When Second Comes First:

Correcting Patent's Poor Secondary Incentives Through an Optional Patent Purchase System

Paper by Jordan Barry

WHEN SECOND COMES FIRST:
CORRECTING PATENT'S POOR SECONDARY INCENTIVES THROUGH AN OPTIONAL PATENT PURCHASE SYSTEM

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As research has advanced, technologies have become more closely knit, and the relationships between them—both complementary and competitive—have become increasingly important. Unfortunately, the patent system's use of monopoly power to reward innovators creates inefficient results by overly encouraging the development of substitute technologies and discouraging the development of complementary technologies. This paper explains how an optional patent purchase system could help ameliorate such problems and discusses the implications of such a system.

[1] Associate, Fried, Frank, Harris, Shriver & Jacobson, LLP. The author would like to thank Mark A. Lemley, Henry T. Greely, Richard Craswell, Richard Epstein, A. Mitchell Polinksy, Barbara Fried, Michael Klausner, Thomas C. Grey, Jeff Strnad, Joseph A. Grundfest, Elizabeth Pollman, Mili Thomas, Nick Jabbour, Kevin Lloyd, Michael Abate, and the participants in both the Stanford Law and Economics Seminar and the Stanford Law School Academic Writing Workshop for their helpful guidance, discussions, and comments.

I. INTRODUCTION

The path to national prosperity and power has long been paved with technology. Governments have recognized this, and accordingly have long sought to foment scientific advancement and innovation.

But encouraging creativity presents thorny problems: Once an innovator shares her idea with the world, she cannot control its dissemination. The idea can then be adopted by others, eliminating any advantage the original inventor might have received from it.[2] Developing an innovation is often a costly endeavor. An inventor, knowing that she will not be able to profit from her invention unless she is able to keep it a secret, will only pursue research if she knows that she will be able to conceal its result.[3]

The concealment of knowledge that this creates is also a problem in itself; if other would-be innovators knew of their companion's discovery, they might also have their own ideas on how to improve it, adapt it to new contexts, or incorporate it into their own projects. Their attempts to address the same problem will likely lead them to devote significant resources to work that is largely duplicative of the research conducted by the first inventor. But ideas are a public good, and from society's perspective, there is nothing to be gained from not sharing them;

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[2] Or, as Thomas Jefferson—the nation's first Patent Examiner—stated more poetically:

> If nature has made any one thing less susceptible than all others of exclusive property, it is the action of the thinking power called an idea, which an individual may exclusively possess as long as he keeps it to himself; but the moment it is divulged, it forces itself into the possession of everyone, and the receiver cannot dispossess himself of it.

Letter from Thomas Jefferson to Isaac McPherson, Aug. 13, 1813, *as reprinted in* 13 THE WRITINGS OF THOMAS JEFFERSON 333 (1905) (Andrew A. Lipscomb & Albert Ellery Bergh, eds.).

[3] It also presents a serious obstacle for an inventor who lacks the resources to bring her idea to market on her own; if she hopes to partner herself with a party that possesses the requisite capital or other means of production, she must first share her idea. But, in doing so, she is vulnerable to an unscrupulous actor who would simply appropriate the idea as her own. This problem has become increasingly important as goods have become more technologically sophisticated.

informing these other innovators increases their capabilities but does not reduce those of the original innovator.[4] Thus, from society's perspective, spreading discoveries increases their value, and the failure to do so represents pure waste.

Our founding fathers knew all of this, and designed our patent system to address these problems. Indeed, they considered these problems to be of such importance that they laid the patent system's foundation in our Constitution itself.[5] While many of the patent system's details have changed since then, both the logic and the basic concepts that animate it remain largely the same: Patents reward an inventor for her innovation by giving her the exclusive right to use her discovery—but only for a limited time. During the life of her patent, the inventor has the legal right to stop others from using her discovery. This generally enables her to act as a monopolist, and thereby to extract enough rent from the market to cover her research and development expenses and make a profit. To receive a patent, an inventor must submit a filing explaining both what her discovery does and how someone "skilled in the art" could replicate it.[6] These filings are made available to the public, which promotes the dissemination of knowledge and enables others to avoid performing duplicative research. After a limited time,[7] the patent expires, and the discovery becomes freely available for use by the public.

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[4] Or, to quote Thomas Jefferson once more on the nature of an idea:

> Its peculiar character, too, is that no one possesses the less, because every other possesses the whole of it. He who receives an idea from me, receives instruction himself without lessening mine; as he who lights his taper at mine, receives light without darkening me. That ideas should freely spread from one to another over the globe, for the moral and mutual instruction of man, and improvement of his condition, seems to have been peculiarly and benevolently designed by nature, when she made them, like fire, expansible over all space, without lessening their density at any point, and like the air in which we breathe, move, and have our physical being, incapable of confinement or exclusive appropriation.

Id.

[5] *See* U.S. CONST. art. I, § 8, cl. 8 (providing that Congress shall have the power to "secure[e], for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries," in order to "promote the Progress of Science and useful Arts").

[6] *See generally* 35 U.S.C.A. § 102(e) (2000).

[7] Generally twenty years from the date the patent is filed with the U.S. Patent and Trademark Office. *See, e.g.*, United States Patent Office, General Information Concerning Patents, http://www.uspto.gov/web/offices/pac/doc/general/ index.html.

By and large, patent is a good system, and it has served us well.[8] Since the inception of the patent system, the United States has experienced robust technological growth, and it continues to do so to this day. And, as research has advanced, technologies have become more closely knit, and the relationships between them—both complementary and competitive—have become increasingly important. Ironically, this development—patent's great success—has ultimately exposed one of its biggest failings.

The problem stems from the patent system's use of monopoly market power as the means through which inventors are rewarded. While monopoly power is an effective mechanism for raising the inventor's profits, it does so at the cost of increasing prices and reducing output. This artificial elevation of prices and reduction of output radically overincents the development of substitutes and discourages the development of complements. Monopolies are usually criticized for their primary effects—that is, the creation of deadweight loss, in the form of unconsummated deals that would improve the welfare of both parties. This loss would not be present in a competitive market.[9] However, for some technologies—those that are the most tightly connected to other technologies—the ramifications of their increased price and reduced output on the development and distribution of related technologies—that is, patent monopoly's secondary effects—will be even more important.

This paper presents and considers a modification to the patent system that helps address this defect of the current system: the optional patent purchase. Under the optional patent purchasing system, the government may offer to purchase a patent from its owner; these proceeds provide the supra-competitive profits the owner would otherwise earn

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[8] Of course, this is not to say that patent systems, or ours in particular, are not without imperfections. For example, the benefit a patent holder receives from her invention diverges from the benefit it confers on society, which can result in an inefficient level of research. *See, e.g.*, Steven Shavell & Tanguy Van Ypersele, *Rewards Versus Intellectual Property Rights*, 44 J.L. & Econ. 524, 530 (2001). Applying for a patent can also be an uncertain proposition, and a rejected application may leave the inventor vulnerable because it provides a blueprint of how to replicate her discovery. Patent applications are also expensive, often costing between $20,000 and $30,000, mostly in lawyers' fees, and only seven percent of patent owners make enough profit to recoup the cost of their patent applications. *See* Tom Harris, *How Patents Work*, Howstuffworks, at http://people.howstuffworks.com/patent6.htm; Michael Agger, *Google Patent Overload*, Slate.com, Jan. 2, 2007, http://www.slate.com/id/2156386/fr/flyout. Litigating a patent infringement claim is even more expensive, typically costing both parties around $1.2 million apiece. Richard Korman, *Lo! Here Come the Technology Patents. Lo! Here Come the Lawsuits*, N.Y. TIMES, Dec. 27, 1998, at C4. But these issues are not the focus of this paper.

[9] A competitive market is characterized by the presence of a large number of producers and consumers, each of which is perfectly informed about prices, and none of which has the market power to influence prices. A competitive market results in a single price for a good, equal to its marginal cost of production, and results in no deadweight loss.

from monopoly sales under its patent. If the owner agrees to sell,[10] the government then makes the patent freely available to all parties. Many firms then enter the market, driving production to its competitive market price and quantity and eliminating the deleterious effects that a patent monopoly would otherwise have on complementary and competitive technologies.

The purpose of this paper is not to convince the reader that this alternative should be adopted; it is not an advocacy piece. The purpose of the paper is expositive, to introduce the system and evaluate some of its implications, both positive and negative. Its goal is both to explain the ways in which an optional patent purchase system might be beneficial for those patents whose secondary effects are most important and to explain why the pitfalls of such a system should give us pause about extending its use beyond this class of patents. With this end in mind, a significant portion of this paper is devoted to presenting the current legal framework, and its corresponding economic implications, against which any proposed system must be gauged. Part III discusses the patent system and its economic effects in greater detail before turning to an examination of subsidies, the traditional economic response to a monopolistic market, in Part IV. Part V explains the optional patent purchasing program in detail, and discusses its virtues and failings relative to subsidy and unmodified patent. The paper then concludes by briefly discussing one area where the optional patent purchase might be particularly beneficial: pharmaceutical patents. Also included for the interested reader is a mathematical appendix that complements the paper's discussion with a more formal analysis. But first, I attempt to place the optional patent purchase into context by briefly presenting some of the relevant academic literature.

II. LITERATURE REVIEW

Patent systems have existed for hundreds of years, and have long been considered a fait accompli by the entire industrialized world.[11]

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[10] The voluntary nature of the sale ensures that the government will not be able to erode their incentives by offering less than what the company expects to earn from the patent in the marketplace.

[11] It is worth noting that this was not always the case. In the late nineteenth century, particularly between 1850 and 1875, patent came under heavy fire from economists. Chief among their complaints were patent's market-distorting effects and individual patent holders' potential to hinder innovation, and they generally proposed reward systems, where the government offers monetary prizes to innovators instead of intellectual property rights, as an alternative. In the United Kingdom, Robert Macfie, a member of Parliament, proposed replacing patent with a government-financed reward system, and the London Economist endorsed the concept. Holland repealed its patent system in 1869. *See* Shavell & Van Ypersele, *supra* note 8, at 526-27.

Patent's chief competitor[12] has been reward systems, in which the government incents technological progress by offering innovators monetary compensation, as opposed to intellectual property rights.[13] The last few years have seen a sharp uptick in the amount of academic writing focused on the subject. This phenomenon can be traced to a variety of factors; the recent congressional extension of copyright terms and its constitutional challenge in the court system have prompted an increased focus on alternate intellectual property regimes[14] and, earlier, fears of terrorist-spread epidemics fueled discussion of the possibility and wisdom of the government acquiring patents on vaccines.[15]

Whatever its roots, this increase in visibility has yielded a rich harvest of academic publications. Perhaps the most substantial work of late is an October 2001 paper written by Steven Shavell and Tanguy Van Ypersele which presented and analyzed a formal, mathematical economic model of both the patent and reward systems. They used their model, which incorporated both systems' respective pre-development influences on research[16] and their post-development market consequences, to assess and compare the expected social utility under each system. Based on their model, Shavell and Van Ypersele concluded that an optional reward system, where inventors could choose between a pre-determined reward and a patent, was superior to a patent system, and that a mandatory reward system could be either better or worse than both the patent and optional

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[12] Though it is generally only a competitor in theory, not in practice.

[13] These systems are also known as prize systems. The two terms are used interchangeably through this paper.

[14] *See* Eldred v. Ashcroft, 123 S. Ct. 1505 (2003).

[15] Many of the articles are broad, policy-focused pieces which, mirroring the writings of the late 1800s, advocate reward systems as a superior alternative to patent. Typical examples include a recent paper by Michael Abramowicz, *Perfecting Patent Prizes*, and Lee Davis's *Should We Consider Alternative Incentives for Basic Research? Patents vs. Prizes*. Michael Abramowicz, *Perfecting Patent Prizes*, 56 VAND. L. REV. 115 (2003); Lee N. Davis, Should We Consider Alternative Incentives for Basic Research? Patents vs. Prizes (June 8, 2002) (unpublished manuscript, on file with author). Others adopt a more skeptical approach, such as *Patent Abolitionism*, where Mark Janis argues for caution in the face of modern enthusiasm for dramatic patent system reforms by drawing on the history of the Victorian-era British patent abolitionism movement and emphasizing the similarities between the modern and Victorian reform movements. Mark D. Janis, *Patent Abolitionism*, 17 BERKELEY TECH. L. J. 899 (2002). Another example of skepticism over the value of switching to a reward system is an article by Keith E. Maskus entitled *Ensuring Access to Essential Medicines: Some Economic Considerations*, which expresses concern over the difficulties in administering a rewards system. Keith E. Maskus, *Ensuring Access to Essential Medicines: Some Economic Considerations*, 20 WIS. INT'L L.J. 563 (2002).

[16] The greater the payoff the system provides to the inventor, the great their incentive to engage in research and development.

reward systems, depending on how good the government's information was relative to that of the inventor.[17]

Although generally an interesting and well-written paper, Shavell and Ypersele's model did not contemplate each system's implications for the development and distribution of subsequent complementary and competitive technologies.[18] This is entirely understandable; as the focus of their piece was on the inefficiencies of the patent system[19] and the ways in which reward systems—in particular, an optional reward system overlaid onto patent—can remedy these problems. This paper, in contrast, focuses on the patent system's deleterious effects on future innovations and the ways in which an optional patent purchase system can ameliorate these shortcomings.[20]

Perhaps the publication that is most similar to this piece is Michael Kremer's *Patent Buyouts: A Mechanism for Encouraging Innovation*.[21] Kremer also starts with a critique of the patent system, but his first-choice

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[17] It is worth noting that this result is dependent upon certain assumptions in their model about the government's a priori knowledge of the value of innovations. This paper does not make such strict assumptions about the government's information. *See also* John F. Duffy, *The Marginal Cost Controversy in Intellectual Property*, 71 U. CHI. L. REV. 37, 42-44 (2004) (critiquing Shavell and Van Ypersele's assumptions about government knowledge).

[18] The authors recognize as much. *See* Shavell & Van Ypersele, *supra* note 8, at 543 ("We did not discuss the issue of subsequent innovations, that is, improvements to innovations or new innovations depending on past ones.").

[19] Specifically, the authors focused on how patent's failure to provide an inventor with the full social value of her invention can result in some socially beneficial inventions not being developed and the effects of the monopoly created by patent on the distribution of the technology after its development. *See id.* at 530.

[20] It is also briefly worth highlighting the differences and similarities between the optional patent purchase system presented here and the optional reward system discussed in Shavell and Van Ypersele's paper. In Shavell and Van Ypersele's model, the optional reward was conceived as an alternative inducement for development of the initial innovation, a substitute for a patent right. It aims to fix both patent's shortcomings in inducing research and its negative effects on the distribution of an innovation after its development. Its scope is therefore broader, and its goals more ambitious, than the optional patent purchase system, which is designed only to address the post-development effects of patent. However, the optional patent purchase system's reduced scope also improves its feasibility: Instituting such an optional reward system requires the government to determine the value of the innovation far in advance of its actual development, and to commit itself to paying such a reward long in advance. An optional patent purchase system, by contrast, only requires the government to determine the value of an innovation after it has been patented. Further, Shavell and Van Ypersele's optional reward system ties government prizes to a technology's social value, whereas the optional patent purchase system enables the government to determine its offering price based solely on the patent's private value—a metric that is far easier to calculate. *See* discussion in Part V.C.1, *infra*.

[21] Michael Kremer, *Patent Buyouts: A Mechanism for Encouraging Innovation*, 113 Q.J. Econ. 1137 (1998).

alternative is not a prize system per se, but "direct government support of research," which he defines somewhat more broadly. He then shifts his attention to patent buyouts, which he advocates as a potentially superior mechanism for fostering innovation than patent alone. The focus of his paper is a mechanism for effecting such buyouts; Kremer espouses second-price auctions with closed bids and a mark-up.[22]

Both Kremer's piece and this paper spend significant time discussing both the potential benefits of a government patent-purchasing system and the pitfalls of its implementation. However, Kremer focuses his attention on the problem of how the government prices the patent. This paper, on the other hand, focuses on the effects of an optional patent purchase system on the development and distribution of related technologies. In doing so, it also takes a somewhat broader and more objective (as opposed to persuasive) approach.

Before proceeding, it is also worth noting that many papers in this field adopt economic models that do not account for distributional affects. For example, Shavell and Van Ypersele reach all of their conclusions based on a social welfare function which considers only the value that individuals obtain from the innovation and the cost of its production and development. It does not monitor whether utility accrues to consumers or producers; its only concern is whether an innovation is developed and how much deadweight loss is created by the method through which it is distributed.

For economists, such a focus on overall social utility, as opposed to monitoring the utility of separate groups, is common and perfectly natural.[23] This practice is commonly justified in one of two ways:[24] the first is to assume that the government has an administratively costless lump sum tax option available to it, so that distributional issues can be handled later at no cost, making the size of the economic pie a social planner's only concern. The second is to assume that if in all scenarios the economic pie is maximized, each individual will lose in some places and gain in others, but that on average everyone's utility will be increased; a rising tide lifts all boats.[25]

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[22] The auction structure is designed to enable the government to take advantage of private-sector information advantages, and the mark-up reflects an attempt to compensate for patent only rewarding the private (as opposed to the social) value of an innovation.

[23] *See, e.g.*, LOUIS KAPLOW & STEVEN SHAVELL, FAIRNESS VERSUS WELFARE (2002) (arguing that policymakers should concern themselves with total welfare and not with issues of fairness).

[24] There is also a third justification, a sort of "we are they" view. Under this view, corporations are often assumed to be public and widely owned by many investors representing broad segments of society, etc., so that the distributional issues become largely illusory or at least divorced from the issue under consideration. Differential

[25] The first assumption is almost certainly untenable in reality; the second is debatable, as it hinges on the assumption that no groups are systematic winners or losers.

Yet, at the same time, it seems strange and unintuitive to completely ignore these distributional effects. Further, doing so can lead to somewhat perverse results; for example, a social planner who cares only about total social utility will find a perfect monopoly, where the monopolist reaps all the gains from the sale of her product, to be equally desirable as the competitive market outcome, and preferable to all others. Were it administratively feasible, such a planner would advocate in favor of a prize system where the prize for every invention were exactly equal to the net benefits to society of its development; one of their primary complaints with patent is that it generally offers private development incentives that are below the social value of the invention.[26] They take this stance because it would create socially efficient research and market allocation incentives. However, it would also have a somewhat unsettling result: Anyone without a financial stake in the invention would be completely indifferent to its development.

On a more pragmatic note, many economics papers put forth recommendations for policy decisions that require legislative structural changes to the current systemic framework. In our democratic society, such legislation is not likely to succeed without broad popular support, which is both intricately and inextricably tied to distributional effects. For example, Shavell and Ypersele correctly note that, under their model, industry should not object to an optional reward system, as it can only raise their profits,[27] but they fail to address consumers, who might or might not support such a measure.[28] In an attempt to address these perceived shortcomings, this paper will focus primarily on developing a system which improves the welfare of all parties.

Having placed this paper into context among the previously existing body of academic literature, I now proceed to provide some context for the optional patent purchase system by discussing the existing patent system and its economic implications.

III. THE U.S. PATENT SYSTEM

A. *Overview and Direct Effects*

[26] This need not always be the case. For an example of patent providing private incentives that are greater than social incentives, see Part III.B, *infra*.

[27] Shavell & Ypersele, *supra* note 8, at 544.

[28] Shavell and Ypersele's model has other defects, most of which they themselves note in their paper: they do not consider the tax financing costs; the effects on the "race to be first," where private incentives favoring early discovery exceed the social benefits, leading to research expenditures above the optimal level, etc. *See generally* Shavell & Ypersele, *supra* note 8, at 541-545.

The U.S. Patent System was conceived with the purpose of "promoting science and the useful arts."[29] Even in the days of the founders, research and development was costly. Inventors would seek to recoup these preliminary costs through the sales of their subsequent innovation. However, once an inventor had successfully developed her technology, others could copy it and enter the market with the same technology. This eroded the profits of the original investor, diminishing her motivations to research, and incented her to closely guard her findings. This was inefficient, as it meant slower technological progress for society and an increase in costly duplicative work.

The patent system addresses these problems by granting inventors temporary monopolies. During the life of the patent, they are insulated from competition, giving them supra-competitive profits and protecting their incentives to do research. The temporary nature of the patent also guarantees that the invention will eventually fall into the public domain and become accessible at the socially efficient competitive market rate. In addition, to be eligible for patent protection, an inventor must submit a filing which explains her invention and how to replicate it. This spreads knowledge and prevents costly duplicative efforts.

An example is helpful to illustrate these concepts: Consider the pharmaceutical industry. Finding, developing, and shepherding a new drug through the regulatory approval process is an uncertain,[30] phenomenally expensive[31] process which can take over a decade.[32] On the other hand, once a drug has been developed and approved, it can typically be produced at a very low marginal cost.[33] There are numerous large

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[29] U.S. CONST. art. 1, § 8; *see also* THE FEDERALIST NO. 43, 288 (James Madison) "The utility of this power will scarcely be questioned."); *id.* (stating that "[t]he public good fully coincides" with granting patent monopoly rights to inventors).

[30] Only one in five thousand experimental drugs makes it to market. *See, e.g.*, MedicineNet.com, *Drug Approvals - From Invention to Market . . . A 12- Year Trip*, *at* http://www.medicinenet.com/script/main/art.asp?articlekey=9877 [hereinafter "Drug Approvals"].

[31] It typically costs hundreds of millions of dollars to bring a new drug through the process to the point at which it can be sold. Some estimates put the figure as high as $900 million per drug. *See, e.g.*, FED. RESERVE BANK OF DALLAS, 1999 ANNUAL REPORT (1999), *available at* http://www.dallasfed.org/fed/annual/1999p/ar99.html (estimating the cost at $350 million); Matthew Herper, *The Half-Full Economy: Big Pharma's Research Drought Ends*, Forbes.com, *at* http://forbes.com/2003/05/28/cx_mh_0528pharma.html (estimating the cost at $900 million). This outlay is merely to get the drug to the point at which it can be sold; it does not include production costs or sales and marketing expenses, nor does it guarantee that anyone will actually buy the drug.

[32] The average time to market for a new drug is twelve years. *See, e.g.*, Drug Approvals, *supra* note 30.

[33] Pundits have quipped that the first pill costs $500,000,000 to produce, the second pill costs a penny. *See, e.g.*, FED. RESERVE BANK OF DALLAS, *supra* note 31; Sam Kazman, *Demonize, Then Pulverize*, NAVIGATOR, Nov. 4, 2004, *available at*

pharmaceutical companies with the ability to cheaply reverse-engineer the drug; this would cause competitive production and resultant low profits for the innovating company. Because of the staggering cost of research and it uncertain nature, this low payoff would thin the river of drug discovery to a paltry trickle.

Patents prevent other companies from producing and selling the drug, guaranteeing the inventing pharmaceutical company a monopoly for a limited time. This enables them to retain enough of the fruits of their labor to earn sufficient profits to make research and development in their interest. The pharmaceutical industry is heavily reliant on patent protection.[34]

Yet patent protection does not come without costs. Monopoly power means decreased output and higher prices,[35] which means fewer people, particularly the poor, have access to the new invention. Worse, it creates a scenario where many people are unable to purchase the invention, even though they are willing to pay more than it would cost the patent holder to produce it. These unconsummated transactions constitute a significant deadweight loss for society, and represent pure social waste. This can be seen graphically in Figures 3.1 and 3.2, below.

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http://www.objectivistcenter.org/showcontent.aspx?ct=986&h=53; Rafe Needleman, *Why Americans Pay More for Software*, ZDNet.com, *at* http://review.zdnet.com/AnchorDesk/4520-7297_16-5132742.html.

[34] *See, e.g.*, Carlos María Correa, WORLD HEALTH ORG., *Ownership of Knowledge – the Role of Patents in Pharmaceutical R&D*, 82 BULL. WORLD HEALTH ORG., Oct. 2004, *available at* http://www.scielosp.org/scielo.php?pid=S0042-96862004001000015&script=sci_arttext&tlng=en.

[35] This is because a monopolist controls the price and the output for her market, subject only to the restrictions of the demand curve. Assuming she can not discriminate among consumers, if she lowers her price, she will gain some sales, raising her profits. However, she also loses profit on all of the sales she would have gotten at the higher price because she will be charging a lower price in those transactions as well. This problem does not arise in a competitive market, because, by definition, in a competitive market each individual firm lacks the power to affect the market price.

FIGURE 3.1: COMPETITIVE OUTCOME

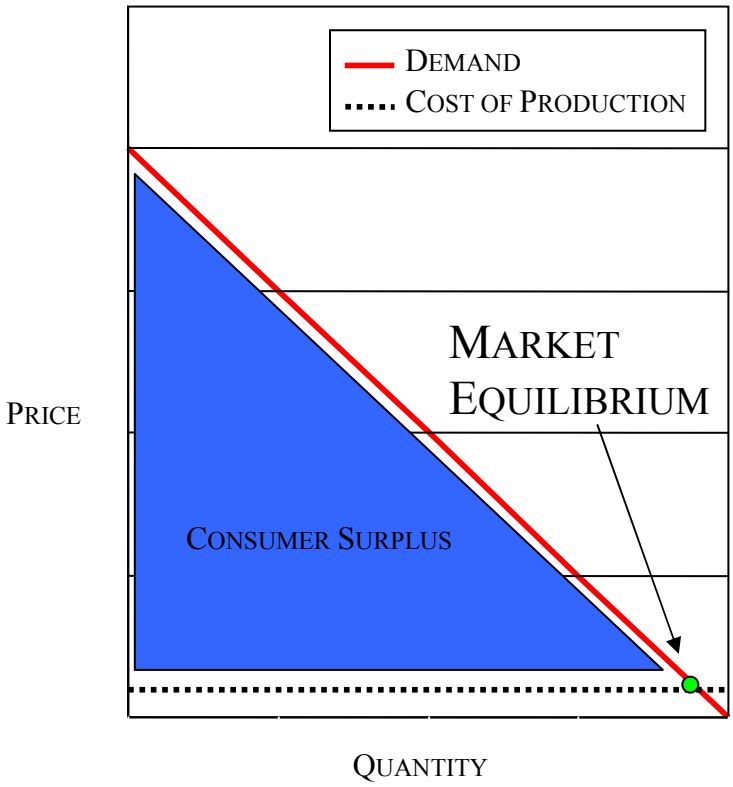
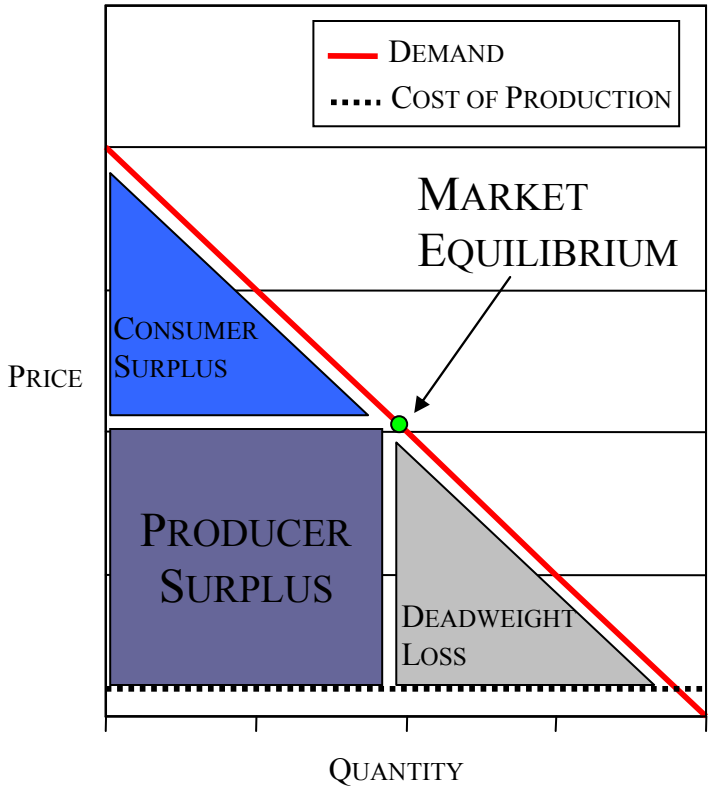


FIGURE 3.2: CURRENT PATENT SYSTEM (MONOPOLY)



B. *Secondary Effects*

The problems discussed so far can fairly be considered direct effects of a patent; they are the pricing and production quantity responses that the firm makes after receiving patent protection. However, the economic landscape is increasingly complex and interrelated, and there are many secondary effects of patent protection which have accordingly become, and continue to become, more important over time.

One such secondary effect is that other firms face strong incentives to develop similar technologies—in economic parlance, substitutes—that they would not have otherwise. Under the patent system, a rival company's incentives to develop a new technology are twofold: The company reaps the reward both for the improvement that the new product represents relative to existing ones and the reward that they receive from converting a monopolistic market into a duopolistic one.[36] In many cases,

[36] It is worth noting that converting a monopolistic market into a duopolistic market intrinsically carries with it social benefits in the form of reduced deadweight loss. Under fairly typical symplifying assumptions—linear, downward-sloping demand curve, and positive, constant cost of production—the deadweight loss created by a monopoly is 2.25

the profits a company reaps from entering a duopoly will dwarf the profits stemming from the product's improvement relative to previously existing alternatives.

The pharmaceutical industry again provides an excellent illustration. The current system causes companies to spend hundreds of millions of dollars to develop so-called "me-too" drugs which have medicinal properties that are similar or identical to other products which have already proven to be commercially successful.[37] Nearly three-quarters of the "blockbuster" drugs[38] approved by the FDA between 1992 and 2001 were "me-too" drugs, such as allergy medications.[39] Although the new technology that these drugs offer provides comparatively little marginal value to society as a whole,[40] companies still face significant

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times as big as that created by a duopoly. *Compare* EQUATION A5, *infra*, *with* EQUATION D5, *infra*. Even so, under the same assumptions, the private incentives to develop a competing product are 1.6 times the social welfare that is created by shifting from a monopoly to a duopoly. *Compare* EQUATION D3, *infra*, *with* EQUATIONS A5 and D5, *infra*. Moreover, the wisdom of so closely linking research incentives to ameliorating artificially created market failures is not at all clear.

[37] *See, e.g.*, NAT'L INST. FOR HEALTH CARE MGMT. RESEARCH & EDUC. FOUND., CHANGING PATTERNS OF PHARMACEUTICAL INNOVATION 1-14 (2002), *available at* www.nihcm.org/finalweb/innovations.pdf; Correa, *supra* note 34 ("According to a report of the National Institute for Health Care Management . . . in the United States, from 1989 to 2000 the [FDA] approved 1035 new drug applications. Of these, [35%] were products with new active ingredients, or new molecular entities (NMEs). The other 65% used active ingredients that were already available in a marketed product. Over half (54%) were incrementally modified drugs, or new versions of medicines whose active ingredients were already available in an approved product. The rest (11%) contained the same active ingredient as identical marketed products."); Merrill Goozner, *The Price Isn't Right*, AM. PROSPECT, Sept. 11, 2000, *available at* http://www.prospect.org/web/page.ww?section=root&name=ViewPrint &articleId=5420 ("FDA statistics for the 1990s suggest that about half of industry research is aimed at developing me-too drugs."). Some of the more famous examples of recent years are the drugs Levitra and Cialis, developed in the wake of the tremendous commercial success of Viagra.

[38] A blockbuster drug is one with annual sales of $1 billion or more. *See, e.g.*, Knowledge@Wharton, *Without the Next Blockbuster Drug, Merck Faces a Murky Future*, Dec. 2003, *at* knowledge.wharton.upenn.edu/article.cfm?articleid=886; Peter Lansbury, *An Innovative Drug Industry? Well, No*, WASH. POST, Nov. 16, 2003, at B2.

[39] Lansbury, *supra* note 38; *see also* Catherine Arnst, Amy Barrett, Michael Arndt & John Carey, *The Waning of the Blockbuster Drug*, BUS. WK., Oct. 18, 2004, *available at* ("[Fifty percent] of blockbusters are heavily marketed me-too drugs, offering little benefit over others in their class . . . .").

[40] Lansbury, *supra* note 38 (noting that between 1982 and 1991, the FDA classified 53% of all newly approved drugs as offering "little or no therapeutic gain"); Goozner, *supra* note 37 ("In 1997 SmithKline Beecham won FDA approval for carvedilol (Coreg), a beta blocker for congestive heart failure. SmithKline launched the drug with much fanfare and won a significant share of the crowded market. However, a study completed last year showed it was no more effective than metoprolol, a generic beta blocker on the market since 1978."). However, these drugs do provide social value in that oligopolies

private incentives to develop them because the market structure created by patent still endows them with duopoly profits.[41] From a social welfare perspective, these development monies could be far better spent elsewhere.

Just as the patent system greatly overincents the development of substitutes, so too does it underincent the development of complementary products and technologies—i.e., products which are only useful, or at least much more useful, when combined with certain other products. If the inventors of two complementary products each holds an effective monopoly on its production (which is what the patent system attempts to convey), each will reduce its output and raise its price. However, each monopolist's price increase affects the other's sales; when consumers purchase both goods together, a price increase in one good means a price increase in the bundle. This reduces consumers' consumption of both goods.

At the same time, when each monopolist sets her price, she will be concerned only with her own profits; she will therefore raise her price until it is no longer profitable for her to do so. She will not take into account the lost profits forfeited by the complementary monopolist as a result of the decreased volume of sales. This will cause both monopolists to raise their prices to levels far in excess of the socially efficient level. This problem, whereby each monopolist separately "marks up" her price to maximize her own profit, is generally called the "double markup" or "double marginalization" problem.[42] The price levels created by the dual marginalization problem are not only higher than the socially efficient level; they are actually too high from the perspective of maximizing the monopolists' joint profits.[43] In such a case, if both monopolists can agree to decrease their prices and increase their output, the result is a Pareto improvement.[44]

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produce significantly less deadweight loss than monopolies do; relative to monopolies, oligopolies also redistribute surplus from producers to consumers. *Cf.* Christopher Rowland, *'Me-Too' Prescription Drugs Win Support in Tufts Study*, BOSTON GLOBE, Nov. 10, 2004, *available at* http://www.boston.com/business/articles/2004/11/10/me_too_prescription_drugs_win_support_in_tufts_study/ ("[F]ollow-on drugs introduce market competition, which holds down prices . . . ."). On balance, it is not at all clear that inducing duplicative scientific research is the optimal way to combat what is essentially an artificially created economic problem.

[41] Or, more generally, oligopoly.

[42] For an excellent and more formal presentation of this problem, see HAL R. VARIAN, INTERMEDIATE MICROECONOMICS: A MODERN APPROACH 453-55 (4th ed. 1996). Varian approaches the problem in the context of one monopolist in a factor market and another in a downstream market, but this case is functionally identical to the complements problem presented here by the patent system.

[43] *Id.* at 455.

[44] At any price above and quantity below the monopoly level, any decrease in price and increase in output increases consumer surplus. It therefore follows that joint

Patents can also impede the development of complements in a more drastic way: Because patents convey a property interest, further improvements that incorporate the patented technology can only be produced and sold with the consent of the patent holder. By refusing to give her consent, the patent holder can effectively prevent others from developing complements to her invention altogether.

In general, the patent holder will often have incentives to reach an agreement with would-be complement-developers to alleviate this problem.[45] However, such an agreement entails transaction costs and reduces the incentives of subsequent developers to make further improvements,[46] as the secondary innovator will frequently need to relinquish some of her profits to the original innovator[47] in order to secure her consent.[48]

Similarly, the property aspects of patent can also give the patent holder a great deal of control over the directions in which the new technology may be developed and the problems to which it may be applied. This can be a significant problem. Suppose that a technology was developed for a use in a particular industry, but that it would be far

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coordination, whereby each monopolist decreases her price and increases her output, will raise consumer surplus as well.

[45] I.e., she stands to make a royalty or obtain a flat fee in exchange for giving her permission to use the patent.

[46] These two factors interact in a very interesting way. If the research is somewhat speculative and requires a significant commitment of resources beforehand which cannot be used for another purpose, then if the subsequent innovator successfully develops an improvement, she finds herself entirely at the mercy of the original patent holder, who is in a position to extract most or all of the value of the new innovation from the new innovator. The other possibility is for the would-be improver to negotiate the rights from the initial innovator before commiting resources and beginning research. However, there is greater uncertainty, which increases transaction costs because neither side knows exactly what is being bargained over. Moreover, the research may be unsuccessful, in which case all the resources which went into negotiating the transaction are wasted as well.

[47] The development of a complement, almost by definition, increases the value of the original invention. However, the holder of the original invention has an advantage because she alone can provide access to the original, essential invention. If there are multiple inventors capable of developing the same complementary technology, but none of them is willing to do so without the prior consent of the original inventor to use her technology (as is likely to happen if developing the new technology entails significant costs), then the original patent holder can essentially pit these would-be inventors against each other. By auctioning off the right to use her patent only to the highest bidder, she can capture nearly all of the benefits of the complementary improvement, greatly reducing the second inventor's incentives in the process.

[48] It should also be noted that, while patent rents to the original innovator do decrease the incentives of subsequent innovators, to the extent that they are anticipated by the original innovator, they incent the development of the initial technology.

more useful in a competing industry.[49] In such a case, the developer may be able to deny her would-be rivals all use of the technology, and any subsequent innovations resulting therefrom. This could drastically reduce social welfare.

Admittedly, a patent that confers sufficient market power to completely prevent the development of complementary products altogether is likely an extreme case. On the other hand, we would expect the double markup problem to be comparatively common, and both effects reduce innovators' incentives to develop substitutes.

Of course, if bargaining is sufficiently easy, we need not worry about either the direct patent blocking problem or double marginalization problem. If all parties are rational and informed and there are no transaction costs, the Coase Theorem predicts that the parties will reach a mutually efficient result. Applying this to the most severe incarnation of the patent blocking problem is instructive: If a rival stands to gain more from using the technology than the patent holder would lose, the two parties will reach an agreement whereby the rival gains access to the technology. In exchange for this privilege, the rival will pay the original patent holder.[50] In a similar fashion, the two firms can defeat the double marginalization problem by agreeing to jointly lower their prices.

Unfortunately, reality seldom presents the idealized conditions that the Coase Theorem requires; thus, in practice, there is no guarantee that the parties will reach such an agreement.[51] Without such an agreement,

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[49] This is not as far-fetched of an idea as it may sound. Many competing industries use similar technologies, and often in today's complex technological society an innovation developed in one arena ends up having far-reaching implications for other applications that were never conceived of when the initial technology was being developed. For example, consider the branch of mathematics known as number theory. Many of its pioneers found it particularly enjoyable because it was purely abstract, and had no potential applications; thus, it could never be used to inflict harm on anyone. *See, e.g.*, G.H. HARDY, A MATHEMATICIAN'S APOLOGY (1940) ("I [begin] by laying stress on the *harmlessness* of mathematics—'the study of mathematics is . . . a perfectly harmless and innocent occupation.'"); *id.* ("I have never done anything 'useful.' No discovery of mine has made, or is likely to make, directly or indirectly, for good or ill, the least difference to the amenity of the world."). Number theory has since proven broadly applicable; all modern militaries now communicate using codes that are based on number theory.

[50] Note that for such a deal to happen, the rival must pay the original patentholder more than it loses in profits from its rival having access to its patented technology. The rival should be willing to pay this much because, by assumption, she gains more from having access to the technology than the original owner loses from her having access. The gains from the technology are not merely zero-sum.

[51] This phenomenon may be heightened, as a practical matter if not a theoretical one, in the case of network goods. In these cases, where the technology's value increases as more users adopt it, an innovator's initial success acts as a bar to entry against future competitors. These situations are susceptible to common adoption of a single standard, and initial successes may be dispositive (consider VHS and Betamax). In theory, a rival who stands to gain more will still be able to strike a deal by borrowing against its future

the patent holder can prevent anyone from using or improving upon her patent. History provides numerous illustrations of this phenomenon,[52] but perhaps the most commonly cited is the case of James Watt, father of the steam engine. To protect his business, Watt refused to license others to use or make improvements on his patent.[53] Watt himself was generally opposed to the use of steam power for transportation and, due to safety concerns, to the utilization of high-pressure steam in particular.[54] Watt's

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profits as the dominant technology. In practice, however, it's hard to imagine a fledgling technology in a contested industry borrowing heavily against its future speculative success.

[52] For example, Thomas Edison and the Wright brothers refused to license their respective patents for incandescent lighting and an aircraft stabilization and steering system. Their behavior temporarily impeded the development of improvements. *See, e.g.*, ADAM B. JAFFE & JOSH LERNER, CUMULATIVE AND OVERLAPPING INNOVATIONS (2004), *excerpt available at* hbswk.hbs.edu/item/4548.html; NAT'L RESEARCH COUNCIL OF THE NAT'L ACADS., A PATENT SYSTEM FOR THE 21ST CENTURY 26 (Stephen A. Merrill, Richard C. Levin & Mark B. Myers eds., 2004), *available at* http://newton.nap.edu/books/0309089107/html. It is worth noting that the Wright brothers' patent blocking was solved by government intervention; the advent of World War I spurred the U.S. government to convince a number of aircraft designers, including the Wright brothers, to pool their patents. *See* JAFFE & LERNER, *supra*. Nor are such practices restricted to such landmark patents. The Romanoff Caviar Company patented synthetic caviar in the United States in order to prevent the introduction of synthetic caviar, which could have been produced more cheaply than natural caviar, into the U.S. market. *See, e.g.*, Kurt M. Saunders, *Patent Nonuse and the Role of Public Interest as a Deterrent to Technology Suppression*, 15 HARV. J.L. & TECH. 389, 392-93 (2002).

[53] *See, e.g.*, Shavell & Van Ypersele, *supra* note 8, at 543. It is left to the reader to speculate as to precisely why the Coase Theorem failed in this instance. It is interesting to note that Watt refused to license his patent even when his business, Boulton and Watt Co., was turning down new orders because it did not have enough skilled workers to fill them. Moreover, even after his patent expired and many competitors entered the market, Watt's engines were of generally higher quality, and accordingly he maintained his high sales price for many years afterwards, and even had an increase in orders. *See, e.g.*, JOHN H. LIENHARD, THE ENGINES OF OUR INGENUITY 94-95 (2003), *available at* www.uh.edu/engines/; Michele Boldrin & David K. Levine, *The Case Against Intellectual Monopoly*, 2003 Lawrence R. Klein Lecture, 45 INT'L ECON. REV. 327 (2004); F.M. Scherer, *Invention and Innovation in the Watt-Boulton Steam-Engine Venture*, 6 TECH. & CULTURE 165 (1965); Vishwas Devaiah, A History of Patent Law, Alternative Law Forum, http://www.altlawforum.org/PUBLICATIONS/document.2004-12-18.0853561257; The Steam Engine in the Factory, fathom.com, http://www.fathom.com/course/21701780/session2.html. *But see* George Selgin & John Turner, *James Watt As Intellectual Monopolist: Comment on Boldrin and Levine*, 47 INT'L ECON. REV. 1341 (2006) (critiquing Boldrin and Levine).

[54] High pressure steam required an engine's boiler to withstand significant pressure. If something went wrong, the boiler could explode, spewing scalding hot metal and steam. *See, e.g.*, LEINHARD, *supra* note 53, at 93-94; Nancy G. Levenson, High-Pressure Steam Engines and Computer Software, presented at the International Conference on Software Engineering, Melbourne, Australia, May 1992, *available at* sunnyday.mit.edu/papers/steam.ps.

conduct delayed the invention of the high-pressure steam engine—and with it, the locomotive—until after his patent expired in 1800.[55]

Even among the limited uses Watt made of his invention, his patent had a staggering effect on its adoption. Before Watt began production, there were approximately 130 steam engines in Britain, mostly following the design which Watt had improved upon, that of Thomas Newcomen.[56] When Watt's patent protection expired twenty-four years later, the number of steam engines in Britain had increased to approximately one thousand.[57] However, less than a third of those followed Watt's design, the rest still followed the inefficient old Newcomen design.[58] The total power output of all the steam engines in Britain at that time was perhaps 10,000 horsepower.[59] Over the next fifteen years, the steam engines installed in England alone had over twenty times this many horsepower.[60]

Thus, while the property right aspects of patent ownership do not appear particularly troubling in theory, the case of the steam engine provides an excellent demonstration of why these features may be quite problematic in practice. Although it is rare[61] that a single patent will have such a transformative effect on society,[62] there are a multitude of others that mark smaller, more incremental steps forward that, when considered together, have deep and far-reaching effects.[63] These concerns strongly

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[55] Shavell & Ypersele, *supra* note 8, at 543. While James Watt did receive a patent for a steam locomotive in 1784 based on the work of his employee William Murdoch, the first steam locomotive to run on rails was built in 1804, after the patent had expired, by Richard Trevithick. *See, e.g.*, LIENHARD, *supra* note 54, at 95. Nor was this the only innovation delayed by Watt. James Pickard had developed and patented a crank and flywheel arrangement to convert the vertical motion of the steam engine piston into the rotary motion of a crankshaft to power machinery. Since neither he nor Watt would allow the other to use their patents, Watt had to resort to a less-efficient "sun and planet" gearing system instead. Boldrin & David K. Levine, *supra* note 53; Devaiah, *supra* note 53; The Steam Engine in the Factory, *supra* note 53.

[56] Boldrin & David K. Levine, *supra* note 53.

[57] *Id.*

[58] *Id.*

[59] *Id.*

[60] *Id.*

[61] Even though it is rare in the sense that the vast majority of patents do not have nearly so large an impact, a few moments of thought is sufficient to produce many pioneers whose inventions marked dramatic steps forward: Guttenberg's printing press, Marconi's radio, Fleiming's discovery of penicillin; Edison's light bulb, Bell's telephone, and the Wright brothers' plane provide easy examples.

[62] Of course, it is easy to see how this example could be adapted to a case of multiple patents that were vested in a single entity. The key issue is ownership of a technological pathway, not the number of patents required to secure that pathway.

[63] It is unclear whether the holders of multiple patents that are only valuable together would be more or less likely to reach an agreement than the owner of a particularly valuable major patent and a more minor improvement to that patent. There are

caution against merely dismissing the patent complements problem as unlikely to arise, or easily cured by the actions of the marketplace.

Indeed, the pharmaceutical industry provides a stark example of a more recent instance where the owners of two complementary patents failed to reach an agreement. Erythropoietin ("EPO") is used to stimulate the development of red blood cells, which is particularly useful to those suffering from anemia, including those suffering from chronic renal failure, chemotherapy patients, and premature infants.[64] Through various patents, Amgen has an effective monopoly on the manufacture of EPO.[65] Treatment is expensive because each patient requires very high levels of EPO.[66] In 1997, another laboratory was issued a patent for a compound that would enable patients to be treated using a much smaller dose of EPO and, accordingly, at a small fraction of the cost.[67] Amgen did not license the new patent, and the newly patented compound went unused.[68]

It is impossible to say whether the substitutes problem or the complements problem is more vexing. On one level, the complements problem is less troubling because it is more amenable to being solved privately. A merger of the two monopolists, or effective joint coordination on pricing, reduces it to the more mild case of monopoly pricing.[69] Since both monopolists stand to benefit from such a transition, there are some grounds for believing that firms can deal with this problem entirely through private contract.

On the other hand, there is no guarantee that the monopolists will reach such an agreement. Transaction costs, regulatory prohibitions, strategic behavior, and commitment problems are only a few of the many potential obstacles that can prevent this from happening. Left unchecked, the double marginalization problem is all the more frustrating because it is a market distortion that literally adheres to the benefit of no one—both consumers and producers are significantly injured as a result.

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arguments supporting both views. In practice, the difference will likely depend on various situation-specific factors.

[64] *See, e.g.*, Saunders, *supra* note 52, at 395.

[65] *Id.*

[66] This is because these patients lack a particular chemical that prevents from being immediately excreted in urine. *Id.*

[67] The compound enabled a patient to retain EPO instead of excreting it immediately. *Id.* A patient who received the newly patented compound needed only between 2% and 10% of the dose of EPO that she would need otherwise. *Id.*

[68] *Id.* Purportedly, this was because Amgen calculated that it was not in its financial interest to do so, as the reduced amount of EPO administered to each patient would not be outweighed by the additional patients who would then use EPO. *Id.* If this was, in fact, Amgen's motivation and its calculations were correct, Amgen still would not have licensed the patent even under the idealized conditions of the Coase Theorem.

[69] Which, of course, is still socially inefficient; see discussion *supra*.

C. *The Uncertainty Costs of Patent*

Enforcing patent rights also creates significant administrative costs. To deter competition to the greatest possible extent, firms patent as much as they can and patent applications are written to cover the broadest class of activity. However, patent law creates limits on what may be patented, both in the abstract and in specific instances.[70] This can lead to a great deal of uncertainty over exactly what behavior is covered by which patents, and whether or not those patents are valid.[71] In the shadow of this uncertainty, patent holders seek to expand the scope of their patent as much as possible in order to insulate their business from competition to the greatest extent. Meanwhile, these same market forces inexorably drive competitors to engage in behavior that is as close to the boundaries of protection as possible without actually crossing them.

This situation is significantly exacerbated by the market distortions patent creates, for the same reasons that the patent system encourages the development of substitutes: A company that successfully develops a comparable technology just beyond the scope of a rival's patent protection reaps more than the value the new product represents relative to existing

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[70] In the words of the United States Patent Office:

> In the language of the statute, any person who "invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent," subject to the conditions and requirements of the law. . . .
>
> . . . .
>
> The patent law specifies that the subject matter must be "useful." The term "useful" in this connection refers to the condition that the subject matter has a useful purpose and also includes operativeness, that is, a machine which will not operate to perform the intended purpose would not be called useful, and therefore would not be granted a patent.
>
> Interpretations of the statute by the courts have defined the limits of the field of subject matter which can be patented, thus it has been held that the laws of nature, physical phenomena and abstract ideas are not patentable subject matter.
>
> A patent cannot be obtained upon a mere idea or suggestion. The patent is granted upon the new machine, manufacture, etc., as has been said, and not upon the idea or suggestion of the new machine. A complete description of the actual machine or other subject matter for which a patent is sought is required.

U.S. Patent Office, What Can Be Patented, at http://www.uspto.gov/web/offices/pac/doc/general/what.htm, *excerpted from* U.S. PATENT OFFICE, GENERAL INFORMATION CONCERNING PATENTS.

[71] Some companies aggressively search for and attack patents that they believe are legally invalid. For example, Barr pharmaceuticals, a generic drug manufacturer, incorporates the search for breakable patents as an important and permanent part of its business model. Korman, *supra* note 8, at C4.

ones, it also reaps a reward for converting a monopolistic market into a duopolistic one. In many cases, the profits a company reaps from entering a duopoly will dominate. Just as patent overincents substitutes, so too does it overincent conflicting interpretations of claims.

The end result is a great deal of patent litigation. Patent litigation has long been an expensive proposition, and it has only gotten more expensive over time.[72] The median cost to each party in a patent trial is $1.2 million; complex trials can run over $6 million.[73] Patent disputes

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[72] As Lord Esher wrote in 1894:

> [T]he moment there is a patent case one can see it before the case is opened, or called in the list. How can we see it? We can see it by a pile of books as high as this [making visual reference] invariably, one set for each Counsel, one set for each Judge, of course, and by the voluminous shorthand notes: we know "Here is a patent case."
>
> Now, what is the result of all this? Why that a man had better have his patent infringed, or have anything happen to him in this world, short of losing all his family by influenza, than have a dispute about a patent. His patent is swallowed up, and he is ruined. Whose fault is it? It is really not the fault of the law; it is the fault of the mode of conducting the law in a patent case. This is what causes all this mischief.

Ungar v. Sugg, 9 R.P.C. 113, 116 (1892) (Opinion of Lord Esher, J.).

[73] Korman, *supra* note 8, at C4. To provide another example, each time that Barr Pharmaceuticals goes to trial to fight what it considers to be a vulnerable patent, it expects to spend between six and eight million dollars. In one case, which Barr ultimately lost, District Judge Malcolm Howard wrote that:

> In the twenty-five months [] between the filing of the initial complaint…and the commencement of the trial…approximately five hundred forty-one pleadings have been filed and dozens of hearings on motions and discovery matters have been conducted... The court has entered eighty-eight written orders and numerous bench rulings…
>
> To state that the case has been hotly contested would be an understatement. The parties have amassed learned, experienced and sizable trial teams who have represented their clients zealously and competently.
>
> The administrative complexity [of] conducting a trial of this magnitude has been enormous for the court and the parties. The sixty-year-old courtroom…has been converted into a contemporary high tech facility utilizing real time court reporting and six computer-integrated video display monitors. It is highly conceivable that the cost of this trial for the parties exceeds $100,000 per day, in addition to the time and expense associated with this court and the jury. As the case enters its fourth week of trial, the parties estimate, somewhat conservatively the court suspects, that the trial will last an additional six to eight weeks.

Burroughs Wellcome Co. v. Barr Lab., 828 F. Supp. 1208, 1209 (E.D.N.C. 1993). Nor is this problem confined solely to our own patent system. *See, e.g.*, Merck & Co. v. Generics (UK) Ltd., 2003 EWHC 2842 (Pat) (quoting Ungar, 9 R.P.C. at 116 (Opinion of Lord Esher, J.)) (noting that by the third day of trial, the two parties had spent over

may be resolved without lawsuits being filed, but this happens less and less frequently, and the more valuable the patent being fought over, the more likely that a case will go to trial.[74]

The uncertainty surrounding patents has other negative effects. Researchers' concerns over the costs of defending against a patent infringement suit and potential liability if they are found to be violating a patent can deter them from carrying out research in certain fields and channel them into others. This encourages the exploration of second-choice research topics—those which the researcher expects to be less promising, those which the researcher is less adept at investigating, or those which the researcher is less motivated to pursue. This problem is real. For example, there is empirical evidence that biotech companies with fewer resources, notably new start-ups, are avoiding those fields which are more crowded with patents and that are more likely to spawn a lot of litigation.[75] To the extent that the course of scientific research is directed away from the most promising areas and down these second-choice pursuits, this impedes scientific progress and creates real and tangible social costs.

IV. THE TRADITIONAL ANSWER: SUBSIDIES

A. *Overview and Direct Effects*

The traditional economic solution to the monopoly production problem is for the government to subsidize production by paying a fixed amount to the monopolist for every unit sold. The idea is that this payment by the government increases the monopolist's profit per unit, helping to offset the profits the monopolist would lose from lowering her price,[76] and inducing the monopolist to raise her output. The amount of the subsidy is chosen to ensure equilibrium at the competitive market price and quantity.[77] In theory, the costs of the subsidy are recoverable via an

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£850,000 "for a trial in which the only issue was one of construction of a very short and easily comprehensible patent dealing [with] comparatively simple chemistry").

[74] *Id.*

[75] *See* Josh Lerner, *Patenting in the Shadow of Competitors*, 38 J.L. & ECON. 463, 465 (1995).

[76] *See* footnote 35, *supra*. Monopolists essentially choose their production levels based on the tradeoff between profit per unit sold and quantity sold. Because demand curves are generally downward sloping, price—and, therefore, profit per unit—is higher when the monopolist reduces her production level. By paying a subsidy, the government raises the monopolist's profit per unit, incenting the monopolist to increase the quantity of units she produces.

[77] Of course, the competitive equilibrium need not be the targeted equilibrium. A smaller subsidy will move the market equilibrium toward the competitive equilibrium, lowering the price that consumers pay and increasing the output that firms produce. A larger

administratively costless lump sum tax on the monopolist, so that, ultimately, consumer and producer surplus is the same as it would be if the good were produced in a perfectly competitive market.

In reality, however, this is seldom workable. Lump sum taxes on individual corporations are not a realistic policy measure; the federal government collects most of its revenues from the federal income tax, which is levied on consumers.[78] This means that these payments, ostensibly made to benefit consumers, are actually coming out of the consumers' pockets;[79] the real beneficiary is the firm whose goods are subsidized. Even if one discounts these distributional concerns, these taxes have distortionary effects which reduce social welfare.[80]

In practice, a subsidy is actually an externality intentionally imposed by the government:[81] Ordinarily, when someone chooses whether or not to purchase a good, they both bear all the benefit of the purchase—i.e., they get to own the good—and all the cost of the purchase, in the form of paying the purchase price. However, under a subsidy, a portion of the purchase price is paid by the government, not by the purchaser. Thus, whenever someone decides to purchase the good, she imposes a small cost on every other taxpayer. However, since the purchaser does not bear this cost, she will not take it into account when

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subsidy will move the equilibrium beyond the competitive outcome, lowering price below the cost of production and raising output accordingly. For simplicity, we generally focus on the case where the chosen subsidy creates the competitive market equilibrium, but the discussion below is essentially equivalent under these scenarios, with the effects changing by a matter of degree.

[78] For example, in 2006 raised over 78% of its revenue from the individual income tax and social insurance taxes. *See* CONG'L BUDGET OFFICE, CBO'S BASELINE BUDGET PROJECTIONS 1 (2007), *available at* http://www.cbo.gov/budget/budproj.shtml.

[79] Of course, it also bears noting that the subsidy the company receives is ultimately passed on to its shareholders, who are consumers. The more evenly that ownership of the company is dispersed among the populace, the less sense it makes to talk about the company and consumers as different groups. Indeed, if consumers have identical preferences and an identical ownership share, a subsidy scheme that creates the competitive market equilibrium will maximize welfare if taxes are administratively costless and non-distortionary. However, the probability of such a scenario arising is vanishingly small. Accordingly, I will distinguish between consumers and producers so as to paint the clearest possible picture. I leave it to the reader to remember and consider that producers are ultimately composed of consumers.

[80] The positive aspect of this is that the funds to pay for the subsidy are likely raised by income taxes, which generally have less distortionary impact than other taxes. The negative aspect is that subsidies tend to be very expensive, requiring a larger tax than an optional patent purchase system. *See* discussion in Part V, *infra*. A full subsidy of a true monopoly could easily be so expensive that the taxes necessary to fund it would actually create a greater deadweight loss than the monopoly itself.

[81] Note that this can also make subsidies, like taxes, an excellent tool for addressing externalities.

making her purchasing decisions.[82] The purchaser will therefore purchase the good as if it were being sold at a lower price than it actually is; consequently, she will buy more of the subsidized good than she would otherwise.[83] Thus, everyone who receives the subsidy will exhibit this same behavior, and will purchase a higher quantity of the good than she would without the subsidy. Indeed, this is precisely the point of the subsidy; to change the outcome relative to that which would be observed under unregulated monopoly market conditions. At the end of the day, the average citizen's consumption level will be the same as it would have been in the competitive market outcome.[84]

But each time a citizen makes a purchase, the government makes a payment to the company. To fund those payments, the government levies taxes on consumers—the same consumers who are making those purchases in the first place.[85] Thus, everyone imposes a negative externality on everyone else—but everyone also has a negative externality imposed on them by everyone else. If each citizen were faced with the full price of the good—the price they pay plus the cost of the subsidy—they would choose to consume far less of the good than they will under the subsidy regime.[86] The subsidy system thus channels far more money and surplus from consumers to producers than a competitive market would.[87] A firm receiving a subsidy earns profits far in excess of what it would

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[82] Technically, a small portion of the amount contributed by the government is paid by the purchaser in the form of higher taxes, either in the present or in the future. However, this component is so small as to be effectively negligible.

[83] While consumption of some goods decreases when their price decreases, these goods are exceptional. They tend to be extremely high-end luxury goods, such as Porsches, and extremely low-end goods, such as SPAM. *See, e.g.*, ROBERT H. FRANK, LUXURY FEVER 217-18 (2001). These goods are very much in the minority, and are particularly unlikely to be subsidized. We therefore do not consider them any further.

[84] Assuming that the cost of the taxes to pay for the subsidy has a negligible income effect on consumers' demand for the subsidized good. Of course, any income effect that does exist can itself be compensated for by further increasing the size of the subsidy, but this is an additional level of recursive complexity that we need not consider here.

[85] Of course, this is an oversimplification. While the income tax is by far the federal government's largest source of revenue, taxes may be levied on a discrete group of consumers instead of the entire populace at large. Similarly, all citizens may not be purchasers of the subsidized product. But, in the interests of simplicity, I generally assume that tax burdens fall equally on all members of the population, and that all members of the population have identical demand for a product.

[86] This corresponds exactly to the unregulated monopoly market. Since the subsidy system was imposed with the explicit goal of increasing consumption, it becomes clear that dismantling the subsidy regime will reduce consumption.

[87] However, if taxes are non-distortionary and administratively costless, total social welfare does increase; hence the attraction of the traditional economic view of subsidies, wherein they are financed by an administratively costless lump sum (and thus non-distortionary) tax. Taxing the producer has the added benefit of squelching any distributional issues.

receive if it merely held a monopoly under patent. Consumers, the supposed beneficiaries of a subsidy, are actually much worse off in the aggregate than they would be in an unregulated monopoly system.[88]

This additional producer surplus is perhaps subsidies' most important and fundamental flaw: To the extent that subsidies are anticipated, they dramatically overincent the development of the subsidized technology.[89] All else equal, firms therefore have much stronger incentives to develop goods whose production will be subsidized than they do to develop other goods. Moreover, there is good reason to believe that subsidies can be anticipated; currently, subsidies are generally awarded only after significant lobbying efforts. Subsidies therefore create significant direct distortions relative to patent.[90]

Subsidies can also be perceived as the government transferring taxpayer dollars to the coffers of large corporations—special interests. Public distrust of these special interests can make subsidies politically difficult or impossible.[91]

Another problem with a subsidy program is that the government must predict the correct subsidy to achieve the competitive production output level. A subsidy that is too low is not overly bad; although it results in output below the competitive market level, it does raise output above the monopoly level, and it costs less than the "correct" subsidy

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[88] Put another way, monopolists are rational entities that maximize their own profits. Once they receive a subsidy, their set of options—and, concomitantly, their expected profit—expands. If a monopolist under a subsidy produced the same amount of output as it did under the non-subsidized monopoly equilibrium, its profits would exceed those under the monopoly equilibrium. This is because the revenue it receives per unit sold has been increased by the amount of the subsidy, while the number of units it sells, as well as its underlying cost structure, have remained unchanged. However, the monopolist chooses to produce at an even higher level under the subsidy; its profits at this equilibrium must thus be higher still. These profits come from payments by consumers, and they would not have chosen a lower level of consumption if they had initially realized the full extent of the cost they must bear; thus, consumers' welfare is lower under the subsidy regime.

[89] Also worth noting is that this extra potential producer surplus is likely to attract significant lobbying efforts by the potential recipients. These expenditures—whose sole effect is to redistribute utility and which do not promote any social goal—constitute a real social cost. *See, e.g.*, Duffy, *supra* note 17, at 44-45.

[90] Some might argue that, to some extent, this is a good thing, since patent only bestows a portion of the social value of the good on its inventor, underincenting development relative to the social optimum. Nonetheless, even many diehard efficiency devotees would balk at the incentives created by subsidy; under basic assumptions (linear, downward-sloping demand curve; constant, positive cost of production), the monopolist's profit under subsidy is double the social value of the subsidized good.

[91] On the other hand, to the extent that they *are* transfers of taxpayer dollars to special interests, these interests are often willing to engage in significant lobbying efforts.

would.[92] A subsidy that is too high, however, is much worse: First, it costs far more than the "correct" subsidy, as the populace both pays more per unit[93] and pays over more units.[94] Second, a subsidy that is too high raises the monopolist's output above the socially efficient level, which means that some of the goods produced will cost more to make than society values them. From a social welfare perspective, this represents pure waste.

B. *Secondary Effects*

The secondary effects of subsidies are even more interesting. Suppose that a firm has just patented a new, useful technology, and enjoys a monopoly as a result. The government, hoping to offset monopoly's social waste, implements a subsidy designed to achieve the competitive market production level.

Now consider the incentives of a rival firm to develop a competing technology. If it enters the market,[95] the rival firm will face the same environment it would face if the first good were being sold at the competitive price.[96] In the sense that, unlike the patent system, it does not overincent the development of substitutes by linking the profits reaped from the intrinsic value of the new technology to the profits reaped from acquiring a position as a duopolist, this is a positive result.

However, the good is not really being sold at the competitive price; in effect, the sale price is the competitive price plus the amount of the subsidy. Since consumers ultimately bear this full cost through their tax burden, this means there is a real disconnect between the price that consumers ultimately pay and the market price that would-be manufacturers of potential substitutes observe. Thus, the subsidy discourages other firms from developing substitutes,[97] which ensures that the subsidy will have to be maintained throughout the duration of the patent.[98] Reliance on a subsidy perpetuates further reliance on the subsidy. The government may correct this outcome by subsidizing the second technology.[99] However, if firms anticipate this,[100] they will

[92] The smaller the subsidy, the better off consumers are in the aggregate. This makes sense in light of the externality discussions above.
[93] This is because the subsidy is higher.
[94] This is because the higher subsidy induces the monopolist to increase her production.
[95] We assume that the rival firm is unable to secure a subsidy of its own.
[96] This is because the price consumers face when they choose whether or not to purchase the good is, by the design of the subsidy, the competitive market price.
[97] Relative to the patent system, that is; it is equivalent to a world in which the subsidized product was produced at its competitive market price and quantity.
[98] In order to keep production at its competitive market level.
[99] Or, of course, removing the subsidy on the first technology.

consider the value of future subsidies when deciding what technologies to research and how many resources to commit. Once again, the government will be overincenting development of substitutes, just as it did under patent.[101]

The presence of the subsidy also changes the behavior of other economic actors. Because consumers are only paying the competitive price when they purchase the subsidized good, they will make planning decisions on this basis. In reality, however, the government is also making payments to the monopolist on every unit that is purchased. The purchaser's calculus does not include the social cost, in the form of deadweight loss, created by the taxes the government must levy in order to make these payments. This will sometimes lead to socially inefficient outcomes.

For example, suppose that a certain useful chemical used in an industrial cleaning process is patented and subsidized. Now suppose that a potential user of the chemical has a choice between two equally effective cleaning systems which both use that chemical: The first is a cheaper, less sophisticated system that uses a larger quantity of the chemical. The second is more expensive and sophisticated, but consequently is more efficient, in that it achieves the same result while using a lesser amount of the chemical. Because the user only contributes a portion of the social resources necessary to purchase the chemical, she will be more likely to choose the first system. The user might have made a different decision if she had to bear the full social cost—i.e., if she also bore the social cost of the taxes required to pay for the subsidy on the chemical.[102]

This concern also applies to the consumption of substitutes to subsidized goods. Sticking with the industrial cleaner example, suppose that a second chemical becomes available with similar uses.[103] This chemical faces an artificial disadvantage in the marketplace because its competitor is subsidized. This is particularly worrisome because a shift from purchases of the subsidized good to the substitute would mean the government paid the producer of the subsidized good less, and, concomitantly, a reduced deadweight loss from taxation. Thus, while the

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[100] And, since firms are currently likely to be able to secure subsidies for their products only after significant lobbying, there is at least an argument to be made that firms have a fair amount of ability to predict when their products will be subsidized. *See* discussion Part IV.A, *supra*.

[101] On the plus side, it only costs half as much to subsidize a duopolistic market into a competitive equilibrium as it would to subsidize a monopolistic one. *Compare* EQUATION B1, *infra with* EQUATION E2, *infra*.

[102] This analysis does not consider distributional concerns, but including them only strengthens this argument.

[103] As discussed above, this chemical is less likely to be developed than it would be under the patent system. Nonetheless, we now consider what happens once it has been developed.

subsidy promotes social welfare by not overincenting imitative technology the way that patent does,[104] it has other problems.

Subsidies also have important effects on the development and distribution of complementary products. Under a subsidy system, the incentives to develop complementary products are higher than the social optimum. Because consumers will behave as if the original product were being sold at its competitive market price, firms will have the same incentives to develop complements as they would if the product were being produced in a competitive market. The problem this raises resembles that raised by substitutes; the real price is not the competitive price, but the competitive price plus the amount of the subsidy. This transfer payment must be raised through distortionary taxes which reduce social welfare.

Once a complement to a subsidized good is developed, in an important sense, the subsidy on the initial product becomes shared between it and its complement. Consider two companies, X and Y, producing complementary products. If Company X's product is subsidized, then, from Company Y's perspective, this is the effective equivalent of a reduction in the price of Company X's product. This will shift the demand curve that Company Y faces.[105] In response, Company Y is likely to change its behavior by raising its price.[106] Thus, Company Y reaps great benefits from the subsidy. For consumers,[107] this means an increase in the price of the bundle—just as if the subsidy had been a smaller one.

Further, a monopolist under a subsidy remains free to change her price and quantity in response to market conditions. While flexibility to market conditions is generally a good thing, it can be problematic here. Market actors will rely on the low price of the subsidized good when they make decisions, and this will change the shape of the demand curve for the

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[104] As discussed above, a benefit of the subsidy system relative to unmodified patent is that it does not overincent the development of substitutes by linking the profits reaped from the intrinsic value of the new technology to the profits reaped from acquiring a position as a duopolist.

[105] This is because many consumers will consider X and Y's products as a package. Once Company X has reduced the price of its product, that package is cheaper at any given price of Y's product. Accordingly, the demand curve for Y's product shifts. Note that this is the other side of the complements problem observed in patent, where the price of the bundle became more expensive when the price of either of the two individual goods was increased.

[106] Company Y's output will then be below the competitive level, but above the level it would be at if both companies operated in an unmodified patent system.

[107] Company X will also respond to Company Y's change in price by changing its price; Company Y will react in turn, etc. Since the primary concern of this paper is the results at equilibrium, I do not devote much time to the consideration of the exact path by which it is achieved.

good.[108] After the demand curve has changed shape, the monopolist will likely want to change her price and output level in response, ultimately creating further inefficiencies. The monopolist's actions can render a previously correctly sized subsidy either too large or too small. Subsequent adjustments to the subsidy in response to changed market conditions can restart this same process.

An example is helpful in driving home this point. Imagine that a private party has built a bridge that significantly shortens the daily commute for many people. Drivers who wish to use the bridge must pay a toll of $5. The government then intercedes by imposing a subsidy; they pay $2 of this toll. Commuters using the bridge now have, by assumption, a significantly shorter commute. Accordingly, they will be less concerned with the gas mileage of the cars they buy, and on the whole they will be likely to shift towards cars that get poorer gas mileage. Commuters who previously chose mass transit systems may also be induced to purchase cars. People may move closer to the bridge, and farther from other routes. They may move to areas that, before the bridge was built, had commutes that they considered to be too long. In these ways, the commuters will become more dependent on the bridge. The company that owns the bridge will realize that its bridge has now become more valuable, and will increase its toll accordingly. The government then faces the choice of either increasing the subsidy to match or allowing the market equilibrium to shift away from that which it originally envisioned.[109]

It is also possible that other market actors will anticipate the future behavior of the monopolist, and will choose not to rely on the subsidized price in their long-term planning. However, to the extent that this is the case, the subsidy has not accomplished its intended purpose of moving the market equilibrium to its competitive level. Moreover, assuming that there are no additional costs when more consumers rely on the bridge,[110] it is socially beneficial for consumers to rely on the bridge when making their planning decisions.[111] Thus, to the extent that consumers do not rely on its existence, this also represents social waste.

Monopoly control of such a resource thus presents a double-edged sword: If consumers rely on that resource's availability at a given price, they make themselves dependent upon it, and therefore vulnerable to later

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[108] In the short run, at the very least.

[109] These same reliance effects would also occur without the subsidy. However, to the extent that a subsidy is imposed for the purpose of achieving a particular market equilibrium, the monopolist response dynamic may greatly complicate this goal.

[110] Such costs would include additional wear and tear on the bridge and increased delays to other bridge users because of traffic.

[111] This analogy does not work particularly well for a physical thing, such as a bridge, which has limited capacity. However, it works very well in the case of an idea or other piece of intellectual property, since such an item's utility is not diminished by successive users, nor does its use by one individual prevent its use by others.

attempts by the monopolist to exploit that dependence. If consumers anticipate this future monopolistic preying, they are effectively behaving as if the good is already being sold at this higher price. This further reduces their consumption below what would otherwise be the monopoly equilibrium level—a level of consumption that itself already represents a significant reduction from the competitive market equilibrium.

V. THE OPTIONAL PATENT PURCHASING SYSTEM

A. *Overview and Direct Effects*

We now consider an alternative to the current system in which the government has the option of buying a patent from its owner. The government must purchase the patent just like any private buyer would; the patent holder is under no obligation whatsoever to sell to the government, and remains perfectly free to maintain her ownership of the patent and consequent monopoly profits. To induce the patent holder to sell her patent, the government will have to offer her an amount greater than or equal to what she would earn from monopoly profits. Unlike a mandatory program, this voluntary aspect ensures that the government cannot force companies to accept lower profits, preserving their research and development incentives.

If the government successfully acquires the patent, it licenses it for free to anyone who wants to use the patent for any purpose, effectively making it available to all interested parties at no cost. For industries where there are many firms with the capability to produce the good, it would be sold at the competitive market price.[112] The funds for patent purchasing would come from general tax revenues.

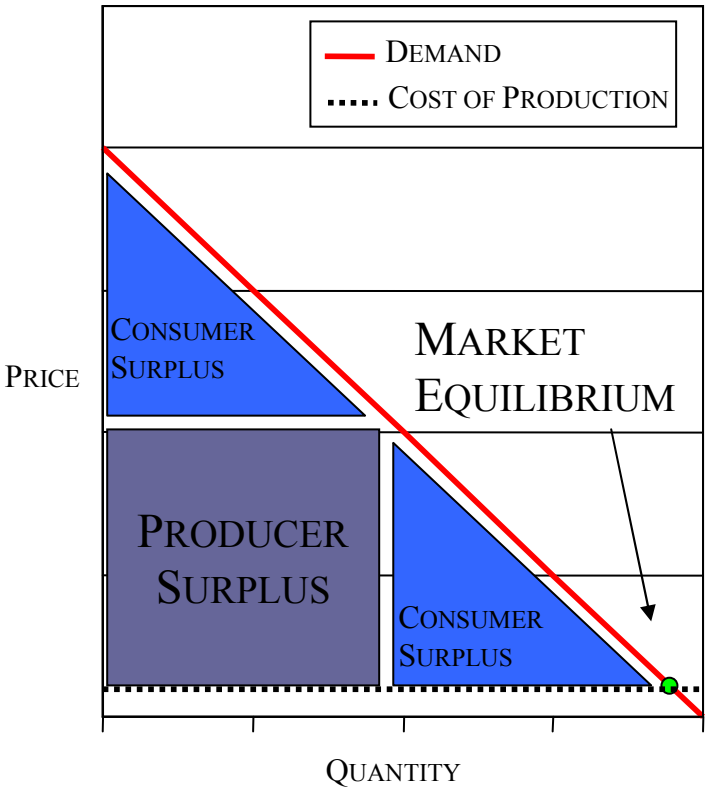
The market equilibrium under such a regime is depicted graphically in Figure 5.1, below. Notice that the considerable deadweight loss present under the patent system, depicted graphically above in Figure 3.2,[113] has been completely eliminated and primarily converted to

[112] This last component—that the item ultimately be produced by the private sector instead of the government—is essential. Maintaining an industry's ability to carry a good through all phases of the production process ensures that selling the product in the market remains a realistic option for companies developing new technologies and goods. If the government controls these channels, there will be no private sector check on the government's ability to cheat down the price it pays for patents, eroding research incentives and ultimately stemming the flow of innovation. To preserve the voluntary nature of the patentholder's decision, the government's purchasing decision must be completely separated from the decision to grant the applicant's request for a patent.

[113] Figure 3.2 also graphically demonstrates that, assuming a linear, downward-sloping demand curve and constant, positive cost of production, a monopolistic market creates a deadweight loss that is exactly one-half the size of the monopolist's profits.

consumer surplus.[114] This represents a tremendous social improvement relative to the waste of the patent system.

FIGURE 5.1: OPTIONAL PATENT PURCHASE SYSTEM



A bit of clarification is in order here. The monopolist will only be willing to sell her patent for a price that exceeds the profit she expects to achieve as a monopolist. Monopoly profit represents the maximum profit a producer can achieve; there is therefore no reason for any private agent to purchase the patent for any more than this sum.[115] The government is willing to pay more than this amount because its motives are fundamentally different from those of a private purchaser. The government does not seek to maximize its profits; its goal is to maximize its citizens' utility. It does that here by eliminating the deadweight loss from monopoly[116] and the other social inefficiencies that patent creates.[117]

[114] Note that Figure 5.1 does not consider the deadweight loss created by the taxes the government imposes to raise the funds it uses to purchase the patent from its owner.
[115] Assuming that the new buyer can not market the product better, produce it cheaper, or function as a more perfect monopolist.
[116] This can be seen graphically by comparing Figures 3.2 and 5.1, above.
[117] For example, overincenting the development of substitutes. *See* discussion Part III.B, *supra*.

It is the only entity with these incentives and it is therefore the only entity willing to pay this much.[118]

We see then that if the government successfully purchases a patent at a price just above the would-be monopolist's profit,[119] the result is a Pareto improvement:[120] The patent holder is better off, as she has earned more profits than she would under patent. Consumers are better off[121] because they are capturing the benefit of what had previously been so much deadweight loss.[122]

It is important to note that the taxes to raise these funds are not costless.[123] Taxes create market distortions and deadweight loss of their own, detracting from social welfare. However, one would expect significantly less deadweight loss to result from raising an amount equal to the monopolist's profits through income taxes than would result from the monopolist's unchecked market behavior.[124] Accordingly, while patent purchasing can fairly be characterized as trading off one type of deadweight loss—that from monopoly pricing—for another—that of

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[118] In theory, there could be some sort of charity or other altruistic benefactor who would have the same motives. However, a patent whose social value is sufficiently high to attract this sort of philanthropic attention is also likely to carry a purchase price that would be prohibitively expensive. Beyond this practical constraint, if the government were actually purchasing patents, it would only make sense for the charity to bid on patents that the government was not interested in purchasing; if both entities intended to put the patent into the public domain, there would be no reason for them to bid against each other, and presumably each would prefer to preserve its own funds as much as possible.

[119] Because firms receive only slightly more compensation for selling their patent to the government than they do from exercising their patent rights, the rent-seeking concerns engendered by a subsidy system are correspondingly lessened. *See* discussion at footnote 89, *supra*; *see also* Duffy, *supra* note 17, at 44-45.

[120] It is worth noting that this analysis is being done at a group level, not at the level of individual consumers. It is likely that there will be some consumers who do not receive a benefit from the patent being placed into the public domain (i.e. those who don't use it), but who pay higher taxes as a result of the purchase. For them, patent purchasing is not a Pareto improvement. However, on average and over time, all consumers might be expected to gain more from having the patents they do utilize available at lower prices than they lose from increased taxes (and concomitant deadweight loss).

[121] *Compare* Figure 5.1, *supra*, *with* Figure 3.2, *supra*.

[122] If one considers the government as an entity in this analysis, it would also be better off after such a purchase, as its goal was to improve the welfare of its citizens, and it has done so. Another, easier, way to see that the government is at least as well off if it makes such a purchase is to recall that it made the purchase voluntarily. Whatever its goals, if the government acts rationally to pursue them, it will only make the purchase if doing so furthers them.

[123] *See also* Duffy, *supra* note 17, at 42-43 (discussing same).

[124] *See* sources cited footnote 80, *supra*.

taxation—there is good cause to believe that there are significant efficiency gains to be made from this trade.[125]

Purchasing a patent costs much less than it would cost to impose a traditional subsidy regime. Concomitantly, the taxes required to fund a patent purchase create much less deadweight loss than those required to fund a traditional subsidy. Under fairly typical basic economic modeling assumptions,[126] the government would only need to raise one fourth as much revenue to purchase the patent as it would need to raise to effect a subsidy.

But in many cases, the greatest benefits of a government patent purchase would be derived from the efficiency gains of incenting development through income taxation instead of through monopolistic pricing; nor would they stem from achieving a subsidy's effect while reducing the accompanying tax burden. Instead, they may stem from the patent purchase's efficient realignment of secondary incentives. It is to these benefits that I now turn my attention.

B. *Effects on Secondary Incentives*

Once a patent has been purchased, it enters the public domain, ensuring that other firms enter the market and drive price down to the competitive market level. Because this leads to the competitive market equilibrium, it creates socially efficient incentives to develop both substitutes and complements—unlike the traditional patent system, which overincents the development of substitutes and underincents the development of complements. I address each of these issues in turn.

1. Substitutes

As discussed above, a major problem of the current patent system is that it overincents the development of substitutes.[127] Under the patent system, a rival company's incentives to develop a new product are twofold: The company reaps the reward both for the improvement the new product represents relative to existing ones and the reward they receive from converting a monopolistic market into a duopolistic one. In the vast majority of cases, the profits a company reaps from entering a duopoly will dwarf the profits stemming from the product's marginal

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[125] Of course, there are always exceptions. If a monopolist could perfectly price-discriminate, the monopoly outcome would be socially efficient, and imposing taxes with which to purchase the patent would lead to a net utility loss. Perfectly price-discriminating monopolists are exceedingly rare, however.

[126] I.e., linear, downward-sloping demand curve and constant, positive marginal cost of production.

[127] *See* Part III.B, *supra*.

improvements relative to previously existing products. From a social welfare perspective, these research monies would be better spent elsewhere.

Under a patent purchase system, however, companies reap only the reward they derive from the intrinsic value of their innovation; i.e., its marginal value relative to existing products. Once the government has bought the patent rights to the first product, it will become available in the marketplace at its cost of production. If a company develops a second, similar product, they will not be able to charge a very high price for it, as there is already a cheap substitute of substantial quality available. This makes the company's patent right in the new technology much less valuable than it would be if the first product were not already on the market. The result is the same as that which results from the competitive market equilibrium.

Some readers may respond that the optional patent purchase system goes too far—that unlike patent, it actually discourages companies from making innovations. However, from an economic standpoint, this argument is incorrect. If the new product costs the same to produce as the existing product, but creates more value for its owner than the previously existing product, then the new inventor can charge a price higher than that of the existing product (but less than the price of the existing product plus the increase in value of the new product) and make a profit.[128] This is ideal, as it guarantees that substitutes will only be developed so long as their social benefits exceed their cost of development. The optional patent purchase system does not deter all improvements; it curtails socially wasteful innovations in favor of more socially beneficial ones.[129]

Yet this raises an important issue: In light of the implications a purchased patent has for potential competitors in the industry, some may be concerned that the sale to the government is far less voluntary than it may appear. More specifically, one might worry that a company must take whatever the government offers, for, if they do not, another company will develop a substitute—and then sell the government the patent for that

[128] Note that this would yield a profit because, by assumption, the cost of production of the new product is the same as that of the old product.

[129] Some industries have upward sloping production cost curves characterized by increasing marginal cost of production. In these industries, having substitutes creates social efficiencies because they allow the previous industry to operate at a lower level of production, which, by assumption, entails an even higher reduction in the level of resources that must be committed. Thus these industries, in a certain sense, naturally incent the development of substitutes, and will continue to do so under a patent purchasing regime. Note, however, that this incentive is socially efficient, as it comes from a reduction in the amount of resources society must expend, unlike the incentives created under patent, which are merely artifacts of a market distortion, not the creation of true social value.

substitute. This will introduce a cheaply priced substitute to the market that will decimate the first company's profits.

However, this concern is grossly overstated, at least in some industries. The second company will anticipate that if it develops a substitute, the first company will know,[130] and will offer to sell *its* patent to the government at a slightly cheaper price. This will create a bidding war that will decimate the second company's expected profits. Anticipating this, the second company will be much more likely to pursue alternative avenues of research, obviating this concern.

In fact, we can go further: It is likely that if the second company anticipates that it will find itself competing with the first company to sell its patent to the government, it will develop a product when doing so would be profitable even if the original product were being sold at its competitive price.[131] Phrased another way, if firms assume that the government is willing to purchase a subsequent patent, the optional patent purchasing system will create incentives to develop substitutes that closely mirror those of a competitive market even when the holder of a patent opts against selling her patent.

This is a somewhat surprising result, and not an entirely positive one. Previous discussion has focused on how the patent system overincents the development of substitutes relative to the competitive market. However, the deadweight loss that results from a monopoly created by the patent system may be artificial, but it is still a real social loss. Though patent still provides subsequent innovators with a private incentive that exceeds the social loss they eliminate,[132] it is likely that this overincentive is better than having no incentive to remedy this market failure at all, which is essentially what subsequent innovators would face

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[130] There are industries where trade secrecy prevents firms from knowing what their rivals are working on. However, as long as the purchases the government is considering are publicly announced in advance, the first company would still have an opportunity to undercut the second's auction price. The second company will anticipate this, and this will discourage duplicative research.

[131] The lowest sale price that firm two will be willing to accept corresponds to the profits that it would receive if the government chooses to purchase firm one's product—an amount that corresponds to the profits it would receive if it entered the market when the first firm's product was being sold at its competitive market price. Firm one will be in a parallel situation. If firm one's patent is purchased, then the second firm's subsequent profits will be those profits it would receive if it entered the market when the first firm's product was being sold at its competitive market price. If firm two's patent is purchased, it will likely be at a price that is only slightly higher than the profits it would have made if it had entered the market when the first firm's product was being sold at its competitive market price.

[132] *See* footnote 36, *supra*.

if they assume that the government will purchase one of the two substitute patents.[133]

However, this problem is easily solved by imposing a firm government policy against buying subsequent substitute patents.[134] That way, if the government does not purchase the initial patent, subsequent innovators have the same incentives to develop substitutes as they have under patent, leaving us no worse off than we currently are. On the other hand, if the government does purchase the initial patent, the product becomes available at its competitive market price and quantity, and subsequent innovators have the socially optimal incentives to develop substitutes. Such a government policy essentially renders the optional patent purchase system a Pareto improvement over the patent system and completely moots the complicated industrial organizational effects that substitute patent purchasing would create.[135]

2. Complements

Just as the optional patent purchase system reduces the patent system's inefficiently high private incentives to develop substitutes, so too does it ameliorate patent's inefficiently low private incentives to develop complements. In fact, there is great reason to believe that the optional patent purchase system will significantly encourage many secondary improvements.

A major problem with patents is that, because patents convey a property right, the owner of the patented technology may be able to

[133] See footnote 36, *supra*. Calculating crudely, an incentive that is .6 times too large is likely better than an incentive that is 1.0 times too small.

[134] There may be a commitment problem here: The government would like to convince the second firm that faces the high private incentives of the patent system to develop substitutes in order to induce it to create a substitute. However, once it has done so, the government would prefer that it purchase one of the substitutes' patent by auction in order to eliminate the deadweight loss that accompanies a duopoly. On the plus side, if the government's commitment is substantial but not perfect (so that it generally does not buy substitute patents but makes some exceptions) then this will serve to dampen the overly high private incentives provided by patent, *see* footnote 36, *supra*, rendering them closer to the actual social value created by converting a monopolistic market into a duopolistic one.

[135] Actually, by credibly announcing its intention to buy one of the two patents at some probability, the government could provide a private incentive equal to any value ranging from the competitive market incentive to the patent incentive. In theory, then, the government could set the private incentive to develop a substitute equal to the social loss that would be ameliorated by the development of that substitute. However, expecting the government to be able to make all of the relevant calculations correctly and then execute such a plan is likely asking too much. In any event, for the purposes of this paper, it suffices to note the benefits of a government policy against purchasing subsequent substitutes, to assume the imposition of such a policy, and to note that superior policies may also be possible.

effectively prevent others from improving it. The optional patent purchasing system completely solves this problem by removing the property right that creates it[136]: Instead of using a patent's exclusionary power as a strategic bargaining tool against would-be innovators, the government freely licenses the patent to all.

Patent purchasing provides an equally efficacious solution to the double marginalization problem: Because the government makes the patent freely available to all, the machinations of the marketplace will reduce the price of the patented good to its competitive market level. The double mark-up problem thus reduces to that of a single monopolist.[137]

Additionally, while the subsequent development of substitutes provides significant challenges for the optional patent purchase system, the subsequent development of complements provides tremendous opportunity. The root cause of this is the double marginalization problem: Recall that because each monopolist considers only her own profits, each will not consider how raising her own price will reduce her complementary monopolist's sales. As a result, each monopolist will raise her price, not only above the competitive level, but actually above the price that she would charge if both patents were held by a single monopolist. This creates extreme inefficiencies, even relative to monopoly: For every dollar of profit that the complementary monopolists earn, they generate twice the social waste that a single monopolist would.[138] By purchasing both complementary patents, the government can eliminate all of this waste in one fell swoop.[139] Even better, because complementary monopolies create twice as much social waste per dollar of producer surplus, the same amount of government spending generates twice as much social value.[140]

B. *The Uncertainty Cost of Patent*

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[136] For patents that are purchased, that is. Owners are still free to refuse to sell, and in such cases the potential for patent holdouts would persist.

[137] The subsequent innovator is the monopolist. If the second patent holder's patent is also purchased by the government, we arrive at the competitive market equilibrium.

[138] This corresponds to a full dollar's worth of social waste being generated for every dollar of monopoly profit collected. *See* footnote 113, *supra*. This extra waste also significantly expands the range of Pareto-improving purchase prices. Given the difficulties that the government faces in calculating purchase prices, *see* discussion, *infra*, this increased buffer zone is most welcome.

[139] It is possible that the monopolists will attempt to capture some of this newly created value through strategic bargaining behavior by holding out for a purchase price that, while still less than the social value created, is higher than the profits that the two companies would earn as double-marginalizing monopolists.

[140] The deadweight loss from the taxes required to finance that spending will be similarly reduced as well.

The patent purchase system also has the potential to ameliorate some of the uncertainty costs of patent in two important ways. First, recall that, under patent, would-be monopolists attempt to construe their patent as broadly as possible in order to stymie potential competitors. These same competitors have incentives, compounded by a patent holder's supra-competitive pricing, to seek a niche that is just beyond the boundary of that patent. As discussed in Part III.C, *supra*, these conflicting claims to title in a legally gray area frequently end in extremely costly litigation.

However, once a patent is purchased, it enters the public domain, where it is available to all. This eliminates the supra-competitive pricing that drives would-be competitors to seek a niche that is just beyond the boundary of that patent. Far more importantly, it ensures that there is no one with either the ability or the motivation to bring suit for patent infringement. In this way, purchasing a patent could greatly reduce the incidence of such expensive and socially wasteful litigation.

In a similar fashion, the elimination of lawsuits for patent infringement in cases of purchased patents will mean that researchers will no longer be deterred from carrying out research in certain fields because of concerns over the cost of defending themselves against a patent infringement lawsuit and their potential liability if they lose. As discussed in Part III.C, *supra*, there is evidence that this is currently a significant problem under the patent system. By removing these artificial roadblocks, the optional patent purchase system has the potential to redirect researchers away from their second-choice research topics and enable them to pursue their top preferences. On the whole, these top choices are likely to be more promising than their second-choice topics. By focusing research on the most promising areas, the patent purchase system has the potential to significantly hasten scientific progress relative to patent.

C. *Pricing Problems and Mechanisms*

Thus far, we have focused on the broad outlines of the program and its implications; we have not yet considered the exact mechanics of the purchase itself in any depth. However, as is frequently the case with such things, the devil is in the details.[141]

As discussed previously, the patent holder will be unwilling to sell her patent unless the government offers her a purchase price that meets or exceeds the profits that she expects to earn under patent. From a social utility perspective, the best result would be if the government is able to keep the purchase price as close to the monopoly profit level as possible, because that minimizes the amount of market-distorting taxes that must be

[141] *See generally* Duffy, *supra* note 17.

levied to finance the purchase.[142] However, in order to effect such a result, the government must overcome two related, but distinct, problems: First, the government must arrive at a valuation of the patent. Second, the government must actually negotiate the purchase. I address each of these problems in turn.

1. The Valuation Problem

The question of how the government reaches an estimate of a patent's value presents a significant problem. Calculating a patent's market value is a task outside the normal realm of government, and one in which the government might reasonably be expected to have little expertise or institutional competency; indeed, the government's inability to value patents and potential areas of research is one of the chief arguments commonly advanced against reward systems.[143]

Before advancing further, however, it behooves us to reiterate that the government need not estimate profits with pinpoint accuracy. The magnitude of the deadweight loss associated with monopoly production creates a significant buffer zone,[144] and if the transaction is carried out at any price within that range, it will increase social utility.[145]

Further, if the government is correct on average, but frequently errs in its calculations,[146] this, by itself, may not be particularly troubling: To maintain existing incentives, all that matters is that prices are neither systematically too high nor too low. Since firms are rational profit-maximizers, they will only be concerned with the expected value of their profits when choosing between different research pathways.[147] If government value estimates are correct on average, firms will essentially choose the same research topics as they would if the government correctly estimated value in each individual case. It seems likely that if firms are able to detect an upward or downward bias in the government's estimates

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[142] Assuming also that we want to maintain the level of development incentives for technology that the patent system provides. If one thought that such incentives were too low, *see, e.g.*, Shavell & Van Ypersele, *supra* note 8, at 529, one might wish that the purchase price had been higher.

[143] *See, e.g.*, Duffy, *supra* note 17, at 42-44.

[144] For example, under fairly typical basic economic modeling assumptions, the magnitude of the deadweight loss created by patent is half the magnitude of the monopolist's profits. *See* footnote 113, *supra*.

[145] As discussed before, a purchase that is executed at a price within this range is Pareto-improving, without including the costs of taxes or the purchase's salutary secondary effects.

[146] I.e., if its mean estimated profit is the mean actual profit, but its individual estimates fluctuate (have non-zero standard deviation).

[147] Unless, of course, firms are not actually risk-neutral. However, this is a fairly standard economic modeling assumption. Note, however, that non-systematic variance in government evaluations may not be a problem even when firms are not risk-neutral.

over time, the government will be able to as well. If the government can detect its mistakes, it can compensate for them.[148]

However, such inaccuracy may pose a serious problem if patent holders are much better at estimating the value of their inventions than the government is. This is true even if both the government and private firms accurately predict value on average. The problem is essentially one of adverse selection; firms will tend to accept those government bids that are too high, while rejecting those that are too low. This has the same effect as systematically skewing the government's estimates, as many patent purchases that would take place at the lower price simply do not happen. Since the company will earn monopoly profits when no purchase is made, and the expected value of a purchase will exceed monopoly profits, this will increase development incentives relative to their levels under patent.[149]

A somewhat extreme example helps to illustrate this point: Suppose that firms always know the exact value of their patent, and that the government's valuation is randomly and uniformly distributed between zero and double the patent's true value. This scenario is a good one for a compulsory prize system, as the government's expected estimate is exactly the patent's value; on average, such a system will create the correct incentives. However, it will work very differently in the context of patent purchases: Firms, exercising their discretion, will only accept the government's offer when the government offers a price higher than the patent's actual value. Assuming that the government offered its valuation every time, such a scenario would mean only half of all sales would go through, and would lead to purchase prices that were too high by 50% on average. This would increase development incentives by 25%,[150] a significant deviation relative to the patent system.[151] The government can

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[148] To the extent that the patent purchase system provides greater rewards than the patent system does alone, research areas which do not generate political support may suffer in the sense that these fields will be less attractive in comparison to those falling under the purchase system. This is likely to be a small effect, however, as the purchase system attempts to imitate the rewards of the patent system, and can be dealt with in other ways.

[149] Of course, there may be other ways of structuring the negotiation to avoid this problem. For example, if patentholders submit buyout prices to the government, instead of having the government present an offer to the patentholders, companies may be induced to submit more accurate bids if the government's budget constraint is sufficiently strong.

[150] The government would purchase half of all patents, and each of these would be bought for, on average, 50% more than the patent's current, actual value. The other half of patents would not be purchased, and would be worth their current, actual value. Taken together, these two outcomes increase the a priori value of a patent—and, consequently, a firm's incentives for development—by 25%.

[151] Note that, as discussed before, not all commentators would think that such deviation is a bad thing. Many proponents of prize systems favor them because they can offer development incentives that are larger than those of patent.

counter this increase effectively by systematically lowering its bids, but this will result in fewer patents being purchased.[152]

Even after all of this discussion of the potential pitfalls of valuation, we have not yet discussed any actual mechanism by which the government might arrive at its valuation. Fortunately, there are many options to draw upon from both experience and theory. Governments frequently make valuations of property; compensation paid to the owners of property condemned by the government under its eminent domain power provides perhaps the most obvious example. Between 1998 and 2002, there were over 46,000 condemnation filings in twenty-three states alone.[153] To value properties, the government generally hires private appraisers, just like a private party would do. And while the use of eminent domain authority has been controversial, very little of this controversy has stemmed from complaints that the government's valuation mechanisms are faulty.[154]

On the other hand, studies of individual governments' eminent domain practices offer some reason to believe that valuation procedures may leave a great deal to be desired. At least two studies have found that the owners of high-valued parcels were paid more than the market value of their property, while the owners of low-valued parcels were paid less than their property's market value.[155] Another, earlier study of one county's exercise of eminent domain found that private property owners were

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[152] For example, in the case discussed, suppose that the government responds by lowering its bids to be 75% of what it calculates to be the value of the patent. Instead of offering prices that range from zero to double the patent's actual worth, the government will now offer prices that range from zero to one-and-a-half times the patent's actual worth. However, firms will only accept the government's offer when the proposed price is at or above the patent's actual worth; thus, only one-third of patents will be purchased. These patents will be purchased for a price that is typically 25% higher than the patent's actual value, creating a priori development incentives that are slightly over 8% higher than those of patent.

[153] *See* Dana Berliner, *Public Power, Private Gain: A Five Year, State-By-State Report Examining the Abuse of Eminent Domain* (2003), at http://www.castlecoalition.org/report (June 2, 2006) (listing the total number of condemnations filed in Alaska, Arizona, Arkansas, California, Connecticut, Delaware, Florida, Hawaii, Illinois, Maryland, Massachusetts, Minnesota, Mississippi, Missouri, New Jersey, New York, North Carolina, North Dakota, Oregon, Pennsylvania, Texas, Utah, and Wisconsin).

[154] *See, e.g.*, *id.*; Dana Berliner, *Public Power, Private Gain: The Abuse of Eminent Domain*, CAPITALISM (Feb. 14, 2005).

[155] *See* Patricia Munch, *An Economic Analysis of Eminent Domain*, 84 J. POL. ECON. 473 (1976) (analyzing condemnation proceedings for an urban renewal program in Chicago); Terrence M. Clauretie, William Kuhn, & R. Keith Schwer, *Residential Properties Taken Under Eminent Domain: Do Government Appraisers Track Market Values?*, 26 J. REAL ESTATE RESEARCH 317 (2004) (analyzing properties seized through eminent domain in Clark County, Nevada); *see also* PAUL GOLDSTEIN & BARTON H. THOMPSON, REAL PROPERTY 159 (2003) (discussing Munch's study).

systematically under-compensated.[156] Additionally, condemnations almost always involve pieces of real property, an asset that is valued more frequently, and that likely is much easier to value, than pieces of intellectual property, such as patents.[157]

Should the valuation methods traditionally used in eminent domain proceedings prove inadequate, the academic literature is rife with proposals to address this problem. Most of these proposals have been put forth in the context of implementing prize systems. While the optional patent purchase system is fundamentally different from a reward system,[158] both systems face the same problem, in that both require the

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[156] *See* Curtis J. Berger & Patrick J. Rohan, *The Nassau County Study: An Empirical Look into the Practice of Condemnation*, 67 COLUM. L. REV. 430, 442-43 (1967) (finding that county appraisals had a significant downward bias, and that property owners frequently got considerably less than the already-low appraisal value: 56.9% of owners received less than 90% of the appraisal value and 8.6% received less than 50%); *see also* GOLDSTEIN & THOMPSON, *supra* note 155, at 159 (discussing Berger and Rohan's study); Berliner, *supra* note 153, at 147 (stating that the owner of a condemned parcel was receiving $62 per square foot in compensation, but that a nearby parcel had been sold for $130 per square foot in a private transaction); Gideon Kanner, *Feeding "Times"*, NAT'L L.J., Jan. 7, 2002, at A29 (discussing the same transaction). *But see* Clauretie et al., *supra* note 155, at 325 (finding that, while government underpaid the owners of low-valued properties, on average they overpaid property owners by 17%).

[157] Though, on a more positive note, the founding fathers apparently did not consider the difficulties inherent in valuing other forms of property to be sufficiently imposing to justify limiting the power of eminent domain to real property. *See, e.g.*, Kimball Laundry Co. v. United States, 338 U.S. 1, 10-11, 16 (1949) (holding that individuals are entitled to compensation for government takings of intangible property, and remanding to the district court to determine the value, if any, of such property); W. River Bridge Co. v. Dix, 6 How. 507, 533-34 (1848) ("A distinction has been attempted . . . between the power of a government to appropriate . . . [physical] property . . . and the like power in the government to resume or extinguish a franchise. The distinction thus attempted we regard as a refinement which has no foundation in reason, and one that . . . avoids the true legal or constitutional question in these causes . . . ."); *City of Oakland v. Oakland Raiders*, 646 P.2d 835, 838 (Cal. 1982) ("No constitutional restriction, federal or state, purports to limit the nature of the property that may be taken by eminent domain."); *accord Eminent Domain*, 26 AM. JUR. 2D § 95.

Nor have concerns about the difficulty of valuation completely prevented governments from exercising eminent domain over personal property. *See, e.g.*, Long Island Water-Supply Co. v. City of Brooklyn, 166 U.S. 685 (1897) (addressing Brooklyn's condemnation of contractual rights); *W. River Bridge Co.*, 6 How. 507 (addressing Vermont's condemnation of a charter vesting the bridge company with the exclusive right to build a bridge over West River and the bridge that was built pursuant to that charter); *Oakland Raiders*, 646 P.2d 835 (addressing Oakland's attempt to condemn the Raiders); *see also* Leesona Corp. v. United States, 599 F.2d 958, 964 (Ct. Cl. 1979) (holding that government infringement of a patent constituted a taking under eminent domain, and, accordingly, the Fifth Amendment's "just compensation" requirement was the appropriate measure of damages).

[158] Reward systems generally operate as an alternative to intellectual property rights; the inventor does not retain ownership over her innovation. The patent purchase system does award the inventor ownership, and merely provides society at large a mechanism for

government to calculate the value of an innovation. Proposals which have been advanced in the context of prize systems therefore have potential application here.

It is also worth noting that, under the patent purchase system, the valuation problem is significantly simpler than it is under a prize system. Since prize systems are generally intended as a way for the government to craft the incentives that innovators face, prize amounts must be established before a path of research is started, which can be many years before the invention will ever go to market.[159] This can be particularly difficult with inventions whose very development will radically change the landscape of their industry. The price of a patent purchase, by contrast, need only be determined at the time of purchase, by which point the technology has been commercialized. Additionally, prize systems often focus on tying the reward the innovator faces directly to the social value of the innovation.[160] This requires a determination of how much utility an invention confers on society. The purchase system, by contrast, merely requires an estimation of the profits that would be earned under patent, a comparatively simple question.[161]

A detailed consideration of the merits and shortcomings of all these various proposals is beyond the scope of this paper. However, it is worth noting just how varied the range of proposals is, as this highlights that, while the valuation problem is significant, there are numerous ways in which it might be approached. Some have suggested the use of test

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purchasing it. Reward systems are often touted because government selection of the prize level allows for greater tailoring of research incentives than does patent. This feature is typically lauded not because it enables the government to better direct the flow of research for social engineering reasons, but because it tends to provide innovators with private incentives that are weaker than the total social value of the innovation (though not always; *see* discussion in Part III.B, *supra*). The optional patent purchase system, on the other hand, is not intended as a mechanism to modify research incentives; it attempts to replicate the patent system's levels as closely as possible.

[159] This can be a bigger problem than it may first appear. Consider the likelihood the government would have had of correctly anticipating the economic value of the cotton gin, the electric light bulb, the automobile, or the personal computer many years before their time. Similarly, the incredible extent to which technology can change in a relatively short time shows how easy it could be for the government to incent the development of hopelessly outdated inventions. This is perhaps the greatest beauty of the patent system: Little is left to anyone's discretion, as the market determines the reward an innovator receives.

[160] *See, e.g.*, Shavell & Van Ypersele, *supra* note 8, at 530; Kremer, *supra* note 21, at 1142.

[161] These facts notwithstanding, there are some valuation methods which are possible under a prize system that would be unlikely to work well under an optional patent purchase system. Most notable among these are methods that fix the prize the government pays the investor ex post, based on a product's sales after the technology has been placed in the public domain. *See, e.g.*, Shavell & Van Ypersele, *supra* note 8, at 541-42; Abramowicz, *supra* note 15, at 228-29.

markets, i.e. placing the product on sale in a given geographic area for a period of time, then extrapolating the product's value nationwide from the results.[162] Others have suggested using auctions to calculate the value of patents, in the hope that, by inducing private parties to bid for the patent, the government will be able to harness their superior information and constrain its own discretion.[163] Still other commentators have suggested such innovative ideas as having the government distribute coupons to consumers and observing the subsequent buying patterns, then using that data to determine the value of the patent.[164]

To this somewhat lengthy list, I also add a new mechanism, one that I consider to be an extension of the valuation practices that government has historically used. When governments condemn property under their eminent domain power, they engage private appraisers to estimate the value of the property at issue. The underlying rationale is that it is fairer, more efficient, and more accurate for the government to rely on the expertise of private individuals who specialize in making such determinations. Unfortunately for our purposes, unlike the case of real property, there is not a deep market for patent appraisers. However, there is another type of expertise that is abundantly present in the private sector that may prove useful: capital market analysts.

Fortunes are made and lost in the stock and bond markets by predicting how the prices of various companies' financial instruments will fluctuate over time. The prices of a company's financial instruments depend on that company's expected profits; accordingly, there is a small army of analysts whose sole job is to estimate companies' future profits from each of their various products.[165] These analysts typically specialize

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[162] *See, e.g.*, Abramowicz, *supra* note 15, at 225-28 (2003); Robert C. Guell & Marvin Fischbaum, *Toward Allocative Efficiency in the Prescription Drug Industry*, 73 MILBANK Q. 213 (1995).

[163] *See, e.g.*, Abramowicz, *supra* note 15; Kremer, *supra* note 21. The details of these proposals vary considerably. For example, some approaches, such as Kremer's, require that the government randomize its purchases.

It is also worth noting that auction mechanisms are likely better suited for patent purchases than they are for prizes: One of the chief problems in adapting auctions for the latter context lies in converting the auction bid's measure of private value into a measure of social value. A patent purchase system, on the other hand, requires only a measure of the patent's private value.

[164] *See* Douglas Gary Lichtman, *Pricing Prozac: Why the Government Should Subsidize the Purchase of Patented Pharmaceuticals*, 11 HARV. J.L. & TECH. 123 (1997).

[165] Technically, these analysts' official jobs are to make buy/hold/sell recommendations, but these are very tightly connected to earnings predictions. *See, e.g.*, Katherine Schipper, *Commentary on Analysts' Forecasts*, 1991 ACCOUNTING HORIZONS 105, 112 ("The basic responsibility of an analyst is to follow stocks—10 to 20 stocks in a given industry or economic sector. . . . Within the analyst's report, the ultimate judgment recommending an explicit action is 'buy, sell, or hold.'").

by industry or economic sector, and typically have a broad range of data at their disposal.

As accurate predictions can yield tremendous profits and inaccurate ones can cause financial ruin, there are significant ex ante reasons to suspect that these analysts' predictions will be fairly accurate. However, we need not rely on mere theory alone; the accounting literature is replete with studies of how analysts make their decisions and on how accurate they are.[166] Many studies of analysts across various industries tend to agree that their predictions tend to be slightly optimistic. A study by Francis and Philbrick estimated that, on average, analysts overestimate earnings, but by less than ten percent.[167] While these figures may still have greater error than some might like, they do seem substantially accurate, and the damage from such estimation errors is far outweighed by the amount of deadweight loss eradicated by the optional patent purchase system.[168] Moreover, as the data available to analysts varies significantly by industry, there is substantial reason to believe that the value of certain types of patents can be predicted even more accurately.[169] This is very encouraging indeed.

In industries that are dominated by large, publicly traded corporations, these analysts could constitute a pool of expertise for valuing patents in much the same way that real estate appraisers have expertise in

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[166] For a discussion of the main points of many such papers, see *id*. For a more general review of the literature on analysts' forecasts, see D. Givoly & J. Lakonishok, *Properties of Analysts' Forecasts of Earnings: A Review and Analysis of the Research*, 1984 J. ACCT. LITERATURE 117.

[167] *See* Jennifer Francis & Donna Philbrick, *Analysts' Decisions as Products of a Multi-Task Environment*, 31 J. ACCT. RES. 216, 217 (1993) ("For our full sample of *VL* analysts' forecasts, we document average optimism of 9% of the EPS forecast . . . .").

[168] *See* EQUATIONS C3 and C4, *infra*, which suggest that the optional patent purchase system is Pareto improving relative to the patent system so long as the purchase price is between 100% and 150% of what the patent holder would have earned in the market.

[169] There are other trends in analysts' reports which are also of interest. Analysts tend to be less optimistic about the stocks they recommend than those they do not. Francis & Philbrick, *supra* note 167, at 217 ("The average optimism for sell stocks is 12% of the EPS forecast . . . and is significantly greater . . . than the average optimism for hold stocks (9% of the EPS forecast . . .). The average optimism for hold stocks is significantly greater than the average optimism for buy stocks (3% of the EPS forecast . . .)."). Francis and Philbrick suggest that this is done out of a desire to cultivate good relations with management, as they are an important source of information for an analyst. *Id.* at 225 ("We interpret these results as consistent with our conjecture that the optimistic forecasts are intended to cultivate or maintain management relations."). This suggests that analysts may pad their most negative analyses (i.e. their sell recommendations), and thus may in fact be making more accurate earnings predictions than they report. *Id.* at 229 ("We argue that analysts may not strive to produce earnings forecasts with minimal error in all circumstances . . . ."). Modern analysts also have access to an ever-increasing supply of information and computing technology, which would also suggest improved forecasting accuracy.

valuing real property. This suggests that there is a wealth of private pricing expertise that the government may be able to co-opt through contracting. There are, of course, problems with this approach. Innovators may be able to induce private analysts to collude. Over time, analysts could conceivably lose their expertise in predicting profit and replace it with expertise in predicting how much the government will be willing to pay. It is also unclear how effective analysts' contractual incentives will be; they may not be as strong as the discipline they would face in the market, and, in the long run, this could lead to less accurate predictions than those we currently see.[170]

However, each of these problems, daunting as they may be, is equally problematic in the context of real estate appraisals. As discussed previously, while government valuations in the eminent domain context have certainly been far from perfect, valuation problems have not proved insurmountable in that context. Accordingly, there is good reason to believe that there is a significant class of patents—those pertaining to industries that are dominated by large, publicly traded companies—where the valuation problem can be overcome in a similar fashion.

2. The Negotiation Problem

For the government, choosing a valuation is only half of the problem; there still remains the matter of negotiating an agreement with the inventor. This negotiation is somewhat unusual: Because the government has incentives that are fundamentally different from those of private actors, it is effectively guaranteed to be the only entity willing to pay enough money to purchase the patent from its owner. On the other side of the table, the patent holder is the only entity capable of conveying the patent. The results of these types of negotiations—i.e., monopsonistic[171]/monopolistic ones—cannot be predicted exactly from conventional economic theory.

This does not imply that we can say nothing at all about such talks. It is obvious that the government will want to pay as little as possible, while the patent holder will want to secure as high a price as possible. The lower bound of these two entities' bargaining range is clear: The patent holder will not accept any amount below that which she would be able to

[170] It is also worth noting that these analysts do not generally value individual patents specifically. However, in certain instances, the valuation of a company is tightly tied to the valuation of its patents.

[171] A monopsony exists when there is only one buyer for a particular product; that buyer is a monopsonist.

earn from keeping her patent monopoly.[172] There is also a somewhat natural but contestable upper bound on the government's willingness to pay: the sum of producer surplus under the patent system and the deadweight loss eliminated by placing the patent into the public domain. If the purchase price does not exceed this figure, the direct effects of the purchase still create a Pareto improvement.[173] This is a natural upper bound to use in guiding our discussion, and we therefore adopt it.[174] Within this range, the exact purchase price is generally indeterminate under economic theory.[175]

Within this range, the closer that the government can keep the price to the profits the innovator will earn under the patent system—i.e., the lower the price is within this range—the more the optional patent purchase system will preserve the market incentives of the patent system. Lower prices also have the added benefit of reducing the amount of money that the government must raise to fund the purchase; since these funds are raised through market-distorting taxes, this is a significant benefit.

Thus, the closer the government can keep the agreed-on price to its valuation, the better. The question then becomes how effective a negotiator the government is likely to be. Since private companies exist with the purpose of making profits, while the government does not, there are good ex ante reasons to believe that private actors will have the edge in these discussions. The defense industry may be the industry whose structure is the most analogous,[176] and this may not be the most encouraging example.[177]

Nonetheless, the two cases are not identical, and there may be some cause for optimism. First, it is worth noting that there is an additional reason why a patent holder may find the notion of selling her patent to the government to be an attractive option. By selling to the government at a fixed price, a patent holder assures herself a given amount of profit. Were she to sell her product in the marketplace, while her

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[172] If the government only offers to purchase the patent for a price lower than this amount, the owner will be better off by refusing to sell and earning monopoly profits in the marketplace.

[173] This does not include the deadweight loss from taxes, nor does it include all of the benefits from the purchase's ameliorative secondary effects.

[174] Of course, other upper bounds are possible and reasonable choices; the amount it would cost the government to achieve the same result through a subsidy, for example.

[175] This range has many names; the Zone of Possible Agreement, the Zone of Positive Agreement, etc. *See, e.g.*, ROGER FISHER & WILLIAM URY, GETTING TO YES (1983).

[176] I.e. one in which a private corporation is the only source of a particular product, and the government is the only buyer.

[177] *See, e.g.*, Matt Kelley & Jim Drinkard, *Secret Military Spending Gets Little Oversight*, USA TODAY, Nov. 9, 2005, at A1 ("The [Pentagon's classified] budget has long been a repository for spending . . . ."); *id.* ("[W]ithin the defense industry, 'there is a coziness that sometimes builds up.['']").

expected profit would be comparable, she would also face a higher degree of risk. To the extent that patent holders are risk-averse, then, the government buyout will be increasingly appealing, and this will give the government additional leverage in negotiations.[178]

Much more importantly, while the government can only buy any given patent from a single purchaser, it is worth remembering that the government's goal is not to purchase any particular patent. Its goal is to increase social welfare, and patent purchasing is merely a means by which it seeks to achieve this end. From the government's perspective, then, every patent is, in an important sense, a substitute for every other patent.[179] As the agency in charge of purchasing patents will have a limited budget, there is good cause for concluding that the market for patent sales is far more competitive than it might initially appear.[180] The fungible nature of utility, combined with these budget constraints, provides good reason to believe that the government may well be a much more effective negotiator than one might initially suspect.

But, even if the government is a relatively poor negotiator, ultimately this may not be overly troubling. If the government buys patents at prices approaching the upper bound of the range we have established—the sum of producer surplus and deadweight loss under monopoly—then, under the same economic assumptions as before, the government will still have successfully achieved the competitive equilibrium while paying approximately one-third of what it would have cost to accomplish the same result with a subsidy. This would also create stronger incentives for innovation, as patent holders would now make significantly more than they did under patent alone. This might result in the development of more technologies than would be developed under the current system, each of which would convey additional consumer and producer (and hence social) welfare. Even if no new technologies were developed as a result, at the end of the day consumers would net the same utility as they do under patent, minus the deadweight loss they bear from the additional taxes, and this may not be very large. These factors suggest that this problem is neither as important nor as troubling as it might initially seem.

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[178] Similarly, if patentholders are risk-loving, they will find the government buyout comparatively unattractive. If patentholders are risk-neutral, they will care only about their expected profit, not about the possible variation in that profit.

[179] Although, to the extent that patents interrelate, many patents will also be complements to other patents.

[180] On the other hand, the same is true of the defense industry, at least to some extent. That said, if the government's goal in patent purchasing is to maximize its citizens' utility, then patents may be interchangeable to a greater extent than rifles and ships and planes are.

A more frightening specter than the fear of inaccurate government patent bidding is the potential for corruption in, or other regulatory capture of, the administrative body empowered to make offers to purchase patents. A corrupt patent czar could literally fritter away billions of taxpayer dollars on worthless patents. Though a frightening possibility, administrative law has long dealt with this problem, and with care it can be prevented. Control of the agency could be diffused across a committee, which would be more expensive to control and make any attempt at bribery riskier. All members could be forbidden from working for any company whose patents they reviewed for a period of years after their tenure of office. These and other measures, combined with the highly public nature of the agency's activity and appropriate accompanying scrutiny, should be sufficient to ensure that acquisitions are carried out with the good of the public in mind.

VI. A NOTE OF CAUTION, AND A GOOD PLACE TO START

It is worth stressing that the optional patent purchase system is an evolution of the existing patent system, and not a revolution, as a prize system would be. Patent purchasing is a policy mechanism that should be used sparingly. Patent is not a broken system, and the optional patent purchase system is not designed to supplant it, but to augment it.

In an excellent paper, John Duffy argued that much of the current debate over patent and prize systems mirrors an earlier debate begun by Hotelling, who advocated government intervention in decreasing-marginal-cost industries (i.e., natural monopolies, such as utilities and transportation) and ultimately won by Coase.[181] While her paper is directed toward prize systems, and not an optional patent purchase regime, it makes a persuasive case for skepticism in the face of calls to fix market marginal cost deficiencies through government intervention. While most of these issues have been discussed throughout the course of this paper, it is worth reiterating that private entities are not powerless to overcome market inefficiencies.[182] Moreover, for all of the salutary effects that accompany a patent purchase, it is still important to remember that the funds to purchase the patent must be raised through increased taxation, which creates inefficiencies of its own.[183] Thus, a patent purchase should be a rare occurrence, and should be limited to helping the patent system better accommodate the cases for which it is most poorly suited—i.e., those areas where the negative secondary effects of patent are particularly pronounced.

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[181] *See* Duffy, *supra* note 17.

[182] For example, a patent holder can reduce the amount of deadweight loss resulting from her monopoly by becoming a more perfect monopolist.

[183] *See id.* at 42.

One area that patent purchasing might be particularly useful is the pharmaceutical industry. First, the pharmaceutical industry is heavily reliant on patent, so every new drug is potentially available for government purchase. One of the main reasons for this dependence is the existence of a large number of competitive firms that are capable of producing the drug; thus, placing the patent into the public domain would likely result in enough producers of the drug to achieve competitive pricing.

Second, pharmaceutical patents are heavily interrelated. Drugs are frequently prescribed and administered with complementary medications; a good example is the "cocktail" of medications, AZT, 3TC, and efavirenz, that are prescribed for patients who are diagnosed with HIV.[184] These relationships can lead to serious problems stemming from the secondary effects of patent. For example, as discussed in Part III.B, *supra*, a staggering amount of current spending on pharmaceutical research is devoted to the development of so-called "me-too" drugs, drugs whose properties are identical to drugs that have already been developed, but that are still subject to patent.[185] The uncertainty costs of patent are also higher than they are in many other areas. Pharmaceutical patents are litigated more often than those of any other technology, and their litigation cost is particularly high.[186]

Third, the pharmaceutical industry is dominated by large, publicly traded corporations, which means that there is a great deal of private expertise, in the form of capital market analysts, for the government to draw upon in making its valuation decision. Additionally, because of the extensive regulatory filings that are required before a new drug can be approved by the Food and Drug Administration, much can be deduced about a drug patent's value before it enters the market. These same filings also make it easier to spot complementary and substitute patents further up the research pipeline than would normally be possible. Thus, analysts will have a great deal of information with which to estimate patents' value, and, accordingly, there is greater reason to expect that their valuations will be accurate.[187]

The combination of these factors—many firms, to ensure competitive pricing, strong relationships between products that make secondary effects particularly important, and the combination of a deep

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[184] *See, e.g.*, Steve Sternberg, *Anti-HIV 'Cocktail' Decided*, USA TODAY, Dec. 10, 2003.
[185] *See, e.g.*, Lansbury, *supra* note 39.
[186] Michael Meurer, Boston University Patent Rights and Licensing Symposium, *available at* http://www.bu.edu/law/scitech/volume6/Panel2.htm.
[187] It is also worth noting that there is a history of government involvement in the healthcare industry in ways that are not present in all industries. It is also likely that a government program to purchase a prescription drug patent would be more politically acceptable than many other purchases might be.

pool of private expertise and available information that should enable accurate patent valuation—make pharmaceuticals an excellent sector for applying the optional patent purchase system. Of course, these features are not unique to the pharmaceutical sector, and, similarly, every pharmaceutical patent should not be considered for purchase. Nonetheless, it would seem that pharmaceuticals could be an ideal field in which to begin implementing the optional patent purchase system.

VII. CONCLUSION

The patent system, which has provided so many benefits to our society for so long, has been a great invention in its own right. Unfortunately, patent's success has led to some of its problems; in those areas where technologies build off of and compete with each other the most intensely, patent creates remarkably poor incentives. An optional patent purchasing system has great potential for ameliorating these deficiencies, and while such a system is not appropriate for all cases, judicious application could yield great benefits. Though experimentation always prevents pitfalls, it would be the height of irony to eschew change based on a conclusion that the patent system itself is a final work that cannot be improved.

MATHEMATICAL APPENDIX

Let the demand for a particular good, $q(p)$, be given by:

$$q(p) = \begin{cases} a - bp & for \frac{a}{b} \geq p \geq 0 \\ 0 & for\ p > \frac{a}{b} \end{cases}$$

Where $a, b > 0$. Then:

$$p(q) = \frac{a-q}{b} \quad for\ a \geq q > 0$$

We assume that the producer is profit-maximizing and has the capacity to manufacture the drug at a constant cost c per unit,[188] where $\frac{a}{b} > c > 0$.

A. *The Patent System*

Profit, $\pi(q)$, is given by:

$$\pi(q) = (\frac{a-q}{b} - c)q = -\frac{q^2}{b} + (\frac{a}{b} - c)q$$

This is maximized at q_m. where:

EQUATION A1

$$q_m = \frac{a-bc}{2}$$

This corresponds to a monopoly price of:

EQUATION A2

$$p_m = \frac{a+bc}{2b}$$

Because $\frac{a}{b} > c$, $q_m < q(c)$; the firm is wielding its monopoly power to lower output relative to the competitive market level in order to artificially raise the price.

The company's profit, then, is given by:

EQUATION A3

$$\pi(q_m) = \frac{(a-bc)^2}{4b}$$

[188] A constant marginal cost of production was chosen for multiple reasons; on large scales, the marginal cost of production is likely to rise very slowly, and it is both illustrative and analytically cleaner to use a constant function. The basic conclusions of the model, however, are largely unchanged under almost any reasonable, non-pathological cost function.

Note that $\pi(p_m) > 0$.
Total consumer surplus is:

EQUATION A4
$$\frac{\left(\frac{a}{b} - p_m\right)q(p_m)}{2} = \frac{(a-bc)^2}{8b}$$

The deadweight loss is given by:

EQUATION A5
$$\frac{(q(c) - q(p_m))(p_m - c)}{2} = \frac{(a-bc)^2}{8b}$$

B. *Subsidy*

We now modify the framework of Part A to include a government subsidy, x, that the government pays to the monopolist for each unit that she sells. The government's goal is to achieve the competitive market outcome, and it chooses x accordingly.[189] The cost of the subsidy is raised through taxes, so that total consumer surplus is equal to their utility from the good minus the cost of the subsidy.[190] The monopolist's profit, then, at ultimate sale price per unit p, is given by:

$$\pi(p) = (a - bp)(p - c + x)$$

This is maximized with respect to p for:

$$p = \frac{a + bc - bx}{2b}$$

So, in order to achieve the competitive outcome, the government will choose x such that:

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[189] One might fairly question whether it would be more appropriate for the government to select x in order to maximize consumer surplus, subject to the constraint $x \geq 0$. However, surplus is given by: $\frac{(a-bc+bx)(a-bc-3bx)}{8b}$, which is a downward-opening parabola with vertex and global maxima at $x = \frac{-(a-bc)}{3b}$. Thus, when consumers ultimately pay the cost of the transfer through taxes, consumer surplus is strictly decreasing with respect to the size of the transfer. Choosing x so as to ensure the market outcome is helpful for our purposes because it facilitates comparison between the subsidy system and the patent and optional patent purchase systems.

[190] We do not consider the market-distorting effects of these taxes here. Also, economic models of subsidy frequently assume that the cost of the subsidy is recovered by a lump sum tax on the producer, so that ultimately it is costless from the government's perspective. However, in real life, this is not a realistic option. A more reasonable assumption is that the subsidy is paid for out of general tax revenues, which primarily come from the federal income tax. Another reason that more traditional economic analyses do not focus on the source of the transfer payment is because distributional concerns are often neglected in the first instance, as they do not reduce the total amount of goods, only shift their ownership, and presumably distributional concerns can be addressed later via transfer payments. *See* discussion Part I, *supra*.

EQUATION B1
$$x = \frac{a - bc}{b}$$

Profit, $\pi(q)$, is given by the product of the producer's profit per unit and the quantity of units sold:

EQUATION B2
$$(c + x - c)q(c) = \frac{(a - bc)^2}{b}$$

Consumer surplus under a subsidy system is the same as that under the competitive market equilibrium, minus the cost of the transfer payment:

EQUATION B3
$$\frac{(a - bc)^2}{2b} - xq(c) = -\frac{(a - bc)^2}{2b}$$

Note that this is a negative number; under a subsidy system, consumers as a whole would actually be better off if the technology had never been developed.

C. *The Optional Patent Purchasing System*

We now consider another modification to the model of Part A: The government, whose goal is to maximize consumer surplus,[191] has the option of offering a payment, *t*, to the corporation in exchange for the rights to its patent. If the corporation accepts the government's offer, the government gives everyone the right to use the technology; we assume that the market is competitive, and that all other firms can manufacture the drug at the constant cost of *c* per unit, the same cost as the original firm.

[191] It should be stressed that this choice is a positive, not a normative one, as good policymaking should take into account the interests of producers as well as consumers. It may be argued that the government should maximize total social welfare, the sum of consumer and producer surplus. However, the model presented here does not include the welfare reductions from the taxes required to fund the transfer; focusing on consumer welfare helps to offset this failing. Additionally, ignoring the distributive effects of the plan make the size of the transfer irrelevant; however, in reality the magnitude and direction of transfers is vastly important. Further, such a social utility function would undercut an important facet of the plan, namely that it is potentially Pareto improving, making both consumers and producers strictly better off than they would be under the patent system.

It is also worth considering whether, in a democracy where each citizen has only one vote, one may well expect that the policies that would be chosen are those that are supported by the most number of people, not those that provide the most social benefit. It is unlikely that a majority of the national electorate will have a sufficiently large stake in the fortunes of any particular pharmaceutical company to outweigh the change in utility they receive in the form of consumer surplus. Therefore, consumer surplus will dominate the government's decision. However, to the extent that one believes in the power of corporate lobbying or public ignorance, this justification may fairly be called into question.

If the corporation does not accept the government's offer, they retain their patent rights and the analysis is identical to that of Part A.

We assume that consumers ultimately bear the cost for the payment t through their tax dollars, and as such we subtract t from consumer surplus if the corporation accepts the government's offer.

If the government's offer is accepted, consumer surplus is given by:

EQUATION C1
$$\frac{\left(\frac{a}{b}-c\right)q(c)}{2}-t=\frac{(a-bc)^2}{2b}-t$$

Consumers are strictly better off under this arrangement if:

$$\frac{(a-bc)^2}{2b}-t>\frac{\left(\frac{a}{b}-p_m\right)q(p_m)}{2}$$

EQUATION C2
$$\Leftrightarrow t<\frac{3(a-bc)^2}{8b}$$

Note that the right hand side of this inequality is always positive, so no matter what the values of a, b, and c, there is some range of transfer values for which consumers are strictly better off.

We now consider the producer's surplus if she accepts the government's offer, given by:

$$\pi(c)+t=(c-c)q(p)+t=t$$

Accepting the offer, then, increases the producer surplus whenever:

EQUATION C3
$$t>\pi(p_m)=\frac{(a-bc)^2}{4b}$$

Thus both parties' utility can be strictly improved relative to their level under the patent system if the government offers a transfer payment above $\frac{(a-bc)^2}{4b}$ and below $\frac{3(a-bc)^2}{8b}$. This corresponds to between 1.0 and 1.5 times the firm's expected profit from monopoly pricing. Because we assume that the government is attempting to maximize consumer surplus, the transfer payment will be just above $\frac{(a-bc)^2}{4b}$. However, it is useful to consider the full range of Pareto-improving transfer payments.

D. *Cournot Duopoly*

We now adapt the framework of Part A slightly to incorporate two producers, firm one and firm two, both of which are rational profit-maximizers, and whose products are perfect substitutes for each other. Mirroring Part A, let demand be given by:

$$p(q_1, q_2) = \frac{a - (q_1 + q_2)}{b}$$

for $a \geq q_1 + q_2 > 0$. We maintain our early assumptions; specifically, $a, b > 0$ and $\frac{a}{b} > c > 0$.

Firm one's profit is then given by:

$$\pi_1(q_1) = \big(p(q_1, q_2) - c\big)q_1$$

Thus, firm one's profits are maximized when:

$$q_1 = \frac{a - q_2 - bc}{2}$$

Similarly, firm two's profits are maximized when:

$$q_2 = \frac{a - q_1 - bc}{2}$$

Therefore, at equilibrium:

EQUATION D1 $$q_1 = \frac{a - bc}{3} = q_2$$

And

EQUATION D2 $$p(q_1, q_2) = \frac{a + 2bc}{3b}$$

Firm one's profit is then:

EQUATION D3 $$\pi_1(q_1) = \big(p(q_1, q_2) - c\big)q_1 = \frac{(a - bc)^2}{9b} = \pi_2(q_1)$$

Consumer surplus is given by:

EQUATION D4 $$\left(\frac{a}{b} - c\right)\frac{(q_1 + q_2)}{2} = \frac{(a - bc)^2}{3b}$$

Deadweight loss can be calculated as:

EQUATION D5 $$\frac{\big(p(q_1, q_2) - c\big)\big(q(c) - (q_1 + q_2)\big)}{2} = \frac{(a - bc)^2}{18b}$$

E. *Subsidy Under Cournot Duopoly*

We now modify the model of Part D to include a government subsidy, *x*, that the government pays to each duopolist for each unit that she sells. The government's goal is to achieve the competitive market outcome, and it chooses *x* accordingly.[192] Firm one's profit function thus becomes:

$$\pi_1(q_1) = \big(p(q_1) - c + x\big)q_1$$

This is maximized when:

[192] For a brief consideration of the merits of and rationale for this assumption, see footnote 189, *supra*.

$$q_1 = \frac{(a - q_2 - bc + bx)}{2}$$

By symmetry,

$$q_2 = \frac{(a - q_1 - bc + bx)}{2}$$

Therefore, at equilibrium,

EQUATION E1
$$q_1 = \frac{(a - bc + bx)}{3} = q_2$$

In order to achieve the competitive outcome, the government will choose x such that:

EQUATION E2
$$x = \frac{a - bc}{2b}$$

Consumer surplus is given by:

EQUATION E3
$$\frac{(a - bc)^2}{2b} - xq(c) = 0$$

Producer surplus then becomes:

EQUATION E4
$$(q_1 + q_2)(p(q_1, q_2) - c + x) = \frac{(a - bc)^2}{2b}$$