The Danger of Underdeveloped Patent Prospects

by Michael Abramowicz*

Commentators have long recognized that much of the work of commercializing an invention occurs after a patent issues. They have not recognized, however, that by the time market conditions make commercialization potentially attractive, the remaining patent term might be sufficiently short that a patentee will not develop an invention or will not spend as much on development as if more patent term remained. The concern about patent underdevelopment provides a counterweight to patent prospect theory, which urges that patents be issued relatively early. By insisting on a substantial degree of achievement before patenting, the patent system reduces the risk of patent underdevelopment. Underdevelopment may still be a problem for some inventions, however, for example in the field of genomics. A possible solution is a system of patent extension auctions. A patentee would be allowed to request such an auction, but could win it only by substantially outbidding third parties. Patentees will call for auctions only when the benefits of ownership continuity, and thus of continued patent development, are relatively high.

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INTRODUCTION

When in possession of property for only a limited time, one may exercise less care with the property than one would if one expected to own it in perpetuity. Someone renting a car, for example, may not treat the car as well as if the person owned the car. Similarly, in the real property context, a life tenant has less than optimal incentives to maintain or to improve property. Real property law addresses this danger with the doctrine of waste, which requires that "the life tenant exercise[] the ordinary care of a prudent person in preserving and protecting the property" and "commit[] no acts that would permanently injure the remainder interest."[1] Yet there is one field of property law in which ownership for a limited time is ubiquitous, but courts and commentators have paid no attention to the danger that owners will have insufficient incentives to maintain or develop the property right. This field is patent law.[2]

A patent owner receives a patent for only a limited time, currently twenty years from the date the patent application was filed.[3] Although the issuance of the patent reflects a

[1] *Life Estate: Termination Because of Waste*, REAL ESTATE L. REP., Mar. 1997, at 5 (citing McIntyre v. Scarbrough, 471 S.E.2d 199 (Ga. 1996) as providing a useful illustration of the doctrine); *see also* Thomas W. Merrill & Henry E. Smith, *The Property/Contract Interface*, 101 COLUM. L. REV. 773, 822-23 (2001) (discussing the evolution of the law of waste in the landlord-tenant context). I am grateful to John Duffy for first pointing me to the analogy between nondevelopment of patents and waste of real property.

[2] Some commentators have considered whether intellectual property law may tolerate waste, but they have not elaborated the nature of the waste or noted that the finite patent term makes the danger of waste particularly severe. *See* Edwin C. Hettinger, *Justifying Intellectual Property*, 18 PHIL. & PUB. AFF. 31, 44 (1989) (recognizing that the incentive to charge high prices for intellectual property might create waste, but not considering the danger of underdevelopment of the patent right); Justin Hughes, *The Philosophy of Intellectual Property*, 77 GEO. L.J. 287, 328-29 (1988) (noting that patent law, in contrast to copyright law, may risk waste by not requiring the right owner to commercialize the property, but not indicating why failure to commercialize is a danger); *see also infra* note 1 (discussing the concept of waste).

[3] 35 U.S.C. § 154(a)(2) (2005).

determination that the patentee has created a new and nonobvious invention,[4] the receipt of the patent is not the last step in the process of innovation. To realize profits, the patentee must still commercialize the invention.[5] This process might include improvement of manufacturing technologies or further scientific testing of the invention. Before a full rollout of patented products, the patentee will often perform limited market tests to ensure that commercialization will be profitable. Even after placing the product on the market, the patentee might need to engage in marketing and advertising expenditures to inform the public about the benefits of the patented product. All of these expenditures have the potential to improve the value of the property right, and they are thus analogous to expenditures that a life tenant might make to improve real property. Just as the life tenant may not make improvements to real property that would be cost-justified considering the interests of both the life tenant and the owner of the remainder interest, so too might a patentee not undertake some commercialization expenses that would maximize the joint interests of it and the public.

Perhaps the problem of patent underdevelopment has received no systematic attention because the problem is less severe in the intellectual property context than in the real property context. Real property often requires continuous maintenance and can benefit from periodic improvements, while intellectual property, once developed and commercialized, might not require additional infusion of resources. Sometimes, for example, the necessary scientific testing of an invention will be completed by the time a patent term expires, and the cost of maintaining the knowledge produced by such scientific testing might be negligible. The owner of a patent, moreover, may sometimes receive an additional intellectual property reward for improving the property, for example when the patentee's further advances in the technology justify the award of an improvement patent that effectively extends patent life.[6] To the extent that this is the case, patent underdevelopment is not a great concern.[7]

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[4] *Id.* § 103(a).

[5] *See generally* F. Scott Kieff, *IP Transactions: On the Theory & Practice of Commercializing Innovation*, 42 HOUS. L. REV. 727 (2005) (considering the implications of new institutional economics for commercialization of innovation).

[6] *See* 35 U.S.C. § 101 (allowing patents for "new and useful improvement[s]" of inventions); Mark A. Lemley, *The Economics of Improvement in Intellectual Property Law*, 75 TEX. L. REV. 989, 1000-13 (1997) (providing an overview of patent law's approach to improvements).

[7] *But see* Part II.C (suggesting that the finiteness of the patent term might suboptimally reduce patentees' incentives to make even patentable improvements to their inventions).

It would be a mistake, however, to conclude that patent underdevelopment is irrelevant to the design of a patent system. First, if patent underdevelopment is rare, that may be because the patent system already includes protections that make the problem less significant, and so an appreciation of the problem may enrich our positive understanding of patent law. Some patent systems explicitly penalize nondevelopment, for example by allowing for compulsory licensing when a patentee fails to take active steps to commercialize an invention.[8] The United States does not take this approach, but even the structure of the U.S. patent system indirectly limits patent underdevelopment. In particular, all patent systems impose nontrivial prerequisites before a patent can be issued,[9] ordinarily ensuring that an inventor will have made substantial investments before a patent is issued. This means less money will be needed to complete the innovation process, making it less likely that a patentee will decide that it is not worth it to spend the remaining amount necessary to commercialize the patent. This observation suggests that proposals to grant patents based on only a small degree of inventive efforts may be flawed. It thus provides a counterweight to Edmund Kitch's famous prospect theory of patent law.[10]

Second, even if patent underdevelopment is rare, it might be of great concern in particular technological fields, and the problem could beset a few inventions in other technological areas. It might appear that even when the patent system does not directly protect commercialization activities, it provides a long enough patent term for development to take place.[11] But it often will be in the patentee's interest to delay commercial implementation until relatively late in the patent term. Indeed, a central observation of Kitch's is that there are often long delays between initial issuance of a patent and commercialization.[12] This observation builds on a theory of Yoram Barzel, explaining that providing a property right in the ability to delay an invention may

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[8] European law allows compulsory licensing when an invention has been abandoned. *See generally* Ronald E. Myrick, *Influences Affecting the Licensing of Rights in a Unitary European Market*, 4 FORDHAM INTELL. PROP. MEDIA & ENT. L.J. 81, 95 (1993) (discussing this doctrine). Courts might have difficulty determining what would count as "underdevelopment," if the law sought to discourage anything short of outright abandonment. For an argument that patent rights should not be surrendered as a result of failure to practice the underlying invention, see F. Scott Kieff, *Coordination, Property & Intellectual Property: An Unconventional Approach to Anticompetitive Effects and Downstream Access* 65 (2006) (unpublished manuscript, on file with author).

[9] *See, e.g.*, 35 U.S.C. §§ 101-103 (setting forth the requirements for patenting inventions in the United States).

[10] *See* Edmund W. Kitch, *The Nature and Function of the Patent System*, 20 J.L. & ECON. 265 (1977). For a brief statement of the prospect theory and an overview of criticisms, see A. Samuel Oddi, *Un-Unified Economic Theories of Patents – The Not-Quite-Holy Grail*, 71 NOTRE DAME L. REV. 267, 281-82 (1996).

[11] Even Kitch assumes that there generally will be sufficient patent term for commercializing an invention. *See* Kitch, *supra* note 10, at 285.

[12] *See id.* at 272 (providing a full-page table listing various inventions and their patent and commercialization dates).

increase private and social welfare.[13] Although Barzel recognized that delay may also have costs,[14] Barzel and Kitch did not recognize the possibility that long delays before commercialization activities increase the risk of underdevelopment, or even of nondevelopment, of patents. Especially when patents are granted on mere "prospects" before commercialization activity is economical, the patent system encourages delay. With only a finite patent term, by the time patents would be worth exploiting in a hypothetical system of infinite terms, the patentee might expect to recover too small a portion of development activity to justify a patent.

The problem of patent underdevelopment might at first appear to be at most a temporary obstacle. For if by the time a patent would be worth exploiting there are only a few years of patent term remaining, at least the patent will soon fall into the public domain. In fact, however, the prospect of an invention falling into the public domain may provide a reason that the problem of patent underdevelopment is more serious in the patent context than in the real property context. At least a life tenant can negotiate with the owner of the remainder interest, with the former agreeing to improve or maintain the property given some contribution from the latter. Such negotiations are not possible for a patent owner facing a patent term that is soon to expire. It is impossible to reach accommodation with all of the entrepreneurs who might like to commercialize the patent later,[15] let alone with all the end users who might benefit from development of the patent during the patent term. Because of the danger of free-riding, each person who might benefit from development of the patent during the patent term by the patentee will have little incentive to contribute to the patentee's present development efforts.

Moreover, the eventual placement of the patent in the public domain does not guarantee that the patent will be developed. Suppose, for example, that scientific testing is needed to determine whether commercialization of a patented invention is feasible. With the patent in the public domain, any private party considering whether to perform such scientific testing must worry about the possibility that third parties will free-ride on the information produced. If such testing produces only information, but not an invention that itself can be patented, there will be

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[13] *See* Yoram Barzel, *Optimal Timing of Innovations*, 50 REV. ECON. & STAT. 348 (1968).

[14] *Id.* at 348, 355 (noting that invention might occur inefficiently late because an inventor cannot capture the full social benefit of an invention).

[15] Each entrepreneur who might hope to sell or improve the patented product after the patent term will have an incentive to free-ride on the development activities of the patentee and on any subsidy to the patentee provided by other similarly situated entrepreneurs.

little incentive for private actors to invest in it. They will anticipate that if the scientific testing indicates that the product will be successful, then the third parties will enter the market too. Precisely the same argument applies to commercial experiments, such as test markets to assess the public's demand for the invention or for products that might incorporate it. Although inventors might keep their precise data from test marketing secret, competitors might be able to obtain some information about sales and then determine whether to enter markets themselves after the end of the original patent term. Incentives to engage in any kind of experimentation, scientific or commercial, decrease near the end of the patent term.

Sometimes, of course, first-mover advantages alone will suffice to spur development of technologies.[16] When the patentee concludes that these are insufficient, even in combination with whatever portion of the patent term remained, third parties also might not be willing to bear the expense of commercialization after the patent expires. If the patentee did not believe that whatever patent term existed was enough to justify the expense of development and commercialization, other possible developers of the technology seem likely to decide similarly not to develop and commercialize, unless some third party has some advantage in commercialization over the patentee and yet was unable to reach an agreement during the patent term to combine efforts with the patentee. Some inventions that would be commercialized with a longer patent term might not be developed, or they might be much delayed.

How significant a problem is patent underdevelopment? Because our patent system in fact is not nearly as much of a prospect system as it might be, probably the problem is worth worrying about only for a minority of patents, particularly embryonic patents. Whether the problem will occur for a particular patent turns on a variety of factors. The lower the costs of developing a patent after issuance, and in particular the lower the development costs that do not themselves produce new patentable inventions, the smaller will be the danger of patent underdevelopment. The greater the initial requirements for obtaining a patent, the less likely it will be that the patentee will decide to abandon the project. The problem, for example, could be

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[16] *See generally* William T. Robinson et al., *First-Mover Advantages from Pioneering New Markets: A Survey of Empirical Evidence*, 9 REV. INDUS. ORG. 1 (1994) (providing an overview of the econometric literature attempting to assess the extent of first-mover advantages). More recent work has emphasized the possibility that first movers may suffer from some systematic disadvantages. *See* Marvin B. Lieberman & David B. Montgomery, *First-Mover (Dis)advantages: Retrospective and Link with the Resource-Based View*, 19 STRAT. MGMT. J. 1111 (1998) (providing an overview). For a discussion of the implication of first-mover disadvantages for the patent system, see F. Scott Kieff, *Property Rights and Property Rules for Commercializing Inventions*, 85 MINN. L. REV. 697, 708-09 (2001).

greatly reduced if commercialization were required before a patent could be obtained, but such requirements would produce considerable costs.[17] At the other extreme, patents on gene sequences and other embryonic inventions may come at such an early stage in the research process that patent underdevelopment is a great concern. Patent nondevelopment will also be a greater problem, the greater the degree of uncertainty and volatility in estimates of the value of a patented product once commercialized. When a particular patent probably would be worthless but has some chance of turning out to be extremely valuable, depending for example on the development of other technologies for which the patented invention would be a complement, an inventor's incentive is to patent early and then wait before sinking substantial development costs.

Because the underdevelopment problem probably applies only to a subset of patents, any solution to it must be carefully targeted, lest the cure be worse than the disease. Patent extensions would help reduce underdevelopment, because a patentee considering investments in the original patent term would be able to realize benefits of this investment in the extension period. But a practice of legislatively authorized individual extensions to patent terms does not seem likely to identify the patents for which the social benefits of such extensions would exceed the costs. Even granting an administrative authority the power selectively to increase patent terms would promote considerable rent-seeking, as each patentee would seek to claim that the patentee would engage in far more investment with a patent extension than without. Indeed, patentees might have a perverse incentive to limit investment early in the patent term, in the hope of persuading the agency that much commercialization work remained to be done. An adequate solution to the problem of patent nondevelopment would need to limit the possibility that patentees could receive windfalls from patent extensions, and therefore that patentees would have incentives to lobby heavily for them

Auctions provide a means of limiting the windfalls that private parties can obtain from governmentally granted property rights, and careful design of the auction structure and set of rules for triggering auctions could limit patent extensions to only those cases in which patent underdevelopment is a strong concern. This Article tentatively proposes a possible design for patent extension auctions, which might be limited to particular fields of technology in which underdevelopment seems likely. In this system, a patentee would be allowed before the end of a

[17] *See infra* Part I.B.2 (illustrating the benefit of granting patents at a relatively early stage).

patent term to request an auction for a patent extension. The catch is that to keep the patent, the patentee would have to top the bid of the highest third-party bidder by a substantial markup. A patentee who calls for an auction and then loses would be required to pay some penalty. The patentee will thus have an incentive to call for an auction only where the benefits of ownership continuity are relatively large.[18] Although this Article cannot determine what the markup should be, it will offer a back-of-the-envelope calculation suggesting a markup of about 25%. Presumably, initial experiments with patent extension auctions would involve much higher markups, so that the first patent extensions granted would be for those patents for which the problem of underdevelopment is especially severe.

The Article proceeds as follows: Part I will show how combining two recent theoretical perspectives on patent law focusing on opposite ends of the innovation process—one on the time at which patent races begin and one on the period after patents are issued—points to the problem of patent underdevelopment. The Part then offers a simulation model demonstrating the danger of patent underdevelopment, and showing how the patent system's insistence that patentees demonstrate a considerable degree of achievement before patents are issued may help to combat it. Part II offers a tentative empirical assessment of the degree to which the patent underdevelopment problem remains despite the high threshold for patentability. Although it would be difficult to design an empirical test that would measure underdevelopment, it is possible to identify the types of patents for which the problem is likely to be the greatest concern and the types of development activities that patentees may forego, particularly late in the patent term. Finally, Part III introduces the proposal for patent extension auctions, considering both the possibility that the government would decide whether to call for a patent extension auction and the proposal sketched above in which the patentee has the discretion to demand an auction of the patent extension.

[18] Additional rules ensure that a patentee who values the patent far more than third parties, but not because of the benefits of ownership continuity, will not call for an auction. In particular, a third-party winner at the auction would be allowed to sell the patent back to the patentee, but only at the end of the original patent term. *See infra* text accompanying note 148. As a result, a third party that recognized the special value of the patent extension to the patentee would bid the full value of the patent extension to the patentee (placing aside bargaining costs), and anticipating this, the patentee would not be able to pay the markup. A third party will not factor the benefit of continuity of ownership in a bid, however, because the rule preventing sale during the patent term will prevent the third party and the patentee from reaching an agreement guaranteeing this.

I. A THEORETICAL MODEL

The danger of patent underdevelopment manifests itself when a patentee decides not to invest in development expenses that the patentee would have undertaken had a longer patent term been available. To simplify the analysis, this Part will focus on the most extreme form of patent underdevelopment: patent nondevelopment. This occurs when a patentee decides to abandon a patent that the patentee would have commercialized if longer patent protection were available. To assess the theoretical danger of patent nondevelopment, however, we must take a longer view of the patent process and determine how such a situation might arise. There are at least two central questions: First, why would a patentee not have undertaken the relevant development expenses earlier in the patent term? Second, looking back in time still further, why would a patentee create the invention and apply for the patent so long before development is feasible?

Each of two recent theoretical works can provide answers to one of these questions, but a complete understanding of the problem of patent underdevelopment requires that insights from these works be combined. The first question finds a straightforward answer in Shaun Martin and Frank Partnoy's *Patents as Options*.[19] Martin and Partnoy recognize that a patent provides its holder a series of options, including a litigation option (should a third party arguably be infringing the patent) and a development option to commercialize the invention.[20] An uncommercialized patent is simply a patent whose development option has not been exercised. An article by John Duffy, meanwhile, analogizes the patent process to an auction, in which one of the inventors who agrees to spend money on inventing earliest wins the right to the patent.[21] Inventors sometimes might need to engage in inventive activity and seek patents well before commercialization is possible, lest they lose the patent race. Combining these insights, competition among inventors forces patenting at an early stage, often so early that patentees will be quite unsure whether it will be worthwhile to ever exercise the development option that the patent provides.

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[19] *See* Shaun Martin & Frank Partnoy, *Patents and Options* (unpublished manuscript, 2005). Martin and Partnoy have yet to release the paper, and the summary here thus reflects a presentation of the anticipated paper made by Martin and Partnoy at Washington University on November 4, 2005.

[20] *See id.*

[21] John F. Duffy, *Rethinking the Prospect Theory of Patents*, 71 U. CHI. L. REV. 439 (2004).

This analysis can contribute to an answer to a longstanding puzzle about the patent system: why so many patents appear to be worthless.[22] A partial answer to the puzzle is likely that patent acquisition serves a signaling function,[23] but that might not be the entire story.[24] Perhaps an additional answer to the puzzle is that many patentees obtain patents for their option value and then frequently fail to develop the patents.[25] This possibility is disturbing in part because the patent process itself is expensive,[26] but also because of the possibilities of nondevelopment or underdevelopment of an invention. The literature has assumed that uncommercialized patents are not worth commercializing, and under that view, the private loss associated with worthless patents is of relatively little social significance. We can safely only assume, however, that uncommercialized patents are not worth commercializing given the limited patent grant. If patent rights are abandoned when term extensions would lead to commercialization and thus to both private and social benefits, then the patent system may be failing to optimize social welfare relative to a hypothetical system that makes it more difficult to obtain patents when the possibility of commercialization is uncertain.

Part II.A elaborates on these articles, and Part II.B reports the result of a simulation that incorporates an insight inherent in the Martin and Partnoy article into a numerical example that Duffy uses to illustrate his model. Although neither Martin and Partnoy nor Duffy recognize that our system of finite patent terms produces the danger of patent nondevelopment, an appreciation of the central insights of both articles makes the problem more worrisome than the analysis of either taken alone would suggest. Duffy's analysis ignores patent nondevelopment because he

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[22] Mark Lemley estimates that only about five percent of patents are ever licensed. Mark Lemley, *Rational Ignorance at the Patent Office*, 95 NW. U. L. REV. 1495, 1507 (2001).

[23] *See* Clarisa Long, *Patent Signals*, 69 U. CHI. L. REV. 625 (2002) (arguing that because the number of patents a firm obtains correlates with less measurable attributes of a firm of interest to potential investors, firms may choose to acquire even patents with little economic value).

[24] For a critique of the signals hypothesis, see Gideon Parchomovsky & R. Polk Wagner, *Patent Portfolios*, 154 U. PA. L. REV. 1, 21-22 (2005).

[25] Commentators before Martin and Partnoy noted that a patent is similar to a stock option in that it may or may not be exercised. *See* F. Russell Denton & Paul J. Heald, *Random Walks, Non-Cooperative Games and the Complex Mathematics of Patent Pricing*, 55 RUTGERS L. REV. 1175, 1194-95 (2004). Commentators have also analogized patents to lottery tickets. *See, e.g.*, Jonathan A. Barney, *A Study of Patent Mortality Rates: Using Statistical Survival Analysis to Rate and Value Patent Assets*, 30 AIPLA Q.J. 317, 328 n.30 (2002); F.M. Scherer, *The Innovation Lottery*, *in* EXPANDING THE BOUNDARIES OF INTELLECTUAL PROPERTY: INNOVATION POLICY FOR THE KNOWLEDGE SOCIETY 3, 4-7, 15 (Rochelle Cooper Dreyfuss et al. eds., 2001) (observing that returns to patents may fit a Pareto distribution, which has a longer and thicker tail than a log normal distribution, and thus that owning large patent portfolios may not entirely provide for diversification of risk). They have not, however, noted that the option characteristics of patents may lead to their acquisition at such an early time as to inhibit development within the patent term.

[26] Lemley, *supra* note 22, at 1498-99 (2001) (estimating the cost of a patent prosecution to be between $10,000 and $30,000 per patent).

assumes that the costs and benefits of patenting are known in advance; Martin and Partnoy, meanwhile, because they ignore that competition among patent racers may lead to acquisition of patents long before commercialization becomes feasible. A dynamic model incorporating uncertainty shows how patent nondevelopment can become a danger, and how the patent system can limit the danger.

A. Options and Auctions

1. Patents as Options

The central observation underlying the Martin and Partnoy analysis is that the future is always uncertain. Someone who owns a patent cannot be sure how profitable commercialization of the patent will be, or even how much it will cost to complete the commercialization process. The future, however, becomes clearer as we move toward it. So, it sometimes makes sense to wait before irreversibly investing substantial resources. A central observation of "real options theory"[27] is that part of the value of an option that may be exercised over some period of time is the right to wait for more information about whether the option will be worth exercising. Indeed, in most contexts, there is no reason to purchase an option rather than the underlying asset if it is apparent at the time of the purchase that it will definitely make sense at a particular time to exercise the option. Because a patent functions as an option (or as a series of options), part of its value lies in the right of the patent owner to wait for the optimal moment to make a decision about whether to exercise the options that the patent provides. Though privately optimal, this waiting increases the risk of patent nondevelopment.

Even though information becomes clearer with the passage of time, a patentee will not always wait forever. By waiting an additional year before making a decision to initiate the development process, a patentee loses a year of potential profits. Suppose, for example, that it will cost $1,000,000 to commercialize a patent with twenty years remaining, and that the patentee believes that there is a fifty percent chance of a good result—a product worth $2,000,000 in present discounted value—and a fifty percent chance of a bad result—a product worth nothing. For simplicity sake, assume risk neutrality and that each year of the patent term would contribute equally to the present discounted value of the commercialized patent, because

[27] *See generally* REAL OPTIONS AND INVEWSTMENT UNDER UNCERTAINTY: CLASSICAL READINGS AND RECENT CONTRIBUTIONS (Eduardo S. Schwartz & Lenos Trigeorgis, 2004) (containing many important contributions to the field).

revenues will increase in value at the same rate as the discount rate. The decision whether to commercialize appears to be a close one, and if waiting were impossible, the patent would effectively be worth nothing. Waiting a year means that, absent new information, the good result scenario will provide value of only $1,900,000, because of the lost year of sales. If the patentee expects, however, that new information will allow for a determination of whether the good result is, say, 60% likely or only 40% likely, it will easily be worth waiting. If such new information is equally likely to be favorable or unfavorable, waiting makes the patent worth an expected value of 0.5 * 0.6 * ($1,900,000 - $1,000,000) = $270,000. The right to delay by one period increases the value of the patent from $0 to $270,000.

It will rarely be obvious when a patent is issued exactly how long the patentee should wait before making a decision about commercialization. At each time period, the patentee will recognize that it may be worth waiting until the next time period. In the interim, the patentee might undertake some limited development or experimentation on the patent to improve the patentee's ability to determine whether additional tentative steps or full-fledged development efforts are financially justified. It might appear that the finiteness of the patent term would reduce the patentee's incentive to wait relative to a hypothetical world of infinite patent terms. In our own lives, after all, deadlines make us move more quickly. The analogy, however, does not strictly apply. The economic decision to wait an additional time period depends on whatever new information might develop and the value of sales attributable to delay, so a rational patentee will not hurry as a result of the finite patent term. Finiteness limits delay only to the extent that confining the patentto a particular term may limit uncertainty.

The finiteness of the patent term, however, does have a significant effect on the patentee's incentives: It makes it much more likely that the patentee eventually will abandon the patent altogether. As Martin and Partnoy recognize,[28] and as the numerical example above reinforces, the right to abandon a patent and save the money that otherwise would fund development of that patent increases the value of the patent right. Although Martin and Partnoy worry that the litigation option sometimes will be more attractive to patentees than the development option,[29] they do not make the broader point that even in the absence of a right to

[28] Martin & Partnoy, *supra* note 19
[29] *Id.*

litigate without developing a patent, the amount of development activity might be inadequate from a social welfare perspective. The solutions that Martin and Partnoy identify focus on reducing the value of litigation options, by increasing the exercise price of those options.[30] For example, a fee-shifting regime for patent litigation might discourage patentees from filing frivolous litigation.[31] These solutions might be worthwhile to consider, because the availability of attractive options besides the development option reduces the probability that the development option will be exercised, but there may be other approaches to addressing patent nondevelopment.

An alternative approach that might appear to be sensible would be to increase the length of the patent term. Patent nondevelopment, after all, is a result of the finite nature of the patent term. With infinite patent terms and no costs of maintaining a patent, a patent might well prove valuable in the future. Indeed, because economies grow over time, with infinite patent terms, patents should become more valuable over time as well, except to the extent that substitutes for the patented technologies are developed in the interim. The danger of nondevelopment might appear therefore to produce an argument for systematically longer patent terms than would otherwise be optimal. To assess additional effects of longer patent terms, we must turn to John Duffy's model of the patent system as an auction, a model that counterintuitively counsels in favor of increasing the length of the patent term even in the absence of a direct concern about patent nondevelopment. Ironically, we will see that the concern about patent nondevelopment ultimately complicates Duffy's case.

2. *Patents as Auctions*

While Martin and Partnoy consider the incentives of inventors who have already received patents, Duffy focuses on the incentives of inventors who race against one another in the hope of receiving them. Earlier commentators had noted the similarity of races and auctions in contexts including patent law, [32] but they had ignored an aspect of this analogy of crucial import to patent policy. A race, the earlier scholars realized, amounts to an "all-pay" auction in which each participant pays the amount of its bid, and participants with higher bids have greater chances of

[30] *Id.*
[31] *Id.*
[32] *See, e.g.*, Wolfgang Leininger, *Escalation and Cooperation in Conflict Situations*, 33 J. CONFLICT RESOL. 231, 233 (1989).

winning.[33] This analysis, however, tended to assume that patent races are like races at track meets, with all racers starting only after the gun goes off. Duffy's insight is that inventors can improve their "bids" and thus their chances of winning the race by committing resources to the race at an earlier time. The patent race is thus more like a treasure hunt in which each contestant may start at any time, and those who drag themselves out of bed earlier have an advantage over the others. Such a hunt would end earlier than one in which the starting time was fixed, and so too in a patent race will the race end earlier because participants are welcome to begin racing whenever they please.

Because the patent term is finite, inventors are racing not only to obtain a patent at the earliest possible time, but also in effect to place the invention into the public domain at the earliest possible time. The patent race provides a benefit to society, and Duffy analogizes it to a Demsetzian auction. In 1968, Harold Demsetz argued that instead of directly regulating the prices charged and quality of services provided by monopolists, the government might hold an auction for the right to be a monopolist, with the franchise awarded to the bidder who commits to the best price-quality package.[34] Similarly, a patent is awarded to one of the inventors who begin the race first,[35] thus agreeing to commit the invention to the public at the earliest possible time. If the auction is competitive, the Demsetzian approach to monopoly regulation pushes the returns of participants down to the level of zero economic profit. So too can the implicit patent auction lead inventors to start racing at the point in time at which they will earn no economic profit from doing so.[36]

The model of patents as Demsetzian auctions makes the patent nondevelopment problem more severe. To the extent that patent races push patenting to a very early stage, the risk that it will not be worth exercising the patent development option increases. In his original article,[37]

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[33] *Id.*; *see also* Michael R. Baye et al., *Rigging the Lobbying Process: An Application of the All-Pay Auction*, 83 AM. ECON. REV. 289 (1993) (providing an additional application for the all-pay auction model).

[34] Harold Demsetz, *Why Regulate Utilities?*, 11 J.L. & ECON. 55, 63 (1968).

[35] Duffy recognizes that research is probabilistic, and in an extension to his model he assumes that inventors will only have some probability in each period of successfully meeting the requirements for patentability. *See* Duffy, *supra* note 21, at 480 -83.

[36] *Id.* at 481 (assuming that "firms' expected profits are zero").

[37] In a subsequent article (written after Duffy read a draft of this one), Duffy recognizes the nondevelopment problem. *See* John Duffy, *Embryonic Patents: Prospects, Prophesies and* Pedis Possessio (2005) (unpublished manuscript, on file with author). Duffy notes that patent law tries to avoid the problem through the "abandoned experiment" doctrine, which allows abandoned experiments to be excluded from the prior art, and thus later patents on a technology to be obtained. *Id.* at 33-35. The doctrine, however, does not apply to a technology that is patented prior to abandonment, and so it does not address the patent nondevelopment problem. Duffy also suggests that patent law might allow a third party to repatent the commercialized realization of an abandoned patented invention. *Id.* at 36-38. As Duffy recognizes, however, "[c]urrent U.S. patent law has no

however, Duffy does not recognize the danger of patent nondevelopment, because he assumes that the costs and benefits of patenting are certain.[38] In the absence of uncertainty, an inventor would never patent an invention and then not commercialize the invention, because the patent process itself is costly. Uncertainty, however, makes it apparent that patents are options, and so as long as there is some chance that the option will be worth exercising, an inventor may have an incentive to seek a patent. An inventor will sometimes be willing to enter a patent race very early because of the possibility that an invention might turn out to be more valuable than expected. Thus, an inventor might obtain a patent fully expecting that the patent term will not be long enough to allow development of the patent, but betting on a small chance that the patent might be worth pursuing within the patent term.

Adding uncertainty to Duffy's model or early patenting to the Martin and Partnoy framework not only makes the patent nondevelopment problem more severe than it would otherwise seem, but also makes an appropriate solution more elusive. We have already seen that Martin and Partnoy's analysis might seem to provide support for a proposal to lengthen patent terms, and interestingly Duffy, in a separate article, also provides a basis for longer patent terms.[39] Lengthening the patent term might appear sure to delay the introduction of inventions into the public domain. But lengthening the patent term makes the acquisition of patents more attractive, and so leads to invention at an earlier time. Under certain assumptions in Duffy's mathematical model, this increased incentive effect dominates the delay effect, at least if the lengthening of the patent term is announced at an early enough point to allow patent racers to respond by entering the patent races earlier.[40] Lengthening the patent term thus leads to inventions being committed to the public domain at an *earlier* time. Duffy's analysis reverses the ordinary intuition: Longer (but nonretroactive[41]) patent terms will not benefit inventors as a class, because more will compete to drive down profits, but they will benefit the public by leading to inventions that fall into the public domain sooner.

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clear doctrine permitting" such repatenting. *Id.* at 36.

[38] Duffy, *supra* note 21, at 465-66 (making assumptions about the benefits and costs of patenting without allowing for the possibility of uncertainty).

[39] *See* John F. Duffy, *A Minimum Optimal Patent Term* (unpublished manuscript, 2004), *available at* http://www.ssrn.com/abstract=354282 (visited Aug. 21, 2005) (offering a model suggesting that an optimal patent term is about as long as the existing patent term or longer).

[40] *Id.* at 4-5.

[41] Duffy has argued against providing windfall retroactive term extensions for intellectual property rights. *See infra* note 133 and accompanying text.

Longer patent terms also might appear to have the benefit of reducing patent nondevelopment, but this is uncertain. If longer patent terms in fact result in patents being placed in the public domain even earlier, then it may never become worthwhile to exercise a development option that otherwise would have been worth exercising. There are, again, two competing effects. On one hand, the longer patent term will mean that if commercialization does occur relatively early, there will be more time periods in which the inventor can reap the benefits of commercialization, and the incentive to exercise the development option at some point before patent expiration will be greater. On the other hand, earlier invention might not mean earlier commercialization, and the effective patent term might be shorter. If we assume that increasing the length of the patent term has no effect other than on the particular invention at issue,[42] then if it would not have made sense to commercialize a patent until a particular year, then it still will not make sense to commercialize the patent until that year in a regime of longer patent terms. But after that year, there will be fewer years remaining in the patent term, if the longer patent term indeed has had the effect of making the date at which the invention is committed to the public domain earlier, and so there will be less of an incentive to exercise the development option. This story suggests that there in fact is a tradeoff in a longer patent term, though not the same tradeoff between static and dynamic efficiency that scholars have long imagined.[43] Rather, a longer patent term can lead to some inventions placed in the public domain earlier, but to a greater number of inventions abandoned. There might well be other more complicated stories,[44] but the welfare effects of systematic patent term extensions at least appear quite complicated.

[42] This assumption might be unjustified. For example, it might be that it does not make sense to commercialize a particular invention until another invention that is a complement to it is developed. But increasing the length of the patent term could also lead to earlier development of that invention.

[43] *See generally* WILLIAM D. HORDHAUS, INVENTION, GROWTH AND WELFARE 76 (1969) (providing the leading account of the competing effects of a longer patent term).

[44] If inventors anticipate that they will not be able to commercialize their inventions until a particular date, we might end up with precisely the opposite result: a reduced risk of nondevelopment, but a delayed introduction of the invention into the public domain. Suppose that it will not be feasible for a particular invention, not yet created, to be commercialized until the year 2025, and suppose that under the existing patent system, invention and patenting would occur in 2015, and the patent therefore would expire in 2035. If the patent term is lengthened by five years, but commercialization still cannot take place until the year 2025, invention will take place no earlier than 2010, with patent expiration still occurring in 2035. Because the invention will likely be more expensive to create in 2010 than in 2015, at least in present discounted value terms, the invention is in fact likely to take place sometime after 2010, say 2011. As a result, patent expiration will occur in 2036.

B. A Re-Rethinking of Prospect Theory

Even if the problem of patent nondevelopment does not justify a longer patent term, patent term extensions might still be useful on a case-by-case basis, if extensions could be granted for the particular patents for which nondevelopment appears to be a danger. We will consider whether this is feasible later.[45] The combination of the Martin and Partnoy approach and the Duffy approach, however, does point to a different possible solution: increasing the minimum threshold for patentability, thus decreasing the proportion of total expenditures on commercialization and invention that must still be made after a patent issues. Though concerned that the patent litigation option might be too attractive in comparison to the patent development option, Martin and Partnoy do not consider this approach, perhaps because they implicitly assume that the dates of invention and patenting are fixed. In *Rethinking the Prospect Theory of Patents*, Duffy, on the other hand, does consider the issue directly, but ends up offering the precise opposite recommendation: that patents should be granted at a very early stage, when they are mere patent prospects.[46]

Duffy's recommendation, however, might not be correct once patent nondevelopment is considered, because the prospect approach increases the risk of nondevelopment. A theoretical appreciation of patent nondevelopment is therefore important not solely because reforms to limit it could improve the efficiency of the patent system, but also because reforms that otherwise might be justified could aggravate the problem of patent nondevelopment. Whether surreptitiously or not, the patent system already to some extent takes the concern of nondevelopment into account by requiring substantial achievement before patents can be issued. Consideration of patent nondevelopment thus helps provide a richer positive explanation of the patent system's standard of patentability.

To understand how concerns about patent nondevelopment might counsel against the prospect theory, we must first understand how Duffy's recognition that the time of invention is endogenous to the patent system supports the prospect approach. If the hurdle for patentability is low, the length of the patent race will be shorter. This means that for each participant in the race, the amount of money the participant stands to lose assuming someone else receives the patent

[45] *See infra* Part III.

[46] Duffy, *supra* note 21, at 471 (offering an illustration of the thesis).

will be less. Inventors anticipate that the length of the patent race will be shorter, and thus that the amount of money that those who lose the patent race will have wasted will be smaller. The expected cost of racing is thus lower, and inventors will begin racing earlier than they otherwise would. This analysis provides an important new defense of the patent prospect approach. Even if, as some commentators have suggested,[47] inventive activity will develop more rapidly if inventors are racing against one another, it might still be useful for patent law to declare winners to races quickly, because the promise of a quick end to the race will make the race start earlier. While the original basis of Kitch's prospect theory was that provision of early and broad patents provided useful ex post incentives, for example by allowing inventors better to coordinate inventive activity,[48] Duffy's argument suggests that the prospect approach offers benefits before the patent initially is issued. The debate on prospect theory is central to an assessment of how high the hurdle for patentability ought to be, and Duffy's contribution helps to demonstrate that concerns about wasteful duplication of effort should matter even to those who adhere to the traditional reward approach to patent law. Wasteful duplication matters not only because it suggests that resources are being diverted from other activities, but because the prospect of such duplication will discourage research in the first place.

Nonetheless, the concern about patent nondevelopment provides a countervailing concern that should at least make policymakers pause before advocating very low hurdles for patentability. The lower the threshold for obtaining a patent, the cheaper the patent option will be to purchase initially, and the greater the danger that the option will never be exercised. To the extent that the patent system acts as an auction for a reduced patent term, it might advance social welfare by accelerating the entry of an invention into the public domain, but it might reduce social welfare by increasing the risk that an inventor will not develop or will not commercialize an invention. Duffy's analysis ultimately highlights why nondevelopment of patents might be an

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[47] *See, e.g.*, Robert P. Merges & Richard R. Nelson, *On the Complex Economics of Patent Scope*, 90 COLUM. L. REV. 839, 908 (1990) ("Public policy . . . ought to encourage inventive rivalry, and not hinder it. [A] rivalrous structure surely has its inefficiencies. But such a structure . . . seems a much better social bet than a regime where any one or a few organizations control the development of any given technology."); *see also* Mark Lemley, *Ex Ante Versus Ex Post Justifications for Intellectual Property*, 71 U. CHI. L . REV. 129, 141 (2004) (concluding that the empirical literature supports the proposition that research will progress faster when no initial inventor is able to control research); Tim Wu, *Intellectual Property, Innovation, and Decision Architectures*, VA. L. REV. (forthcoming 2005) (arguing that decentralized decisionmaking, as occurs in the absence of patent protection, might produce more breakthrough inventions).

[48] Kitch, *supra* note 10at 276.

even more serious problem than waste in the real property context.[49] If the patent process functions as a declining term auction, then effective patent terms might be quite short. Inventors will not seek patents if they know for certain that by the time they complete development, there will not be sufficient term remaining to allow them to recoup their costs. But the expected net benefits of development might change after a patent is issued, and a project that initially appeared likely to be profitable might become unprofitable. Moreover, the possibility that the expected net benefits will rise might lead inventors to obtain patents very early for their option value, even when they expect that it likely will never be profitable to develop them.

To make these points more formally, I will begin with a numerical example that Duffy uses to explain his case,[50] and I will then show how adding uncertainty into the model might alter Duffy's conclusions. In the numerical example, a single firm will obtain a patent in the first year at which obtaining the patent would produce positive rents, recognizing that if it did not incur the costs necessary to obtain the patent in that year, another firm would. The invention produces social benefits that grow at an annual rate of 5%, reaching $10 per year in 2010 and higher levels beyond. The cost of the invention is $100 in the year in which the invention occurs, but a prospect patent costs only $1 in the year it is obtained, with the invention then costing $99 to complete in the year of invention. Finally, the annual rate of return on capital (i.e., the discount rate) is 10 percent.

With these assumptions, we can calculate for different regimes the present discounted value of the net social benefits of the prospect system and of a stylized nonprospect system, in which no patent is granted until an invention is fully developed. We can also calculate for each system, the year at which patenting and commercialization will occur (which will by definition be the same for the nonprospect system). The ultimate goal of this analysis is to show how the problem of patent nondevelopment might strengthen the case for a nonprospect system. To do this, we will integrate a point suggested by Martin and Partnoy, that the costs and benefits of patenting may be uncertain, directly into the Duffy model. To provide for a more complete analysis of the threshold for patentability, however, we will first relax some other assumptions in

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[49] *See supra* note 1 (discussing how real property deals with the problem of waste).

[50] *See id.* at 465-66. Duffy does not explicitly calculate the social benefit of a prospect system compared to a nonprospect system. While he notes that the prospect system produces a social gain from the innovation entering the public domain sooner, *see id.* at 469, he does not note that this gain is partly offset by the innovation's being introduced later in a prospect system than in a nonprospect system.

Duffy's model: first, that the public obtains no value from a patent during the patent term besides what is captured by the patentee; and second, that a patent race always produces a unique winner.

1. Appropriability of Social Surplus

In the simplest version of his model, Duffy illustrates that a patent prospect system can produce patenting, and thus entry into the public domain, two years earlier than a nonprospect system.[51] This simple example illustrates a previously unrecognized consequence of Barzel's point that the right to delay inventive efforts provides benefits to the patentee. Because the returns to the patentee count in social welfare, the patentee's right to delay can increase social welfare. It might seem at first glance, however, that the public would suffer from delayed introduction of the invention to the public. Barzel placed aside this effect by assuming that an inventor could appropriate the full social surplus of an invention, thus placing aside the interest of the public altogether. He recognized, however, that relaxing this assumption might mean that invention would occur too late, rather than too early.[52] Duffy's analysis is important because it shows that the right to delay can benefit not only the inventor, but also the public, which receives the invention earlier.

By considering the effects of patent expiration, Duffy's model thus relaxes the assumption in Barzel's model that the patentee captures all the social surplus of the invention. Duffy, however, continues to assume "that the patentee captures all of the social benefits *during the patent term*."[53] This assumption is unrealistic, because a patentee is unlikely to be able to engage in perfect price discrimination, and because a patentee will not be able to prevent all uncompensated uses of the information in the patent. Once we relax this assumption, we can show that even if the prospect system results in inventions being placed in the public domain earlier than a nonprospect system (i.e., one in which one must complete development of the invention before obtaining a patent), it might reduce social welfare by inefficiently delaying the introduction of the invention.

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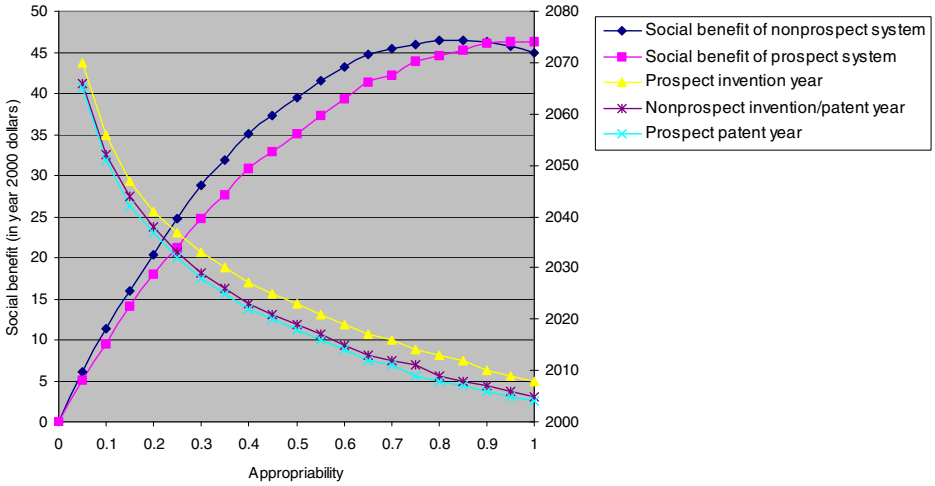
[51] Duffy, *supra* note 21, at 469.
[52] Barzel, *supra* note 13, at 355 tbl.2.
[53] *Id.* at 466.

Figure 1 illustrates the effect of allowing the portion of rents that are appropriable to vary.[54] The x-axis reports the proportion of the social benefits of the patent that the patentee, rather than the public, is able to appropriate. The left y-axis reports the present discounted value of the total social benefits of the patent, including those captured by the patentee and those captured by the public. The curves beginning at the lower-left of the graph show this value for both a prospect system and a nonprospect system for each possible appropriability proportion. The right y-axis, meanwhile, represents years, and the curves beginning at the upper-left show the year that patenting will take place in the prospect and nonprospect systems, and the year that invention will be completed in the prospect system, which is the system that allows the patentee to delay completion of the invention until after the patent.

Figure 1. Effect of varying appropriability on social benefit and years of patenting and invention



As Duffy's analysis suggests, the patent system leads to slightly earlier patenting and yet later invention in a prospect system than in a nonprospect system, and this holds regardless of the proportion of the social benefit that the inventor can capture. A prospect system produces greater total discounted social benefits than a nonprospect system when the inventor can appropriate all the social benefits of the patent during the patent term, but the difference is very small. Atlower levels of appropriability, moreover, a nonprospect system produces somewhat greater social

[54] The numbers used to derive the numbers in this and subsequent charts were obtained from a computer program developed in C++. The program is available from the author. The program calculates benefits and costs from the year 2000 to the year 2250 and discounts those benefits and costs to the year 2000. Because the discount rate is higher than the rate of growth, the effect of years past 2250 on the present discounted value of social welfare in the year 2000 is trivial.

benefits than a prospect system. The delay between the acquisition of the prospect patent and the date of invention is socially excessive, because the patentee does not fully internalize the social benefits of earlier development of the invention. A prospect system might thus cause excessive delay in a world in which the spillovers from patents are relatively high.[55]

2. Multiple Participants in the Race

This numerical example, of course, should not lead to a conclusion that nonprospect systems dominate prospect systems in the real world. Slight changes in assumptions could reverse that conclusion.[56] Most significantly, Duffy argues that a significant virtue of a prospect system is that it reduces duplicative efforts to develop an invention.[57] But in Figure 1, there is no duplication of efforts. The first inventor willing to bear the costs of the invention immediately spends the needed sums and wins the race.

Figure 2 modifies this by assuming that two firms are competing for the patent and continuing to invest equal resources in obtaining the patent until, at the moment of patenting, the patent is issued to one firm or the other. In this figure, the benefit of limiting duplication is sufficient to ensure that a prospect system comfortably dominates a nonprospect system for the full range of appropriability values. A principal reason for this is that invention occurs much earlier with the prospect approach, because the promise of reduction in duplicative effort leads the firms to start racing earlier. Of course, this figure should not lead one to conclude that a nonprospect system necessarily dominates the prospect system either. With changes in some of Duffy's other assumptions, the nonprospect system once again can catch up to the prospect system. In particular, consider the possibility that the award of a patent may not end a patent race.

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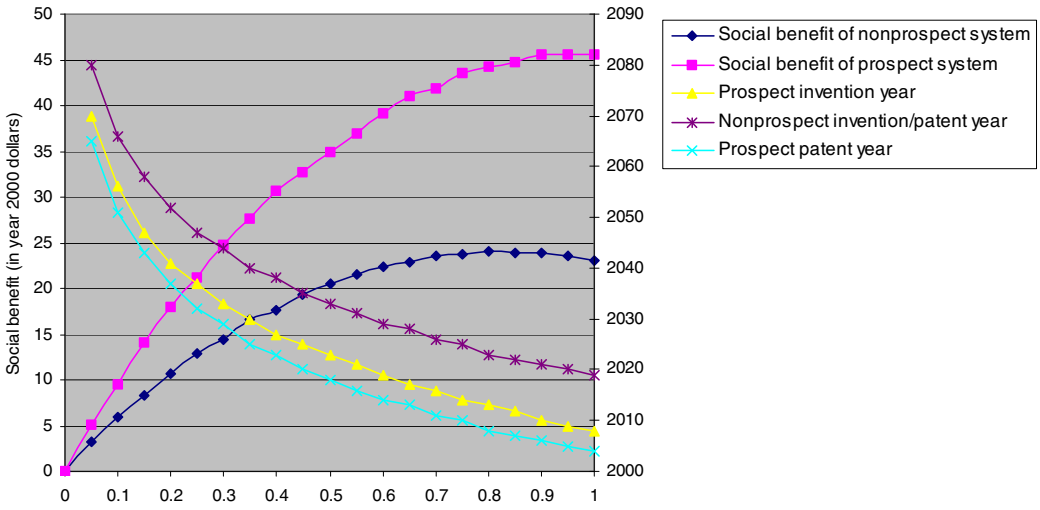
[55] For studies suggesting that there are considerable spillovers from patents and other research and development, see Timothy F. Bresnahan, *Measuring the Spillovers from Technical Advance: Mainframe Computers in Financial Services*, 76 AM. ECON. REV. 742, 753 (1986); and Edwin Mansfield et al., *Social and Private Rates of Return from Industrial Innovations*, 91 Q.J. ECON. 221, 234 (1977).

[56] For example, it would be more realistic to assume that once the invention enters the public domain, social benefits increase somewhat, because there is no longer deadweight loss. This seems likely to have only a slight effect in Figure 1, however, because the dates of patenting in the prospect and nonprospect system appear quite close.

[57] *See* Duffy, *supra* note 21, at 469-75; *see also id.* at 443-44 (noting that this is not necessarily counterbalanced by increased competition to obtain the patent prospect, because rents also can be dissipated by earlier patenting).

Figure 2. Two firms competing for the patent



Under Kitch's view of prospect theory, patents should be granted early and broadly. Duffy argued that patents need not be broad,[58] but his model implicitly assumed that patents would be sufficiently broad to ensure that there is only one winner to the patent race. Yet we know that patents using distinct technologies might target the same consumer market. For example, although Prozac was the first selective serotonin reuptake inhibitor, a number of other SSRI's since the introduction of Prozac have earned patents and market share.[59] Each drug might have somewhat different characteristics that might make each optimal for different types of patients.[60] To the extent that "inventing around" produces patents with overlapping functionality, however, the same inefficiency that might characterize patent races can exist. In effect, where different inventors are pursuing different technological means to the same or a similar outcome, a patent race can have multiple winners.

As Figure 3 shows, the existence of multiple winners to a patent race largely eviscerates the benefits of a prospect system relative to a nonprospect system. As in Figure 2, two firms are racing against one another for patents, but in Figure 3, both firms obtain patents. Unsurprisingly,

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[58] Duffy, *supra* note 21, at 499-500.

[59] *See Which SSRI?*, 45 MEDICAL LETTER 93 (2003) (providing an overview of different SSRIs).William Landes and Richard Posner use SSRIs to illustrate the point that a patent race may have multiple winners. *See* WILLIAM N. LANDES & RICHARD A. POSNER, THE ECONOMIC STRUCTURE OF INTELLECTUAL PROPERTY LAW 301-02 (2003).

[60] *Which SSRI?*, *supra* note 59at 93 ("Some patients who fail to respond to one SSRI may respond to another, possibly because of differences in tolerability.") (citation omitted).

the dramatic benefits of the prospect system in reducing duplication disappear. In Figure 3, even though the patentees are working on different technological means to the same end, they are nonetheless effectively duplicating one another's efforts after the patents are received. The prospect system thus differs from the nonprospect system only in that the prospect system continues to allow inventors to delay innovation, as in Figure 1. Thus, once again, there is a slight advantage for the prospect system with complete appropriability of social surplus and a slight advantage for the nonprospect system with incomplete appropriability. The early granting of patents will improve welfare only to the extent that early patents succeed in discouraging other players from engaging in further inventive activity.

Figure 3. Two firms competing for two patents

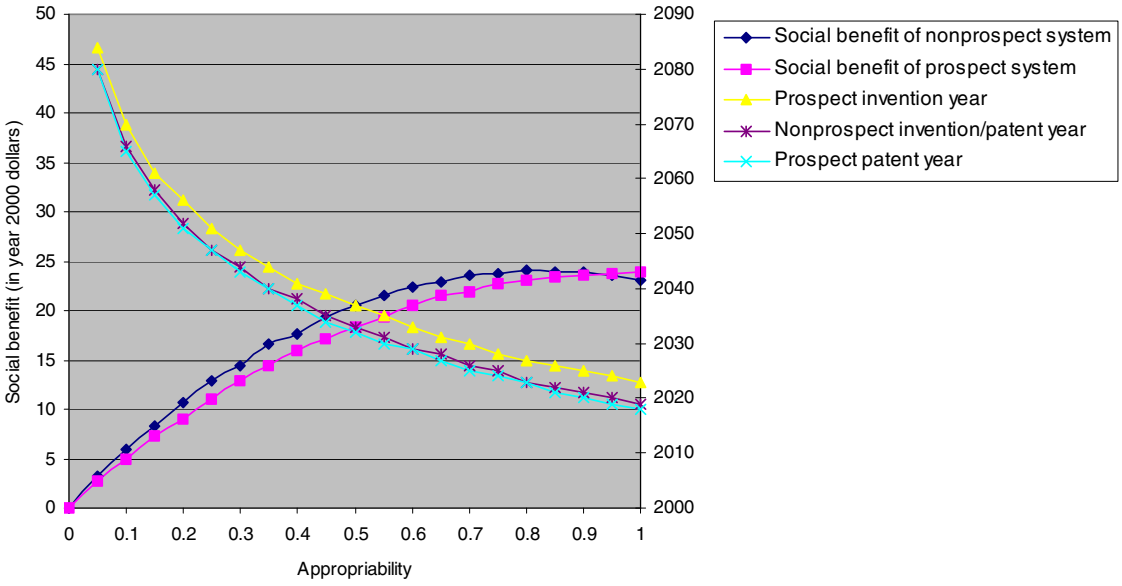

Figure 3 does not take into account that a patent system that results in multiple patents targeting the same consumer demand might produce other benefits, such as a greater range of products from which consumers can choose and reduced prices.[61] These considerations, however, generally militate against a prospect system that gives broad control to a patentee. A patentee might not develop a product within the scope of the original patent that provides some subset of consumers with a benefit relative to the original product, even if a competitor would develop the

[61] These benefits provide some of the justification for a recent proposal for a nonexclusive patent system. *See* John S. Leibovitz, Note, *Inventing a Nonexclusive Patent System*, 111 YALE L.J. 2251 (2002) (arguing for a patent system that would grant patents to more than one participant in the patent race).

product in a world in which the second product were not covered by the first product's patent. The patentee, unlike the competitor,[62] takes into account that some of the customers of the new product will be switching from the old product. If greater product development and variety benefit consumers,[63] then broad prospect rights are likely undesirable. The existence of alternative possible technologies to serve the same market demand serves as an additional consideration that undermines the case that a prospect system necessarily dominates a nonprospect system.

3. Uncertainty of Costs and Benefits of Patenting

Taken together, the analysis so far might appear to indicate that the consequence of the delay in a prospect system between the patent grant and the date of invention is slight, at least relative to the consequence of duplicative efforts. Delay, however, can have a pernicious effect that assumptions underlying Figures 1 through 3 obscure. Delay increases the risk that a patentee will decide *not* to develop a patent. In the analysis so far, the benefits and costs of developing a patent are entirely predictable in advance, and so a patentee will never receive a patent that the patentee later regrets. In the real world, however, after a patent is issued, the patentee's estimate of the demand for the patented product or process might change, as might the patentee's estimate of the cost of developing the patent. If benefits turn out to be smaller than anticipated or costs turn out to be greater than anticipated, the patentee might decide not to invent the patent within the patent term.

Figure 4 illustrates the result of a simulation model incorporating such uncertainty. The simulation introduces a stochastic shock that occurs immediately after the year in which a prospect patent would be obtained. This shock results in the anticipated benefits changing by an amount randomly selected from a uniform distribution of -25% to 25%, and independently, the anticipated costs changing by an amount randomly selected from the same distribution. In a prospect system, the decision of whether and when to seek a patent will depend on these

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[62] The failure of a market entrant to care that some of its business is coming at the expense of existing market participants is known in the industrial organization literature as "demand diversion" or "business stealing." *See generally* N. Gregory Mankiw & Michael D. Winston, *Free Entry and Social Inefficiency*, 17 RAND J. ECON. 48 (1986) (showing how this failure may lead to economically efficient entry).

[63] The economic literature on product differentiation suggests that it is possible to have too many or too few differentiated products in an imperfectly competitive market. *See, e.g.*, Avinash K. Dixit & Joseph E. Stiglitz, *Monopolistic Competition and Optimum Product Diversity*, 67 AM. ECON. REV. 297 (1977).

Figure 4. Uncertainty as to the costs and benefits of patenting

Appropriability	Prospect social benefit	Prospect patent year	Prospect development occurs	Prospect invention year	Nonprospect social benefit	Nonprospect development occurs	Nonprospect patent year	Ratio prospect nonprosp
0	0		0		0	0		
0.05	0.37143	2057	0.042	2061.67	3.1947647	1	2080.47	0.116
0.1	0.443	2042	0.025	2046.64	6.1723387	1	2065.98	0.0717
0.15	1.04411	2034	0.042	2038.55	8.7257142	1	2057.74	0.119
0.2	1.11513	2028	0.035	2032.69	11.02448	1	2051.95	0.10
0.25	0.83702	2023	0.021	2027.62	13.333341	1	2047.14	0.0627
0.3	1.84308	2020	0.042	2024.55	15.472943	1	2043.27	0.119
0.35	1.85189	2017	0.038	2021.42	17.066944	1	2040.31	0.108
0.4	2.17631	2014	0.04	2018.5	18.539468	1	2037.82	0.117
0.45	1.57793	2011	0.026	2015.73	20.32783	1	2035.14	0.0776
0.5	4.28689	2010	0.071	2014.52	21.134152	1	2033.12	0.202
0.55	1.41638	2007	0.021	2011.76	22.363857	1	2031.07	0.0633
0.6	3.56508	2006	0.052	2010.46	23.284992	1	2029.23	0.153
0.65	5.04384	2005	0.074	2009.39	23.669679	1	2027.74	0.213
0.7	3.62406	2003	0.049	2007.35	24.709464	1	2026.05	0.146
0.75	2.55688	2001	0.033	2005.55	24.622176	1	2024.74	0.103

distributions. For each appropriability value (in 0.05 increments), the patent race begins in the first year in which the average private benefit from racing is anticipated to be positive, based on 1000 simulations of the costs and benefits of patenting in different years and taking into account the benefit of being able to delay invention after the award of the patent. Even with this relatively simple model and relatively small level of uncertainty, Figure 4 shows that the results were dramatic.[64] The nonprospect system now easily dominates the prospect system. In a large percentage of cases,[65] the prospect patent is obtained so early that development of the invention never occurs, and thus there are no social benefits from it. This is so even though Figure 4 assumes that two firms are competing for the patent and that the patent race will end as soon as a patent is received.

Negative shocks are not the primary explanation for this dramatic change. Rather, the possibility of positive shocks increases the risk of patent nondevelopment. The possibility of positive shocks leads to earlier patenting. When patenting is relatively cheap, it might be worthwhile to obtain a patent even at a time when it is highly unlikely that it will be practical to develop the patent, as long as there is some chance that a patent might become worth developing. In these cases, the inventors are obtaining patents for their option value. When they do so, there

[64] In Figure 3, the prospect invention year line reflects only those cases in which the patent in fact is developed. A consideration of the gap between receipt of a patent and the time of development thus understates the results.

[65] For example, when the appropriability factor is 0.5, the invention is developed in the prospect system only 5.4% of the time. Note that in Figure 3, the prospect invention year refers to the average year of invention only in those cases in which the invention is in fact developed. The development rate predictably increases with higher levels of appropriability. Note that this simulation was run beginning in 1980, not 2000, because with uncertainty, it became profitable to acquire patents earlier. The prospect patent year line, which is cut off in the graph, descends to 1996 with appropriability = 1.0.

is a substantial risk that they will not have enough of a patent term in which to develop their inventions.

Nonetheless, Figure 4 should not be read as an indictment of our patent system, and indeed this analysis might support the existing patent system, for two reasons. First, the development of the patent sometimes will produce improvement patents. An inventor will be willing to invest in development if that investment will have the effect of extending the patent term. Figure 4 implausibly assumes that when there is insufficient patent term to justify development of the invention, the invention will *never* be developed. More realistically, first-mover advantages eventually will make it profitable for someone (perhaps the original patentee) to develop both the invention and a patentable improvement, in exchange for a patent on the improvement. Of course, the same risk of nondevelopment applies to improvement patents, and there is some risk that these too might not be developed. Nonetheless, the danger of patent nondevelopment strengthens the case for a patent system that allows improvement patents. The analysis thus counters arguments that improvement patents inappropriately allow patentees to extend the lives of their patents.[66]

Second, and more importantly, our patent system is not a pure prospect system, but in fact lies somewhere between the prospect and nonprospect approaches illustrated. For most inventions, it seems likely that more than 1% of the cost of the invention process (the assumption in Duffy's numerical example) must be spent before the patent will issue.[67] The analysis in Figure 4 suggests only that an extreme version of a prospect system might lower social welfare by increasing nondevelopment. The higher the hurdle for patentability, the more expensive the patent option is, and the less expensive it will be to complete the commercialization process.

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[66] *Cf.* Thomas L. Irving & Michael D. Kaminski, *Double Patenting: One Way, Two Way; Whose Delay?*, 1 U. BALT. INTELL. PROP. L.J. 180, 185-86 (1993) (considering policy justifications in support of the doctrine preventing "double patenting" of the same invention as a means of extending patent term).

[67] Further simulations reveal that if 10% of the cost of the invention process is demanded before eligibility for a patent, then the development rate rises to about 82% if half of the social benefit is appropriable, and with 50% of the cost of the invention process demanded, all inventions are developed, according to additional simulations. But this should not lead to complacency that nondevelopment is a nonproblem, because the assumed shock distribution, with an absolute value averaging 12.5%, is very conservative. With many patented products, there will be substantial uncertainty about the cost of completion and especially about the benefit, because even many developed products turn out to be commercial disasters. With 50% of the cost of the invention process demanded in the prospect system and an absolute average shock of 37.5%, only about 25% of inventions will be developed and a nonprospect system produces greater social value than the prospect system. As these numbers suggest, more empirical analysis of the information available to inventors is necessary before confident assessments about the relative merits of a prospect system and a nonprospect system can be made. A more complete model would also need to consider the effects of asymmetric information among racers and the possibility that different racers may have information about the relative success of other racers' efforts.

Accordingly, if a greater investment is required before a patent issues, the danger that patentees will patent so early that they will have insufficient patent term in which to develop the invention will be lower. Assuming that with our patent system the process of invention generally costs considerably more than 1% of the full costs of development,[68] our patent system might well strike roughly an appropriate balance between granting prospects too early and granting them too late. Kitch's and Duffy's arguments in favor of a prospect system remain powerful, though analysis of the problem of nondevelopment suggests that these arguments can be taken too far.

II. TOWARD AN EMPIRICAL ASSESSMENT

Patent underdevelopment is difficult to measure empirically. The first question is how patentees might have behaved differently if it were possible to obtain a longer patent term, and the second question is whether the difference in behavior would have had positive or negative consequences for social welfare. The first question is counterfactual, and absent a natural experiment in which some patents randomly receive patent term extensions, there is little if any data from which we might extrapolate an answer. Measuring what is happening in the patent system is difficult enough;[69] measuring what might happen in a patent system different from the one we have now is virtually impossible absent experimentation. And even if we knew, say, the additional number of patents that would be commercialized given patent term extensions, the second question would be challenging. Although scholars have made some progress in developing methodologies for valuation of patents,[70] calculating social benefits will be more difficult still.[71]

Although direct empirical measurement will likely thus be impossible, we can nonetheless make some progress on assessing the patent underdevelopment problem by identifying particular situations in which underdevelopment or nondevelopment might arise and thus informally inquiring into the extent of the danger. The theoretical model of Part I suggests

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[68] For an argument that the patent system does not in fact give as much control over future development as Kitch claims, see Beck, *The Prospect Theory of the Patent System and Unproductive Competition*, 5 RES. L. & ECON. 193 (1983). The requirements for a patent, moreover, are nontrivial, so an assumption that patents are granted when only a tiny fraction of the work is completed may be unrealistic.

[69] For examples of work that seek to overcome these difficulties, see John R. Allison et al., *Valuable Patents*, 92 GEO. L.J. 435 (2004); and James Bessen & Eric Maskin, *Sequential Innovation, Patents, and Imitation* (MIT Working Paper Dept. of Econ., Nov. 1999).

[70] *See, e.g.*, F. Russell Denton & Paul J. Heald, *Random Walks, Non-Cooperative Games, and the Complex Mathematics of Patent Pricing*, 55 RUTGERS L. REV. 1175 (2003).

[71] *See* articles cited *supra* note 55 (seeking to measure spillovers from research activity).

that the patent system already responds somewhat to the danger by establishing a relatively high threshold for patentability. Part II.A develops a corollary, that the problem of patent underdevelopment will be greatest where patent protection is provided at an early stage. In technological fields for which the patent system most resembles a prospect system, and thus fields in which a great deal of development must occur after patenting, patent underdevelopment will be a danger, except to the extent that the legal system counters it. Whether patent underdevelopment occurs also will depend on the degree to which development activities will themselves be entitled to legal protection. Part II.B identifies three types of development activities—scientific experimentation, market experimentation, and marketing—that produce information that a patentee cannot protect with intellectual property. Finally, Part II.C assesses whether the underdevelopment problem vanishes to the extent that the development activity consists of improving the invention. Although improvements generally are patentable, some may be unpatentable or not worth patenting, and inventors may have socially suboptimal incentives late in the patent term to develop even patentable improvements.

A. Embryonic Inventions

The standards the existing patent system demands for granting patents are nontrivial. An invention must be new and nonobvious, and although many commentators argue that the patent office and courts allow many patents that ought not to be seen as meeting these requirements,[72] the patent system presumably weeds out most inventions that are plainly anticipated in the prior art, or at least in easily accessible prior art. Perhaps more importantly from our perspective, a patentee must offer a written description of the invention that would enable a person having ordinary skill in the art to create it.[73] To meet the doctrinal requirements, an inventor ordinarily will at least have to think carefully about the invention and about the "best mode" for practicing it.[74] The costs of inventing and of patenting are sufficiently large that inventors will at least

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[72] *See, 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 (2004).

[73] There is some debate about whether the written description and enablement requirements are distinct or one in the same. *See* Univ. of Rochester v. G.D. Searle & Co., 375 F.3d 1303 (Fed. Cir. 2004) (Newman, J., dissenting from the denial to rehear the case en banc) (noting a "burgeoning conflict in pronouncements of this court").

[74] *See* Bayer AG v. Schein Pharmaceuticals, Inc., 301 F.3d 1306, 1323-24 (2002) (Rader, J., concurring) (discussing the best mode requirement).

hesitate if there is a very high probability that the options that the patent provides will not be worth exercising.

Nonetheless, as John Duffy points out in a recent article, in many respects, patent law tolerates embryonic invention. For example, "[n]o working models are required,"[75] and indeed "[t]he inventor need not ever have built or tested the invention."[76] The willingness to grant patents early will reduce wasteful duplication and promote patent races that take place at an earlier time,[77] but, as this Article suggests, might also increase the risk of patent underdevelopment. Eventually, the inventor will need to create a working model or build and test the invention, if the inventor is to exercise the patent's development option. Even if the cost of these development activities is the same before and after patenting, because the patent system does not require that these development activities occur before the patent is issued, the cost of exercising the development option after receiving the patent will be greater than if these development activities were prerequisites to receiving a patent. The higher exercise price means that the option is less likely to be developed.

In some fields, the cost of developing inventions will be particularly high. The pharmaceutical field is perhaps the most obvious example. Even Mark Lemley, who is generally critical of Kitch's prospect theory and of the possibility that the award of a patent might provide *ex post* as well as *ex ante* benefits,[78] has acknowledged that the pharmaceutical industry might be an example in which the prospect theory is both descriptively accurate and normatively justifiable.[79] The patent system hypothetically could grant grants only after the manufacturer receives FDA approval of the drug, based on studies establishing safety and effectiveness. But there would be obvious problems with such a regime. Pharmaceutical companies might be less willing to invest in the early stages of research if it were difficult to maintain their findings as trade secrets, because other companies might specialize in testing promising substances found by others. There is, however, a cost to the existing approach. A pharmaceutical company might

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[75] Duffy, *supra* note 37, at 6; *see also* In re Strahilevitz, 668 F.2d 1229, 1232 (C.C.P.A. 1982) (holding that working models need not be submitted for patents to be obtained).

[76] Duffy, *supra* note 37, at 6.

[77] *See* Part I.B.2.

[78] *See* Lemley, *supra* note 47.

[79] *Id.* at 141 ("Prospect theory is needed when control over subsequent development is a necessary part of the incentive to produce the pioneering invention in the first place, as is arguably true with pharmaceuticals.").

receive a patent on a drug and then not develop that drug as much as it would if patent protection were granted at a later stage of development.

Given the uniquely high cost of developing pharmaceutical products, it should not be surprising that there exist idiosyncratic responses to the problem of patent nondevelopment. (Thus, once again, recognition of the problem of patent nondevelopment is as important in helping to explain and justify existing features of the patent system as it is in suggesting the possibility of reforms.) For example, the Orphan Drug Act provides seven years of exclusivity to a drug company that is willing to take the drug through the clinical testing and governmental approval processes.[80] Congress recognized that even if a given medication existed, there might be insufficient incentives for any company to conduct the scientific testing needed to establish whether the drug is safe. Although the Act focuses specifically on drugs for diseases suffered by 200,000 or fewer individuals,[81] the Act also provides for protection in cases in which in the absence of protection, there would be no means of recovering research costs.[82] The Act can even provide for protection for a drug that still has some patent protection remaining,[83] thus in effect allowing for an extension of the patent term.

The Hatch-Waxman Act provides additional accommodations to the patent underdevelopment problem.[84] Hatch-Waxman provides for patent term extensions equal to half of the time needed to investigate the new drug plus the time taken by the FDA to review the new drug application.[85] The statute thus recognizes that some inventions require greater development time and costs and extends the patent term to reduce the risk that it will not be worthwhile to exercise the development option, or still worse, that it will not be worthwhile to create such inventions in the first place. Interestingly, the statute addresses the concern of patent underdevelopment with a stick as well as a carrot. If a patentee is not diligent in developing an

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[80] Orphan Drug Act, Pub. L. No. 97-414, 96 Stat. 2049 (1982) (codified as amended at 21 U.S.C. §§ 360aa-360ee (1994), 26 U.S.C. § 45C (Supp. II 1994), 42 U.S.C. § 236 (1994)). The seven-year exclusivity provision is found in 21 U.S.C. § 360cc(a).

[81] 21 U.S.C. § 360bb(a)(2)(A).

[82] *Id.* § 360bb(a)(2)(B).

[83] *See* Orphan Drug Amendments of 1985, Pub. L. No. 99-91, 99 Stat. 387 (1985).

[84] For an overview of Hatch-Waxman and its legislative history, see Gerald J. Mossinghoff, *Overview of the Hatch-Waxman Act and Its Impact on the Drug Development Process*, 54 FOOD & DRUG L.J. 187 (1999).

[85] 35 U.S.C. § 156. The statute, however, allows for a maximum extension period of five years, and no more than a fourteen-year period of market exclusivity.

invention over a period of time, the period of lack of diligence is subtracted from the sum of the terms that is used to calculate the patent extension period.[86]

Within the pharmaceuticals area, one context in which the problem of patent underdevelopment might be particularly acute is genomics. Identifying a genetic sequence is only the first step toward identifying a particular therapeutic use for that sequence, and one danger of granting patents in gene sequences is that by the time research develops to the point where a therapeutic use might be on the horizon, the patent might have expired,[87] or too little patent term will be available to make research financially worthwhile. Nonetheless, property rights in genetic sequences might be useful to reduce the danger of duplicative research and to assure potential researchers that others will not free-ride off their efforts. The Patent and Trademark Office's Utility Guidelines provide a partial solution to this problem,[88] requiring that applications for gene sequences demonstrate a specific and substantial utility, but it is possible that broader property rights coupled with a longer patent term might increase development incentives.

Industry-specific responses such as the Orphan Drug Act, the Hatch-Waxman Act, and the Utility Guidelines help limit the danger of patent underdevelopment, and the theory developed in this paper provides a justification for including such legal regimes as supplements to the patent system within our system of innovation. Nonetheless, the existence of such protection cannot provide confidence that the patent system has entirely conquered the danger of patent underdevelopment. Genomic inventions provide one example of a field in which these responses might be inadequate to foster an optimal amount of further research and development, and there is no guarantee that the additional periods of exclusivity provided by the Orphan Drug Act and the Hatch-Waxman Act will be long enough even for non-genomic drugs. Moreover, it remains possible that there exist many individual inventions in other technological fields that

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[86] *Id.* § 271(e)(1) (overturning the result of Roche Products v. Bolar Pharmaceuticals, 733 F.2d 858 (Fed. Cir. 1984)).

[87] The genomics revolution also presents a related problem: Once it becomes feasible to test many people for individual genetic variations, testing of many existing treatments will be needed to determine which groups can benefit from those treatments, but in the absence of protection for the underlying treatments, there will be little incentive to engage in such testing. *See* Arti K. Rai, *Pharmacogenetic Interventions, Orphan Drugs, and Distributive Justice: The Role of Cost-Benefit Analysis*, 19 SOC. PHIL. & POL'Y 246, 249-51 (2002).

[88] Utility Examination Guidelines, 66 Fed. Reg. 1092 (Jan. 5, 2001). The concern animating the Guidelines was not the problem of patent nondevelopment, but simply the concern that patents were being granted without sufficient inventive accomplishment. *See generally* Lawrence T. Kass & Michael N. Nitabach, *A Roadmap for Biotechnology Patents? Federal Circuit Precedent and the PTO's New Examination Guidelines*, 30 AIPLA Q.J. 233 (2002) (providing an overview of the Guidelines).

would be developed if only more patent term remained. Although "prophetic"[89] claiming of anticipated research results is particularly significant in the biotechnology sector,[90] it occurs in other technological areas as well,[91] and generally signals that continued development will be necessary after the patent is issued. The next section identifies the specific types of development that patentees might not perform.

B. Nonpatentable Development

One possible solution to the problem of patent underdevelopment is for the patent system to reward development activity with a patent term extension. We have seen that the Hatch-Waxman Act adopts a version of this approach,[92] and later we will consider the possibility of a systematic approach to patent term extensions.[93] The patent system, however, already has a built-in mechanism providing additional patent term for development activities: the system of improvement patents. If an improvement to a patented invention or inventions itself meets the criteria for patentability, an improvement patent issues.[94] When the recipient of an improvement patent is a third party, then both the original inventor and the third party own "blocking" rights preventing the other from practicing the new technology during the term of the relevant patents.[95] When the original inventor receives an improvement patent, then there is no blocking, but the original inventor receives a fresh patent term, although third parties will be permitted to practice the original invention after the end of the original term.

By providing an exclusivity reward for improving the original invention, the patent system might encourage some development activity that otherwise would not have occurred as a result of the finite patent term. Nonetheless, improvement patents cannot serve as a complete solution to the problem of patent nondevelopment. The primary reason is that some forms of

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[89] Under patent claiming rules, "[s]imulated or predicted test results and prophetical examples . . . are permitted in patent applications." PTO Manual of Patent Examining Procedure § 608.01(p)(D) (2005).

[90] *See, e.g.*, Harold C. Wegner & Stephen Maebius, *The Global Biotech Patent Application*, 666 PLI/Pat. 87, 96-97 (2001) (discussing the challenges of prophetic claiming of biotech patents).

[91] *See, e.g.*, Energy Absorption Sys. v. Roadway Safety Srvcs., Inc., 1997 WL 368379, **5 (Fed. Cir. 1997) (discussing the prophetic examples doctrine in the context of a mechanical invention).

[92] *See supra* notes 84–86 and accompanying text.

[93] *See infra* Part III.

[94] *See supra* note 6 and accompanying text.

[95] *See generally* Michael S. Mireles, *An Examination of Patents, Licensing, Research Tools, and the Tragedy of the Anticommons in Biotechnology Innovation*, 38 U. MICH. J.L. REFORM 141, 168 (2004) (explaining the phenomenon of blocking patents).

patent development do not themselves entitle the original patent holders to new patents.[96] If third parties will be able at least partly to free-ride on such development activities after the patent term, patentees might have insufficient incentive to engage in them during the patent term. These include investments to perform studies assessing the effectiveness of the invention, to test commercially the public's demand for the invention, and to inform consumers or others about the invention.

1. Scientific Testing

The most obvious, though perhaps not the commercially most significant, form of unpatentable development activity is scientific testing of an invention.[97] The need to encourage scientific testing of inventions is particular acute for pharmaceuticals, thus helping to explain particular statutory responses such as the Orphan Drug Act.[98] A wide range of inventions, however, might benefit from further testing to see how well the invention will perform. If an invention will not perform well, then the product might be less likely to be commercially successful, so the decision to engage in scientific testing may be a prelude to a later decision whether to fully commercialize an invention. It is also possible that some patentees will commercialize products without testing them (and thus without finding solutions to potential problems), and the incentive to take this approach is greater, the lower the amount of patent term remaining.

The patent system could not easily adapt by granting improvement patents on scientific testing, because it generally is not possible to distinguish the scientifically tested invention from the original. If any scientific testing of an invention were sufficient to entitle a patent holder to a new patent, that would provide a mechanism for extending virtually all patent terms ad infinitum, unless patent offices were to apply a subjective test of whether the scientific testing is sufficiently important to justify a patent term extension. An important exception is that it is possible to obtain patents on new uses for existing inventions,[99] so to the extent that research

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[96] An additional reason is that the incentives provided by improvement patents even for patentable development activities may be suboptimal. *See infra* Part II.C.

[97] Kitch recognized the importance of scientific testing of inventions after patents are issued, but assumed that the underlying patent itself would provide sufficient incentives. *See* Kitch, *supra* note 10, at 277 ("Absent a patent, firms have less than the optimal incentive to invest in providing information about and techniques for using the new technology."). Even with a patent, the finite length of protection means that firms' incentives to engage in such investments are less than optimal.

[98] *See supra* notes 80–83 and accompanying text.

[99] *See, e.g.*, Joseph M. Reisman, *Physicians and Surgeons as Inventors: Reconciling Medical Process Patents and Medical*

points to a new use, the patentee may be entitled to an improvement patent. For example, a use patent might cover the use of a drug for a new medical condition. Such improvement patents, however, may be difficult to obtain, because the possibility of the "new" use might have been obvious, even if it would not have been obvious that the new use would have been effective. A use patent also might be difficult to enforce enforce, because the patentee might not be able to obtain reliable information on whether particular consumers are using the invention for its original or new purpose, or why sellers are encouraging consumers to use the invention.[100]

The courts, unsurprisingly, have been skeptical of efforts to obtain broad patent protection for scientific studies. For example, the Federal Circuit recently upheld the invalidation of a patent for growing and eating cruciferous sprouts, such as broccoli, to reduce the level of carcinogenic substances and thus possibly the risk of cancer.[101] "While [the patentee] may have recognized something about sprouts that was not known before," the court concluded, the patentee's "claims do not describe a new method."[102] The patentee argued that in fact it had discovered a new method, such as a method for "selecting the particular seeds that will germinate as sprouts rich in glucosinolates,"[103] but with this claim rejected, there was no possibility for additional patent protection. Cruciferous sprouts, of course, were not under patent protection, but just as the Federal Circuit's decision means that the patent system itself may not provide the incentive to research known but unproven scientific hypotheses about public domain products, so too does it mean that the patent system might provide only a limited incentive for patentees to research their own products. Given the difficulty that the courts would have in determining the extent to which a particular experiment reduced scientific uncertainty, the decision is likely a good one, but it means that non-patent innovation incentives, such as governmental scientific grants, may be needed as an adjunct to the patent system, even to encourage research on patented or once-patented inventions.

The empirical uncertainty is how often patentees neglect to engage in scientific experimentation that they would have engaged in with a longer patent term. There exists at least

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Ethics, 10 HIGH TECH. L.J.355, 389 -91 (1995).

[100] *See* Rebecca S. Eisenberg, *The Problem of New Uses*, 5 YALE J. HEALTH POL'Y L. & ETHICS 717, 720 (2005) ("The discovery of a new use for an old drug might support a patent on a method of treatment, but such a patent offers little effective protection against generic competition once the drug itself is off-patent and may lawfully be sold for an older, unpatented use.").

[101] *See In re* Cruciferous Sprout Litigation, 301 F.3d 1343 (Fed. Cir. 2002).

[102] *Id.* at 1352.

[103] *Id.* at 1351.

anecdotal evidence that drug makers are less willing to conduct trials near patent expiration. For example, a *New York Times* editorial criticized NitroMed for conducting full testing of its heart failure drug, BiDil, only in a population of African-American patients.[104] "Some experts believe that . . . it would have been possible to devise a better study to test the drug in a broad population, not just a single racial group," according to *The Times*. But with the patent on the underlying drug expiring in 2007, NitroMed had insufficient incentive to conduct tests on the population as a whole, and so it targeted only a narrow group, recognizing that it could obtain a use patent for using the drug to benefit a targeted group.[105] If enough patent term remained on the underlying drug, then NitroMed might have had an incentive also to test the drug on a broader population. Although NitroMed still engaged in *some* testing of the drug, there might be other patentees that decide to stop scientific testing altogether, when they might have made a different decision with a longer patent term. The empirical problem, of course, is that it is difficult to determine whether a particular decision not to engage in testing is attributable to the limited amount of patent term remaining.

2. Commercial Experimentation

There is an additional type of experimentation that patents generally encourage, but which may be suboptimal as a result of the limited patent term: commercial experimentation. Some inventions might be obviously worth commercializing, and in far more cases, by the end of the patent term, it will become apparent that the underlying inventions are not worth commercializing. But there might be some inventions that could be commercially successful. Patent protection, F. Scott Kieff has argued, helps to provide incentives for commercial experimentation on patented products, because in the absence of such protection, third parties might be able to free-ride off the information from the inventor's commercial experiments.[106] A corollary is that the limited patent term will mean that a patentee might not engage in some commercial experiments that the patentee would engage in with a longer patent term.

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[104] *The First Race-Based Medicine*, N.Y. TIMES, June 19, 2005, § 4 (Week in Review), at 11.

[105] *Id.* NitroMed received U.S. Patent No. 6,784,177 (2004).

[106] F. Scott Kieff, *Property Rights and Property Rules for Commercializing Inventions*, 85 MINN. L. REV. 697, 708-09 (2001) (noting the possibility of second-mover advantages when "mere knowledge of a first mover's success eliminates a great deal of risk from the second mover's decision whether to embark on the same enterprise").

The problem is particularly severe for inventions that have a small probability of large commercial success, and a great probability of failure. Once an invention falls into the public domain, someone considering commercializing the invention faces the prospect of bearing the entire cost of the experimentation if it turns out to be a failure. If it turns out to be a success, however, the initial innovator will enjoy only a fraction of the benefits, because third parties will enter the market and take some portion of market share. As a result of trademark protection, the original experimenter is likely to enjoy a larger market share than subsequent entrants,[107] but entry by third parties will dissipate at least some of the rents that the initial commercial experimenter would enjoy in a regime of perpetual patent protection. Because of other costs of perpetual protection, we have only protection for a limited time, and inventors will forego at least some experiments that they otherwise would have undertaken.

Given the considerable gap that often exists between the date of invention and initial commercial experimentation for many products for which experimentation does eventually take place,[108] the finite patent term might discourage many commercial experiments. That does not mean that the underlying inventions will never be commercially tested. Eventually, as the potential market for an invention grows and the cost of producing it falls, it might be worth it to some entrepreneur to perform the commercial test, enjoying whatever advantages lead-time and trademark law provide. But commercialization might be considerably delayed as a result of the finite patent term. Once again, calculating how long such delays are in practice might be an empirical impossibility. Because commercial experimentation is common in all technological areas, however, the absence of sufficient incentives for commercial experimentation might be a more serious problem than the absence of sufficient incentives for scientific experimentation.

3. Marketing and Advertising

Even once a patentee has fully scientifically tested an invention and has decide to commercialize it, the patentee must decide how much marketing and advertising to engage in. Some commentators argue that advertising can be economically efficient because it serves to

[107] Gideon Parchomovsky and Peter Siegelman have argued that the "leverage" of a patent that a trademark provides may be socially optimal, because this leverage increases the incentive to invent without increasing deadweight loss. *See* Gideon Parchomovsky & Peter Siegelman, *Towards an Integrated Theory of Intellectual Property*, 88 VA. L. REV. 1455 (2002).

[108] *See supra* note 12 and accompanying text.

provide information to consumers and may result in lower prices.[109] The less patent term remaining, the less advertising patentees can be expected to engage in, because third parties can enter the market and free-ride off the advertising investment. This finding does have empirical support. Studies suggest, for example, that pharmaceutical companies sharply cut back on marketing expenses shortly before a patent falls into the public domain.[110]

The more difficult empirical question is the extent to which advertising is socially suboptimal. Some economists suggest, for example, that advertising may be socially excessive, for example leading consumers to purchase products that in fact they do not need.[111] To the extent that this is so, the finite patent term will tend to raise rather than lower social welfare. On the other hand, by introducing competition, the finite patent term might increase one form of inefficient advertising, seeking to induce customers to purchase from one producer rather than from another, even where there are no real quality differences.[112] Any complete empirical analysis thus seems likely to produce different conclusions for different inventions, though at least in some situations, the finiteness of the patent term might lead to less useful and more useless information being provided to consumers.

C. Patentable Improvements

The analysis so far has focused on development activities that produce information off which a third party can free-ride. To the extent that a development activity results not just in information, but in a new patentable invention, we have seen that the possibility of an improvement patent can provide for renewed patent protection, thus reducing the danger of patent nondevelopment.[113] The possibility of improvement patents, however, does not mean that incentives to engage in research expected to lead to improved inventions will always be optimal.

Consider first incentives during the original patent term. Suppose a potential inventor anticipates that research will lead to improvements that, if incorporated into the patentee's

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[109] *See* Timothy J. Muris, 2000 SUP. CT. ECON. REV. 265, 293-302 (2000) (providing an overview of the literature).

[110] *See, e.g.*, Ernst R. Berndt et al., *The Long Shadow of Patent Expiration: Do RX to OTC Switches Provide an Afterlife?* 2 (Nat'l Bureau of Econ. Research, Conference on Research in Income and Wealth, Symposium on Scanner Data and Price Indexes, 2000) (reporting that pharmaceutical companies decrease their spending on drug advertising before patent expiration, even though advertising of the trademark continues to provide some benefit to them).

[111] *See, e.g.*, Nicholas Kaldor, *The Economic Aspects of Advertising*, 18 REV. ECON. STUD. 1 (1950).

[112] *See, e.g.*, Avinash Dixit & Victor Norman, *Advertising and Welfare: Another Reply*, 11 BELL J. ECON. 753 (1980) (suggesting the possibility of socially inefficient competitive advertising).

[113] *See supra* text accompanying notes 94-95

product, could lead to an additional $1 million of profit for the patentee during the original patent term. If the patentee is the potential inventor, then the patentee will be able to retain all the additional profits that result from improvements during the patent term. Patenting the improvement might produce spillovers in the form of information or consumer surplus, but this is always the case.[114] Third parties, however, may have suboptimal incentives to create improvements, even placing aside concerns about spillovers. Because each of the patentee and the improver can block the other from practicing the invention during the patent term, the parties will have to negotiate an agreement, meaning that the surplus from the improvement must be shared between the improver and the patentee. Sometimes, a patentee might seek to precommit to giving a relatively large portion of this surplus to improvers as a way of generating more improvements,[115] but it may be difficult to fashion such precommitments. Thus, at least considering only the remainder of the patent term, the incentives of a third-party improver to engage in research and development may be suboptimal.

The economics of improvements become more complicated once we consider the years following the conclusion of the original patent term. The problem is that different improvements may be substitutes for one another. Suppose, to take an extreme example, that there are two mutually incompatible improvements to an invention, and either of these improvements would allow the patentee of that improvement to earn an additional $1 million in profit. If both improvements are created, however, each might be worth only $500,000, or even less as a result of price competition between the rival improvers. The possibility of a second improver ironically might mean in some circumstances that no one will improve at all, or that improvements will come later. The danger of inadequate incentives will be especially acute if the first improvement produces valuable information about the size of the market.[116]

This concern can be understood through the lens of recent developments in the prospect theory of patent law discussed above.[117] Because patent protection provides considerable control

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[114] *See supra* note 55

[115] *See* Oren Bar-Gill & Gideon Parchomovsky, *The Value of Giving Away Secrets*, 89 VA. L. REV. 1857 (2003) (suggesting that patentees do this by publishing without patenting aspects of their inventions).

[116] Suppose, for example, that there is a 50% chance that there will be no market at all for the improved product and a 50% chance that consumers will be willing to spend enough extra for the improved product to produce an additional $2 million for a single improver. If the underlying invention remained under patent protection, then the patentee would be willing to invest up to $1 million in the improvement.

[117] *See supra* Parts I.A.2, I.B (discussing Duffy's model).

over the development of improvements, a patentee need not worry too much about competition from rival improvers,[118] and a patentee need not worry at all about the prospect of rivals making substitutes to its own improvements, because the patentee can block such improvements during the patent term. This provides the patentee with assurance that it will be able to reap the benefits of its research and development on improvements, potentially leading to earlier and greater investment. Once the patent falls into the public domain, however, this benefit is lost, and so also when only a relatively short portion of a patent term remains, incentives to make improvements might be suboptimal. Because of the possibility of losing a hypothetical patent race to improve a patent nearing expiratino, both the patentee and third parties might not yet find it worthwhile to enter the patent race. The possibility of improvement patents, to be sure, means that there will be considerably better incentives to engage in development activities that might produce such patents, but aggregate investment even in such activities might be lower than if a longer patent term remained.

Improvement patents also will not encourage development activities that might produce improvements that will not subsequently receive patent protection. One reason that improvements might not be patented is that they might not themselves meet the standards of patentability. For example, the Patent and Trademark Office might conclude that a particular improvement would have been obvious to a person having ordinary skill in the art,[119] even though such a person will obviously not work for free. Even some valuable and innovative improvements might not be entitled to patent protection,[120] though the Office's relatively relaxed standards suggest that this problem at least is not so severe.[121] Even if all improvements are potentially patentable under current patent administration practices, however, some improvements might be too small to justify the expense of patent prosecution.[122] These concerns might be of relatively little economic significance, but they provide a further basis for worry that the end of patent protection might decrease development expenses.

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[118] *See* Duffy, *supra* note 21, at 490 (arguing that the patentee has an advantage, though only a limited on, over competitors in the search for improvements). Arguably, however, Duffy's analysis provides a basis for providing a stronger property right for patentees, since assurance of being able to win races for improvements should lead to earlier searches for such improvements.

[119] *See* 35 U.S.C. § 103.

[120] *See* Douglas Gary Lichtman, *The Economics of Innovation: Protecting Unpatentable Goods*, 81 MINN. L. REV. 693, 712-14 (1997) (discussing the possibility that some significant inventions might not be eligible for patent protection).

[121] *See* JAFFE & LERNER, *supra* note 72 (document this problem and suggesting potential reforms).

[122] *See supra* note 26 (discussing the cost of patent prosecution).

III. A POSSIBLE SOLUTION

The analysis so far suggests a central tradeoff that patent law presents, a post-patenting version of the classic tradeoff between providing incentives to invent and ensuring access to inventions. If a patent term is too short, the patentee might have socially insufficient incentives to develop the patent by engaging in nonpatentable research and commercialization activities, but if it is too long, excessive deadweight loss will result. The difficulty is that this tradeoff cannot simply be optimized, even in theory, by setting the patent term to an appropriate length, because if a patent race amounts to an implicit patent auction,[123] longer nominal patent terms will push inventive activity earlier and thus result in shorter effective patent terms.

An alternative approach might be to allow patentees some power to delay the issuance of their patents, and indeed the practice of continuing applications, combined with the old system that measured patent life from issuance effectively accomplished this. There were serious drawbacks to this system, including the creation of "submarine patents" that defeated the reasonable expectations of other inventors.[124] In theory, of course, the patent system could provide a formal mechanism for allowing delayed initial effectiveness of a patent, while still ensuring immediate issuance. An inventor would then be able to delay patent issuance until the patent is most valuable. An additional benefit of the system is that it would encourage invention of fundamental building block technologies long before they become commercially useful. There would, however, be drawbacks. In some cases, a delay would amount to no more than an extension of the patent monopoly, because other firms would not be willing to use a technology that they knew would later fall under patent protection. In other cases, firms might not delay despite the danger of patent underdevelopment, because of the reputational benefits of being first to market.

As a practical matter, the patent system accommodates the concern about patent underdevelopment with a separate policy lever, the designation of the quantum of achievement required before a patent will be awarded. Requiring more achievement reduces the risk of patent underdevelopment but increases inefficient duplication. Insisting on up-front investment to decrease the risk of later lack of investment is a crude policy response. The policy lever must be

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[123] *See supra* Part I.A.2.

[124] *See generally* Mark A. Lemley & Kimberly A. Moore, *Ending Abuse of Patent Continuations*, 84 B.U. L. REV. 63 (2004).

exercised at the beginning of the patent term, when the risk of nondevelopment will be least clear. Thus, even if the patent system sought to take into account nondevelopment risk in determining whether a patent should issue, a difficult factor to tailor to particular patents in any event, it would be making that assessment prematurely. This leaves two possible sets of strategies for penalizing nondevelopment: one involving a stick, and the other a carrot. The stick approach would impose an affirmative requirement that the patentee proceed with development. Europe adopts such an affirmative requirement by demanding compulsory licensing in the absence of development.[125] A more drastic affirmative requirement, which Oren Bar-Gill and Gideon Parchomovsky come close to endorsing in a brief discussion in a recent article,[126] would be to provide that such patents should be placed in the public domain. These approaches run into serious problems. Presumably, mere token development expenses would not count, but that means courts would need to engage in a difficult line-drawing problem to determine how much development should count as enough. More worrisome, such legal requirements might encourage patentees to engage in modest wasteful "fake development" simply to preserve the value of their development options.

There is, however, an even more fundamental problem with the stick approach, that the remedy might be worse than the disease. Once the patent is in the public domain, nobody will have an incentive to develop it,[127] and probably no one will develop a product through a compulsory license when the initial patentee did not think that development without having to pay a license fee would be profitable. The infeasibility of the stick approach thus suggests that a carrot is needed instead, but it would be hard to develop a suitable carrot within the patent term. To be sure, the government can provide research subsidies, but it would be difficult to target those subsidies to situations in which nondevelopment is a particular danger. A carrot is probably best offered near the end of the patent term. At this point, it might be clearer what additional

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[125] *See supra* note 8.

[126] *See* Oren Bar-Gill & Gideon Parchomovsky, *A Marketplace for Ideas?*, TEX. L. REV. (forthcoming 2006). Bar-Gill and Parchomovsky argue that there should be intellectual property protection for those who conceive of ideas that need development, with idea registrants required to auction their ideas to potential idea developers. If the high bidder in the development stage fails "to produce a patent or product within a given time period, say two years," *id.* at 23-24, then the idea would be placed in the public domain. Because Bar-Gill and Parchomovsky's idea regime is virtually identical to the existing patent regime, *see id.* at 31-32 (imposing traditional requirements for patentability, along with a requirement of "developability"), in effect their proposal is close to one that would combine mandatory auctions with a development requirement. To the extent that nondevelopment is a significant concern for their proposal, a better approach might be to penalize a nondeveloper by reauctioning the intellectual property right, with the auction revenues payable this time to the government.

[127] *See supra* note 16 and accompanying text. A development mandate will thus succeed in achieving its goal only if placement of the idea in the public domain served as a successful deterrent to nondevelopment and thus did not often need in fact to occur.

development activities extra patent term might enable, and it might also be easier to determine the cost of a longer period of protection. There might be instances, for example, it which it might be clear that a product simply will not be developed in the absence of a patent extension, even if the patent is placed in the public domain, and thus that the public would be better off with a patent extension than without it.

A relatively naïve way to implement the carrot would be for Congress to grant patent extensions on an ad hoc basis, or for an administrative agency to do so. In the early nineteenth century, Congress did occasionally grant patent term extensions in individual cases.[128] In the 1980s, Congress enacted a few specific extensions to compensate patentees for time lost to premarket review by the Food and Drug Administration,[129] and in 1984, Congress enacted a systematic patent extension program for inventions that required FDA premarket review.[130] Pharmaceuticals might well be a category of invention in which the risk of nondevelopment is likely to be particularly high, because of the expensive and nonpatentable commercialization activities that must be undertaken.[131] The congressional action, however, appeared to be based more on fairness concerns than on concrete concerns about patent nondevelopment. The predictable result of any case-by-case patent extension grants is rent-seeking, and the patents most likely to justify lobbying expense and thus to receive extensions are likely to be those that have already shown strong commercial success, not necessarily those that need additional time. Of course, the anticipation of the possibility of an extension might stimulate additional development effort, but an ad hoc case-by case extension system provides little guarantee that extensions will be anything but windfalls. In short, the carrot should not be too sweet.

Patent extension auctions provide a straightforward means of providing patent extensions in particular cases in which patent underdevelopment seems likely to be a danger without creating windfalls. In a simple patent extension auction regime, the right to a patent extension term would be auctioned to the highest bidder, which might not be the same as the original patentee. The same approach can be used for copyrights. William Landes and Richard Posner

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[128] For a history of nineteenth-century private patent extension bills, see Richard M. Cooper, *Legislative Patent Extensions*, 48 FOOD & DRUG L.J. 59, 60-61 (1993).

[129] *Id.* at 63-73.

[130] The Drug Price Competition and Patent Term Restoration Act of 1984 (Hatch-Waxman Act), Pub. L. No. 98-417, 98 Stat. 1585 (1984); *see supra* notes 84-86 and accompanying text.

[131] *See supra* Part II.C.

have suggested that indefinite copyright terms might be optimal,[132] but this argument by itself does not justify providing copyright holders with the windfall of copyright extensions. As John Duffy has pointed out, if the benefits of extending existing copyright terms exceed the costs in deadweight loss, this still might be accomplished by auctioning the copyright rather than granting the extension automatically to the copyright holder.[133] A straightforward second-price sealed bid auction[134] can allow the holder of an intellectual property right to receive an extension, but only by paying to the government what the intellectual property right would be worth to the next highest valuer. If the original right holder wins the auction, the right holder will still receive only a small windfall, equal to the difference between its valuation and the second-highest valuation of the right. And expectation of such small windfalls would slightly strengthen the reward function of the intellectual property system, increasing incentives for and thus investment in future inventions and copyrights, so in the long run these small windfalls would not be a transfer payment but part of the incentive to create.

That patent extension auctions can largely eliminate windfalls while reducing the risk of patent nondevelopment does not mean that they are optimal. The extension of a patent term, like the extension of a copyright term, will impose a deadweight loss, and thus an auction should occur only when the social benefit of reducing the risk of nondevelopment, exceeds costs, including in addition to deadweight loss, the administrative costs of the auction and the research costs of bidders. Parts III.A and III.B will consider two alternative decisionmakers for determining when patent extension auctions should occur: the government and the patentholder itself, constrained by an auction mechanism that will provide an incentive to call for an auction only in the situations in which such an auction will generally be optimal. Although I will make the case that both approaches might increase welfare, the possibility of giving the patentholder incentives to make an appropriate decision is the more intriguing. Because patent law applies largely in the same way to all technology classes and all inventions,[135] variables such as the

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[132] *See* William M. Landes & Richard A. Posner, *Indefinitely Renewable Copyright*, 70 U. CHI. L. REV. 471 (2003).

[133] *See* John F. Duffy, *Intellectual Property Isolationism and the Average Cost Thesis*, 83 TEX. L. REV. 1077, 1094 (2005) (arguing that "[i]n a world in where . . . government-conferred property rights are increasingly auctioned rather than gifted," laws providing intellectual property extensions "look more anomalous, and there is a general and principled theory for resisting them").

[134] In a second-price sealed bid auction, the winner pays the amount of the second highest bid; this gives each bidder an incentive to bid the bidder's actual valuation. *See* William Vickrey, *Counterspeculation, Auctions, and Competitive Sealed Tenders*, 16 J. FIN. 8 (1961) (introducing this auction form and discussing its benefits).

[135] *But cf.* Dan L. Burk & Mark A. Lemley, *Is Patent Law Technology-Specific?*, 17 BERKELEY TECH. L.J. 1155 (2002) (arguing

patent term necessarily reflect crude attempts at balancing benefits and costs. Although government might seek to tailor patents to the characteristics of particular inventions,[136] the task, if feasible, is more likely to be accomplished by harnessing the information of private parties.

A. Government-Decreed Patent Extension Auctions

Let us first consider a regime in which the government could decide case by case whether to auction a patent extension. Conceivably, such an auction might take place just when a patent was about to fall into the public domain, ensuring that there would be additional years in which development activities could occur. A problem with this approach is that the patentee would have little incentive to engage in nonpatentable development activities in the final years of the patent term. For example, a marketing campaign to make consumers aware of the benefits of a patented product might be useful primarily to ensure robust sales after the patent is set to expire.[137] Even if the patentee anticipates that the patent extension will be auctioned at the end of the patent term, the patentee will be unable to harness these benefits. A patent extension will be worth more to all bidders as a result of the auction, and thus the marketing campaign would increase the amount that the patentee would have to pay at auction to receive the patent.

For example, assuming a cash auction with payment due to the government,[138] a marketing campaign that would cost $500,000 and increase the value of the patent during the extension period by a present discounted value of $1,000,000 would not be worthwhile. The patentee would have to pay the $1,000,000 in the form of a higher bid, and so, if the marketing campaign did not affect pre-expiration sales, even anticipating victory in the auction, the campaign would end up costing $1,500,000 for $1,000,000 in benefit. Of course, a patent extension auction immediately following patent expiration might still be justified. If the extension is for a sufficiently long period, then the winner of the auction, whether the original patentee or a third party, will have an incentive to launch the marketing campaign. The

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that although the rules of patent law are the same across technology areas, the application of those rules may and should differ somewhat).

[136] For an analysis of the possible benefits and costs of individualized tailoring of intellectual property protection, see Glynn S. Lunney Jr., *Patent Law, the Federal Circuit, and the Supreme Court: A Quiet Revolution*, 11 SUP. CT. ECON. REV. 1, 39-48 (2004). For an article suggesting the possibility of nonuniform patent terms, but with patentees selecting their own patent terms based on a fee schedule, see Francesca Cornelli & Mark Schankerman, *Patent Renewals and R&D Incentives*, 30 RAND J. ECON. 197 (1999).

[137] *See supra* Part II.B.3.

[138] Payment ought to be to the government, rather than to the patentee. Otherwise, the patent extension auction program is simply a patent extension program in disguise, and the patentee would always be able to keep the patent by entering a very high bid.

campaign, however, will have been inefficiently delayed until the expiration of the original patent term.

An alternative approach would be to auction the patent extension before the end of the patent term. For example, five years before the end of the patent term, the government might hold an auction for the patent right in a period immediately following the patent term. That way, if the patentee won the extension, the patentee would have an incentive to continue development activity in the closing years of the patent term. Even if a third party won the extension, the patentee and the auction winner might negotiate agreements to ensure continued development, with the auction winner paying some of the costs of the development. A challenge in executing this approach is to determine just when the auction should be held. The earlier the patent extension auction occurs, the weaker will be information about whether it is necessary. Holding the patent extension auction at the beginning of the patent term would provide the strongest assurance against patent nondevelopment, at least assuming the patentee wins the extension, but the least confidence about whether the benefits of the patent extension auction are worth the additional deadweight loss.

The central question for government-decreed patent extension auctions is whether the government, either acting through Congress or through an administrative agency, will do a good job in determining when to hold the auctions. False negatives—inefficient decisions *not* to hold auctions—at least leave the patent system no worse than the status quo, but false positives could mean unjustified increases in deadweight loss. The attraction of auction revenue might lead the government to hold auctions that amount to inefficient taxes. Of course, this is nothing new. The government always must make decisions about how to raise revenue. Even if a particular auction is inefficient, it might be less so than the alternative means of raising the same revenue. Auctioning monopoly rights to fields that could be competitive seems in general likely to be an inefficient approach to revenue generation,[139] but if such auctions allow patentees to internalize the benefits of their development expenses,[140] they might well raise welfare. The question, a

[139] *See* Michael Abramowicz, *Perfecting Patent Prizes*, 56 VANDERBILT L. REV. 115, 201-02 (2003) (arguing that the monopoly distortion from patents is generally greater than the distortion associated with taxation).

[140] The more common situation in which taxes may promote internalization involves negative externalities. *See generally* A.C. PIGOU, THE ECONOMICS OF WELFARE (Macmillan & Co. 4th ed., 1978) (1920) (providing the classic defense of using taxation to internalize negative externalities). A patent extension achieved through an auction may allow internalization of the positive externalities of patent development.

difficult one, is whether adding an additional option to the revenue menu will tend to increase efficiency or decrease it.

An important consideration is the effect of the government's power on rent-seeking activities. Because auctions limit the windfalls that private parties will receive, they will generate less rent-seeking than pure government largesse. The auction itself provides a mechanism for dissipating rents, and so additional rent dissipation will occur only to the extent that there is a single party that will benefit in particular from an auction. With patent extension auctions, the patentee will generally be eager to lobby for patent extension auctions only if it believes that it will win and have a substantial advantage over other potential bidders. One such advantage is that of continuous ownership, that the patentee, unlike any third party, will be able to capture the benefits of development activities that occur during the original patent term, including both benefits realized during the original patent term and benefits realized during the extension period. Thus, although other factors might also give a patentee an advantage over third parties,[141] patentees will have a greater incentive to lobby for patent extension auctions when the costs of nondevelopment are great. The lobbying expenses are still a social cost, but at least there is a rough correlation between cases in which patentees will seek extension auctions and cases in which such extension auctions will be socially beneficial.

B. Patentee-Decreed Patent Extension Auctions

The social cost of lobbying expenses, however, can be reduced by giving a patentee the exclusive power to seek a patent extension auction. The danger is that the patentee will elect the extension auction option inefficiently. A patentee might anticipate that it will have some advantage over other bidders, but this advantage might not be the advantage of continuous ownership, of being able to capture returns to development both within the original patent term and beyond. For example, the patent might be complementary to another patent in the patentee's portfolio, or the patent might help the patentee to extend its monopoly into another market.[142] Ideally, we would like the patentee to elect the option only when the advantage that it enjoys is

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[141] *See infra* notes 142, 148 and accompanying text.

[142] For an overview of how an owner of an intellectual property right might seek to tie the protected product with another to extend the owner's market power, see Troy Paredes, *Copyright Misuse and Tying: Will Courts Stop Misusing Misuse*, 9 HIGH TECH. L.J. 271, 298-302 (1994).

attributable to ownership continuity.[143] A relatively simple auction regime can provide a reasonable assurance that this is the case. Part III.B.1 describes this mechanism, and Part III.B.2 considers whether a similar mechanism might be used to determine patent scope when a patent initially is awarded.

1. TheMechanism

The auction mechanism would work as follows: Congress would specify a field of technology, or perhaps even individual patents, in which patent underdevelopment seems likely to be a problem. In theory, Congress might apply the auction mechanism to the entire patent system, but at least initially, much more narrow experimentation would be preferable. In the authorized field, a patentee at any time would be able to request an auction for a patent extension and to specify, perhaps within limits, the length of time of that extension. The patentee initially would not bid in the auction. Third parties, however, would have a chance to bid, and the patentee would then be given an opportunity to purchase the patent extension for a set markup over the top bid. For example, if the statute authorizing patent extension auctions declared the markup to be 25%, and the high bid at the auction were $1,000,000 for the patent extension, then the patentee would have an opportunity to purchase the patent extension for $1,250,000.[144] If the patentee declined the purchase, then the high bidder would win the auction, paying an amount equal to the bid of the second-highest bidder.[145]

An auction that results in the patent being transferred to a third party might be a social failure, for such auctions would increase deadweight loss without increasing the incentive to develop the patent within the original patent term.[146] The third parties must, however, have some

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[143] There might be other reasons besides patent nondevelopment that a patent extension might be useful, for example if the patentee has special expertise in price discriminating and thus in improving efficiency. *See generally* Harold Demsetz, *The Private Production of Public Goods*, 13 J.L. & ECON. 293, 301-02 (1970) (explaining how price discrimination can improve efficiency in the provision of public goods). My focus here, however, is solely on whether an auction mechanism might help provide a solution to the patent nondevelopment problem.

[144] A variant would require the patentee to submit a sealed bid at the same time the third parties submit sealed bids and then award the patentee the patent if and only if its sealed bid exceeded the next highest by at least the markup. In this regime, it might be possible to allow third parties to offer bids as percentages of the patentee's bid, up to a specified maximum. This might be useful if third parties are not expected to have good information about the value of the patent. A third party would then need to consider only the extent to which the patent would be less valuable to it, because of the lack of ownership continuity and the transactions costs associated with selling the patent after expiration back to the patentee.

[145] *See supra* note 134 and accompanying text (discussing the approach of second-price sealed bid auctions).

[146] Conceivably, we might use auctions to reduce the cost of that failure. For example, the government might use the auction mechanism suggested by Michael Kremer. *See* Michael Kremer, *Patent Buyouts: A Mechanism for Encouraging Innovation*, 113 Q.J. ECON. 1137 (1998). Under this mechanism, an auction would be used to value a patent, but the auction would be consummated with only some low positive probability. With high probability, the price signals from the auction would be used to

incentive to participate in the process to ensure a competitive bidding regime. The trick is to ensure that the patentee will have an incentive to call for an auction only when it actually expects that it will have a strong probability of winning, and yet to ensure at least some reasonable third-party bids. The patentee will ordinarily already have some incentive not to call for an auction that it does not expect to win, because it might be worse off with a patent in the hands of a third party than with the patent in the public domain, particularly if it wishes directly to sell a good or service represented by the patent. But it would be straightforward to add additional incentives, for example requiring a patentee to pay the high bidder a penalty percentage of its high bid should the patentee end up declining the option to purchase the patent.[147] This would have the additional benefit of increasing auction competitiveness. Auction competitiveness also might be furthered by promising to give to the high bidder a percentage of the purchase price in cases in which the patentee does exercise the patent extension option.

2. *The Details*

a. *Post-Auction Sales of Term Extensions*

Two rules are essential in cases in which the patent is purchased by someone other than the original patentee:

First, the purchaser cannot be allowed during the original patent term to sell the patent extension to the original patentee. Otherwise, even where a patentee is clearly the most efficient patent owner, a third party's bid will be based on its estimate of the original patentee's valuation. The difference between what the original patentee is willing to pay and what the third party would be willing to pay would be attributable to the anticipated combined bargaining costs of the transfer negotiation. The auction mechanism will work appropriately only if the difference is largely attributable instead to the benefit of development of the patent within the original patent term. To force the third party to consider only its own valuation of the patent, and not the possible increased benefits from patent development, the third party must not be allowed to resell

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arrive at a value to compensate the patent holder, in this case the winner of the patent extension at the initial auction. There are obvious affinities between my proposal and Kremer's; we both seek to use information from bids for patents at auction to overcome problems with the patent system. The ends, however, are opposite. Kremer's proposal is potentially useful when there are efficiency advantages to placing a patent in the public domain, while the approach described here is useful when there are efficiency reasons to prevent a patent from falling into the public domain. They could, however, be combined to account for cases in which the patentee's initial decision turns out to be a mistake.

[147] The optimal markup would decline with an increase in the penalty percentage, because the penalty percentage would make the option of declining the patent extension less attractive.

the patent during the patent term. Likewise, the original patentee should not be allowed to sell the remainder of the original patent term to the purchaser of the extension period.

Second, the purchaser should be allowed to sell the patent extension to the original patentee *after* the original patent term has expired (or once expiration is so close that it would be too late for the original patentee to engage in further meaningful patent development within the patent term). One reason is that this will ensure that the patent is held by the highest-valuing user. A more important reason is that this assures that at patent extension auctions in general, the difference between the original patentee's valuation and the third party's valuation is attributable to the benefit of development of the patent within the original patent term, and not to some other factor that makes the patent particularly valuable to the patentee. Critically, this rule will not undermine the previous one. A patentee who loses a patent extension auction will not ordinarily be willing to undertake development costs in the hope of recouping them by buying the patent extension after the original patent term expires. Because the development would make the patent more valuable, the patentee would have to pay the extension right holder for the increase in value attributable to the patentee's own development expenses.

Suppose, for example, that a patent needs no further development, but it is twice as valuable to the patentee than to the highest-valuing third-party bidder. Because no further development is needed, the unique value to the patentee must come from market power during the patent extension term, for example because the patent will have more value as part of a patent portfolio than alone.[148] If a third party could not sell the patent extension back to the original patentee during or after the original patent term, then the third party would not incorporate this unique value into its bid. Thus, as long as the markup were less than 100% (and disregarding the possibility of penalties in the interest of simplicity), the patentee would win the patent extension, for reasons contrary to the goals of the patent extension auction system. But as long as the third party anticipates being able to sell the patent extension back to the original patentee, it will anticipate being able to capture the full amount of the markup and thus will bid as much as the patentee. Anticipating this result, the patentee will not call for an auction in the first place.

[148] *See generally* Parchomovsky & Wagner, *supra* note 24 (arguing that patents may be more valuable as part of patent portfolios than alone).

b. Determination of the Markup

Aside from determining whether contracts assigning patents meet the above rules and from oversight in conducting the auction, the auction mechanism would involve no government intervention. Patentholders would have an incentive to call for and then win an auction only where the benefits of patent ownership continuity are sufficiently great to justify the markup. The challenge for the government is to determine the size of the required markup. If the government sets too low a markup, then relatively small benefits from continuity will lead to auctions, even if significant deadweight loss results. Our existing patent system, which does not allow extensions, is tantamount to a system with an infinite markup. Initially, a government creating a system of patent extension auctions might start with a very high markup, so that only a few auctions would be held, and studies could assess whether the extensions benefited the public. The markup might then gradually be lowered if patent extension auctions appeared to increase welfare. Conceivably, the government might eventually offer different markups for different patents, because the amount of deadweight loss might vary depending on factors such as the ease with which price discrimination can be accomplished, though individuation would encourage rent-seeking.

Though perhaps varying across patents, a simple algebraic argument suggests that a first approximation of the value of the optimal markup might be 25%. Let m represent the markup, let v represent the total value of the patent extension to the highest-valuing third-party user, let s represent the social benefit of increased ability to develop the patent, and let p represent the proportion of this benefit that the patentee will privately capture. The patentee will call for an auction if $ps > mv$. The government would like to induce an auction if and only if $s > d$, where d is the deadweight loss. Thus, the government should set $m = pd/v$. With linear demand, $d/v = 0.5$.[149] Meanwhile, the patentee is unlikely to be able to perfectly price-discriminate, but a reasonable assumption might be that the additional producer surplus attributable to the development will be equal to the additional consumer surplus, so $p = 0.5$. Therefore, the government should set $m = 0.25$. To be sure, these assumptions are gross simplifications, and the

[149] *See, e.g.*, Douglas Gary Lichtman, *Pricing Prozac: Why the Government Should Subsidize the Purchase of Patented* Pharmaceuticals, 11 HARV. J.L. & TECH. 123, 132 n.21 (1997) ("When facing linear demand and zero marginal cost, a monopolist maximizes profit by selling to exactly half the consumers. Geometrically, this means that [consumer surplus] = [deadweight loss] = (0.5 * [producer surplus]).").

analysis assumes perfect information on the part of the patentee, thus disregarding the possibility that the patentee will ever need to pay a fine.

3. The Variations

a. Alternative Auction Currencies

We have assumed so far that the auction "currency" would be cash payable to the government. In a separate article on the possibility that auctions of rights to inventive fields might serve as alternatives to the patent system, I noted that such auctions might use different currencies.[150] The same argument applies to the patent extension auctions contemplated here. A benefit of the cash-to-government approach is, of course, that it provides the government with revenue. Alternative auction currencies, however, potentially can help advance specific goals of the patent extension auction system. Two such currencies will be considered immediately below; it would also be possible for the government to hold a "multiple currency auction,"[151] using some formula to aggregate bids that span different components.

First, the currency might be cash to be invested in development activities, rather than cash to be paid to the government. If the patentholder in fact intends to engage in substantial development activity during the remaining original patent term, then the patentholder will tend to be willing to spend more than the high bidder, which would not have incentives to spend money until after the patent term. The cases in which the patentholder would spend significantly more on development are precisely the cases in which additional deadweight loss from a patent extension is worth suffering, so the logic above applies even more clearly. This approach would encourage more total investment in patent development than the cash-to-government approach. A weakness of this approach is that it limits the auction winner's flexibility if changes in circumstances make further patent development inadvisable. In addition, for this approach to work, the government needs to be able to asses whether funds are in fact being spent on development activities.[152]

Second, if injunctive relief were disallowed in patent extension periods, the currency could be patent damages. Ian Ayres and Paul Klemperer have noted that in the absence of

[150] *See* Michael Abramowicz, *Patent Auctions* (2004) (unpublished manuscript, on file with author).
[151] *See id.*
[152] *See id.*

injunctions, lowering patent damages in effect reduces the price that patentees will charge for their inventions.[153] Patentees will set prices anticipating the possibility of unauthorized competition, and patentees and licensees negotiate in the shadow of eventual lawsuits. The winning bidder in the initial auction therefore might be the party that offers to accept the smallest proportion of patent damages. The original patentee would receive a patent extension only if it agrees to accept an even smaller proportion of patent damages. This system therefore would require a markdown, rather than a markup. The benefit of this approach is that lower prices reduce deadweight loss, so if a significant concern is that patent term extensions will result in continued high prices for consumers, this approach partly offsets the concern.

A problem with this approach is that agreements to charge only low prices reintroduce the problem of patent underdevelopment. If the goal is to encourage development, then allowing a patentee to capture only a small proportion of surplus can be counterproductive. Particularly troubling here, a third party could offer the best bid by agreeing to only nominal damages, and then the patentee could accept even more nominal damages, but then not develop the patent any further. Thus, a bid for a low price would likely need to be accompanied also by some form of cash payment or investment commitment, so that the level of patent damages would not be too low. The greater the amount of cash commitment, the less danger that the auction currency itself will reintroduce the problem of patent underdevelopment, but the greater the concern about deadweight loss. Alternatively, the auction structure could be the reverse, with a fixed relatively low level of patent damages for the patent term extension, and bidders offering cash or investment commitments. The Ayres and Klemperer argument provides a general reason for a lower level of patent damages and limits on injunctive relief, but the price level need not be determined through an auction mechanism.

b. Repeated Extensions

Regardless of the auction currency, the process might be repeated iteratively. As the end of the patent extension period approaches, the patentee will consider whether to demand another auction and thus seek another extension.[154] The patentee should have roughly appropriate

[153] 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, 1028-31 (1999).

[154] Conceivably, a third party that wins an auction also could seek another patent extension. The victory by a third party, however, ordinarily would signal that the benefits of continuity of ownership were not as high as the patentee thought.

incentives in determining when to request patent extension auctions and how long of a patent extension to request. Each time, the patentee will have an incentive to wait long enough to ensure that additional development will be needed, but to seek an extension early enough to ensure that it will be able to recoup its development expenses. Similarly, the patentee will want a relatively short patent term so that it does not end up paying a premium for a portion of a patent term in which it has no advantage over the victorious third party. But it will want a relatively long patent term to ensure that it will own the patent long enough to be able to recoup expenses. This does not prove that the patentee's privately optimal decision will be socially optimal, but the balance of considerations likely places the patentee in a better position than the government to determine when patent extension auctions should occur and the length of term extensions.

c. Copyright Term Extensions

The result of this system would be a regime of indefinitely renewable patents,[155] analogous to the regime of indefinitely renewable copyrights suggested by Landes and Posner.[156] The differences are that in the patent extension auction system, the price of renewal would vary with the value of the intellectual property right and that the intellectual property right holder will generally have an incentive to seek renewal only where renewal is likely to be socially beneficial. Auctioning copyright term extensions through any means would accomplish the first of these two goals in the copyright context, but not the second. Copyright extension auctions through a method analogous to the patent extension auctions described here might attempt to accomplish the second goal. In copyright, however, nondevelopment is not likely to be a great concern, because the owner of a copyright can obtain a new copyright on a derivative of the original work.[157] Moreover, the copyright term, even before the Copyright Term Extension Act, is sufficiently long that a copyright holder will probably not spend much on marketing the

[155] Mark Lemley anticipates that an implication of theories that intellectual property rights may ensure efficient management of property is that "there seems little reason to terminate that right after a period of years." Lemley, *supra* note 47, at 131. Indeed, my analysis suggests that a definite termination may not be optimal. Lemley might overstate the point, however, because those who advance what he refers to as "ex post" justifications for intellectual property concede that intellectual property rights have costs, including deadweight loss. The challenge, which I seek to meet here, is to find a way to extend patents just long enough to allow for efficient management and development of the property rights, until the cost of further extensions would exceed the benefit.

[156] Landes & Posner, *supra* note 132.

[157] 17 U.S.C. § 106(2) (2000).

original work, and there well be little need for commercial experiments to test the public's demand for the original.

In copyright, the danger is thus less likely to be underdevelopment than overdevelopment, producing what Landes and Posner refer to as "congestion externalities."[158] For example, Landes and Posner justify the long copyright term through a worry that if Mickey Mouse were in the public domain, different authors might use him in different ways, thus blurring the character and reducing the total social value that the character produces.[159] A slightly different mechanism, in conjunction with a shorter initial copyright term, might provide an efficient way of allowing long copyright terms only in cases in which such congestion externalities are an issue. For example, the initial auction might be for three different licenses to the copyrighted work. The copyright holder would then have an opportunity to keep the copyright without giving away a license by paying an amount equal to some multiple of the average of the top three bids. The copyright holder's valuation is likely to be particularly high relative to the bids for licenses when the competition among the licensees risks oversaturating the public or causing inconsistent development of the copyrighted work in sequels.

IV. CONCLUSION

Although intellectual property commentators have long discussed the optimal length of the patent term, they have assumed that the existing term is long enough to give patentees sufficient incentive to commercialize their patented inventions. Two new developments, one empirical and one theoretical, make such assumptions problematic. First, patents increasingly are being granted on embryonic inventions, particularly in the field of genomics. Such inventions may require study for a period longer than a patent term. Second, economic models of intellectual property suggest that inventors may acquire patents at a relatively early stage of development for their option value. By the time a patent option would be worth exercising if most of the patent term remained, so little might remain that commercialization is not feasible.

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[158] Landes & Posner, *supra* note 132, at 484-88; *see also* Michael Abramowicz, *A Theory of Copyright's Derivative Right and Related Doctrines*, MINN. L. REV. (forthcoming 2005) (arguing that the derivative right is justified in part because it reduces the number of derivative works that would be made).

[159] Landes & Posner, *supra* note 132, at 487-88 ("Not only would the public rapidly tire of Mickey Mouse, but his image would be blurred, as some authors portrayed him as a Casanova, others as catmeat, others as an animal-rights advocate, still others as the henpecked husband of Minnie.").

The patent system includes some mechanisms that significantly limit the underdevelopment problem. First, by imposing substantial requirements for patenting, the patent system reduces the proportion of expenses that would need to be made after patenting. The patent underdevelopment concern thus provides a counterweight to the prospect theory of patents, which argues that patents should be granted early. Second, improvement patents can in effect extend the patent term. Improvement patents, however, may not be available for some types of development activity, including scientific experimentation, commercial testing, marketing, and research producing subpatentable inventions. As a result, patent extensions, though probably welfare-decreasing for the vast majority of inventions, might enhance social welfare for a small subset.

Auctions for the right to patent term extensions provide a possible solution to the problem. Under this approach, a patentee would be able to call for such an extension before the end of the patent term. The patentee, however, would need to offer a winning bid substantially in excess of that of the runner-ups to win the extension, and a patentee who calls for but does not win an auction would pay a fine. This approach will tend to result in patent extensions only in cases in which the value of continuity of patent ownership is relatively high. These will be the cases in which the patentee would like to make investments in the remainder of the original patent term that would pay off primarily in the extension period and thus in which the degree of patent underdevelopment otherwise would be high.