphasized that the licenses are not tied to particular patents, so an end user would not be able to purchase the right to stop a particular patentee from charging a monopoly price unless she purchased all the available licenses for that patent-issuance year. Such an undergoing would, of course, be a prohibitively expensive means for an end user to protect herself from a patentee's monopoly pricing. More generally, we believe that, as with other broadly available commodities, "cornering the market" risks are low. But they could be handled with regulations that parallel the market-manipulation prohibitions of the security markets.

CONCLUSION

In this Article, we explored how price- and quantity-based regulation of patents may help overcome patent thickets and clear the path for future innovation. The main innovation of the Article itself was to introduce the option of tradable patent rights as a policy tool for combating overpatenting. Admittedly, the analysis leaves many important questions open. Should we weed progressively more over the life of a patent cohort, or should we weed more assiduously at the beginning of a cohort's life? Should we weed with price, quantities, or some combination of prices and quantities? Can price or

quantity regulations weed out socially costly patents without unduly burdening patents that are on net socially beneficial?

Nevertheless, we hope to have at least shown that policymakers have an array of weeding tools that go well beyond simply increasing the initial standards for non-obviousness. Price and quantity regulations deserve to be among the policymaker's gardening implements as they open up new possibilities for economizing on patentees' private information throughout the life of the patent.