How Do the Social Benefits and Costs of the Patent System Stack Up in Pharmaceuticals?

Daniel J. Gifford

University of Minnesota Law School, giffo001@umn.edu

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HOW DO THE SOCIAL BENEFITS AND COSTS OF THE PATENT SYSTEM STACK UP IN PHARMACEUTICALS?

Daniel J. Gifford *

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* Robins, Kaplan, Miller & Ciresi Professor of Law, University of Minnesota. The author acknowledges helpful comments on earlier drafts from Dan Burk, Dan Farber, Brett McDonald, David McGowan, Ruth Okediji, and Greg Polsky.
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I. INTRODUCTION

This Article examines, from both theoretical and policy perspectives, a limited but important aspect of the patent system: its role and operation in supplying global demand for widely recognized health needs. It concludes that although the patent system is without peer in routing resources to the creation of the technological needs of modern societies, some aspects of that system operate better than others. In this connection, this Article directs attention to ways in which the patent system may produce less than optimum results in the markets served by the pharmaceutical industry, as well as to related issues about how research on the world's widely recognized health needs should be funded.

The patent system, once largely ignored by nonspecialists, has recently received increased attention from legal academics, economists, and policy makers. These analysts have focused both upon the system's domestic effects and upon its effects in the global economy. The creation in the 1980s of the Federal Circuit Court of Appeals with oversight over patent litigation brought renewed strength to the domestic patent system. Partly as a result of this reform, academic examinations of the system, which began in earnest in the 1960s, have increased dramatically. The negotiation of the World Trade Agreement in 1994 brought all of intellectual property into the world trading system through the ancillary TRIPS agreement, subjecting it to new critiques from those sensitive to the impact of this property system upon the publics of the world's less developed regions.

Although some economists have been skeptical about the impact of the patent system in generating new technology, others have recognized its potency. Perhaps Kenneth Arrow's 1961 inquiry into the differing innovation incentives found in concentrated and competitive markets provided the initial spark for the substantial attention that the patent system has received from economists. Later in that decade, William Nordhaus moved theoretical research a giant step forward with the publication of his seminal work on the economics of the patent system.

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5 WILLIAM D. NORDHAUS, INVENTION, GROWTH AND WELFARE; A THEORETICAL TREATMENT OF TECHNOLOGICAL CHANGE, ch. 5 (1969).
a work that stimulated an immense amount of analytical attention to the patent system and its operation. Edmund Kitch provoked the interest of legal scholars when, in the 1970s, he explained how the patent system operates as a vehicle for staking out a particular area of technology for exclusive development, a condition often critical to the investment of needed resources. Louis Kaplow drew the attention of the legal community to the costs and benefits of the patent system in his important 1984 work comparing the welfare effects of antitrust and patent market restraints. Robert Merges took the lead in examining the operation of the patent system in a series of articles in the early 1990s. Since Merges's pioneering work, legal scholars have joined others in a flood of works examining the patent system and its operation. Recently, Mark Lemley and Dan Burk provided a major contribution to this research with an examination of how the patent system operates in different industries.

Throughout this period, policy makers generated new legislative modifications to the patent system. In the 1970s, congressional concern about the impact of time-consuming FDA review of new drug applications resulted in legislative extensions of the patent term for pharmaceutical companies that had lost initial years of patent protection to that review. In the 1980s, policy makers focused upon the patent system as an agent for economic rejuvenation, with the result that Congress created the Federal Circuit Court of Appeals. And in the 1990s, Congress approved the NAFTA and WTO agreements that provided new strength to patents and other intellectual property rights throughout North America and the world.

Currently, the operation of the patent system is on the forefront of controversies, both domestic and international, about its effects upon pricing and exclusion in the pharmaceutical industry. We allow patentees to exercise exclusive rights—rights that may sometimes be equivalent to monopolies—over their inventions for a term of years precisely to create incentives to invent. And yet users of pharmaceuticals, especially the elderly, have complained so much about high pharmaceutical prices that Congress has legislatively reformed the Medicare

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Act to subsidize the purchase of pharmaceuticals.\textsuperscript{13} The public policies that foster monopoly pricing in the patent law and those that subsidize purchasing in the Medicare Prescription Drug, Improvement, and Modernization Act of 2003 (amended Medicare Act) appear to be in some tension. These Congressional actions are in further tension with the actions of Canadian and European regulatory schemes that are designed to place upward limits on pharmaceutical prices.\textsuperscript{14} They are in even greater tension with strongly held beliefs of third world governments and their publics that the patent systems of the United States and other Western nations are depriving the world’s poor of essential medications.\textsuperscript{15}

This Article addresses the broad interplay between the incentive structure of the patent system and that system’s social benefits and costs, viewed both on a national scale and, to a significant extent, on an international one. The Article examines the relation of private and social value to investment (and thus focuses upon the basic economics of the system) with a view to identifying the system’s weaknesses. It draws heavily from Louis Kaplow, who developed a way of conceptualizing the marginal social costs and benefits of the patent system. It also draws from Kenneth Arrow, who described incentives for innovation in competitive and monopoly contexts.

This Article compares the operation of the incentive structure of the patent system with other mechanisms for fostering inventive activity as important background for the Article’s ultimate focus upon the relationship between the patent system and the generation of life-saving drugs. Although the Article readily concedes the general superiority of the patent system for eliciting inventive activity, the Article suggests that its superiority may not extend throughout the entire range of potential inventive activity. Indeed, the Article raises the question as to whether the patent system is superior in the context of pharmaceutical


products that play, or could play, critical roles in the control of certain life-threatening diseases or other disabilities.

The Article builds on the Kaplow perspective for assessing social costs and benefits. In so doing it attempts to articulate a perspective for carrying on the debate about the operation of the patent system and its application to pharmaceutical research. Drawing from that perspective, the Article raises at least two important policy issues especially connected with marketing pharmaceutical products and fostering pharmaceutical research. First, it raises the issue of price discrimination. Are laws, customs, or other practices discouraging or otherwise impeding the very price discrimination that could reduce deadweight loss and thereby increase social welfare? Second, when should public policy foster inventive activity through means other than the patent system?

Part II of the Article reviews the standard incentive theory underlying the patent system. It summarizes the theory under which the patent law is said to harness the incentives of the inventor for the benefit of society. Part III examines the incentive structure, with particular emphasis upon two factors that affect the profitability of that research: (1) the probabilities that the firm undertaking the research will succeed in obtaining a patent for a commercially valuable result, and (2) the effects of the time lag between the period in which funds are committed to research and the period in which the results of that research produce revenue. Part IV employs the marginal analysis developed by Louis Kaplow to sketch out a schema for balancing social benefits against social costs, a schema that initially employs a linear analysis. Part IV also introduces the time dimension discussed in Part III into the analysis of social costs and benefits, concluding that as the patent term increases, the rate of increase of social benefits slows while the rate of increase of social costs increases. Finally, Part IV expands its schema by dropping the linear constraint from its model. With that modification, the model reveals that the proportionality between social benefit and cost that would accompany a linear model can be transformed, at least in theory, into a vastly disproportionate relationship. Part V then raises the question of whether price discrimination can remedy these welfare problems. Part VI attacks the welfare problem from another angle. It inquires whether there may be a class of new pharmaceutical products for which financing schemes other than the patent system would better maximize aggregate welfare.
II. PATENT THEORY, MARKET FAILURE, ECONOMIC INCENTIVES AND SOCIAL WELFARE: THE BEGINNINGS OF ANALYSIS

A. IN GENERAL

The theory of patent law is straightforward. Society benefits from new technology. Yet in the absence of patent protection, invention would often go unrewarded. Unless a portion of this newly created economic value can be captured by its inventor, there is no incentive to innovate. Indeed, in certain cases there would be a negative incentive: Invention often requires the expenditure of substantial resources in research and experimentation. This failure of the market to supply the incentive to invent is a result of a crucial absence of property rights.

When people provide goods and services, the property rights regime enables them to capture the economic value which they create by providing these goods and services. A producer or merchant owns the goods which are produced or provided. This enables him to trade the goods for compensation. In a similar way a service provider ensures that it provides services only on condition of being paid. The common law property regime requires augmentation in those circumstances in which property rights do not provide a means for an inventor to capture at least a portion of the economic value which she has created. This void in the common law is filled by the patent law.

To an inventor who can meet its stringent standards, the patent law confers an exclusive right to make, use or sell the invention for a twenty-year period, commencing with the date on which the inventor files his patent application. Since the patent office normally takes one to three years in evaluating the patent and in negotiating with the patentee over the scope of his claims, the effective legal term may closer to seventeen years. For products like pharmaceuticals that require regulatory approval before marketing can begin, the effective period of protection may be further reduced. The inventor's reward, as it is sometimes

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17 Id.
19 Id.
21 Professor Lemley concluded in 1964 that the average time consumed in patent prosecution was 864 days or 2.36 years. Mark A. Lemley, An Empirical Study of the Twenty-Year Patent Term, 22 AIPLA Q.J. 369, 385 (1994).
22 This problem of regulatory delay was recognized by Congress in the provisions of the Hatch-Waxman Act, which permits extensions of the patent term equal to the time in which the patentee
called, allows her to exploit these exclusive rights. Her reward is thus
determined directly by the receptivity of the market to her product. If the
product is in high demand, then she is likely to profit handsomely. Yet however
ingenious the invention, there is little or no reward to the inventor unless buyers
appreciate it and are willing to pay for it.

The patentee’s dependence upon the combination of the exclusive rights
conferred by the patent law with the incentives of the market has both positive
and negative effects. On the positive side, the system ensures that incentives are
directed towards generating products that people want. On the negative side, the
patent system does not provide incentives to produce products for which there
is a social need but no economic demand, such as drugs for diseases (like sleeping
sickness) that primarily affect populations with little purchasing power. The
patent system, almost by definition, also does not work to stimulate primary
research. In these latter areas (the needs of the poor, and primary research)
alternative systems of stimulating research and invention, such as by government
funding or by post hoc government rewards, are, or may be, necessary. The
patent system also generates inefficiencies: The patentee’s exclusive rights permit
it to charge super-competitive prices for the patented product, with the result that
some potential customers who value the invention at more than its cost of
production but at less than the price charged by the patentee go unserved.

In the language of economists, this is a deadweight loss, or a loss to society resulting
from a misallocation of resources.

awaited final FDA approval plus one half of the post-patent issuance time taken for running clinical
tests. 35 U.S.C. § 156(c)(1), (2) (2002). The period calculated in this manner, however, together with
the remaining patent term cannot exceed fourteen years. Id. § 156(c)(3), nor can an extension can exceed five years. Id. § 156(g)(6)(A).

23 GLADSTONE ET AL., supra note 16, § 1:30.
27 Scholars have advanced numerous suggestions for a reward system of stimulating research. The focus of many of these proposals has been the elimination of the deadweight loss problem. See, e.g., Michael Abramowicz, Perfecting Patent Prizes, 56 Vand. L. Rev. 115, 122-27, 169 (2003); Steven Shavell & Tanguy Van Ypersele, Rewards Versus Intellectual Property Rights, 44 J. L. & Econ. 525, 529 (2001).
28 These potential customers are represented in the portion of the demand curve that lies below
the super-competitive price set by the patentee and above the point at which the marginal-cost curve intersects the demand curve. In Figure 1, infra, Part IV.A, this would be the portion of the curve DD’ between points A and B.
29 ROBERT S. Pindyck & Daniel L. Rubinfeld, Microeconomics 292 (5th ed. 2001); see also
Because the patent system operates through harnessing market-based incentives, the structure of those incentives bears examination. The expected value of the patented invention provides the incentive to undertake the research and development that ultimately produce it. Before a potential inventor commits an investment to research and development activities, it assesses the expected profit from that investment. And, of course, it compares that expected profit with expected returns from alternative investments.

B. THE PATENT SYSTEM AS AN ADJUNCT TO THE MARKET

Although the patent system is not the only means available for fostering invention, it possesses certain characteristics that enable it to mesh with the market more or less seamlessly. We observed earlier that the patent system solves a market failure: In the traditional property regime the absence of rights over inventions means that the economic incentives that elsewhere foster productive behavior would not, in the absence of the patent system, foster inventive behavior. By providing these missing rights, the patent system broadens the reach of the market, endowing it with a major responsibility for stimulating invention in both end products and technology.

It is in this augmentation of market mechanisms where the advantages and disadvantages of the patent system lie. By providing missing property rights and relying upon the market to provide both the inventive stimulus and ultimate reward, the patent system maximizes the extent to which inventors direct their focus to the needs and wants that society most values (as measured by market demand), and minimizes the extent to which inventors will direct their focus to unwanted goods and services. Throughout the operation of the patent system, the market plays the key role. Potential inventors look to the market for clues as to what kinds of products are likely to be rewarded. They gear their efforts according to the clues that the market provides. And the extent to which they are,
in fact, rewarded for their inventive activity is determined by the market. The objective forces of the market thus perform critical roles in directing the course of inventive activity. Because no other decision-making mechanism can match the market's predictive abilities or its ability to continually reassess and reevaluate, the patent system, which incorporates these market mechanisms, partakes of these advantages. The superiority of the patent system over alternative means of fostering inventive activity thus lies in its ability to harness the powerful forces of the market to its ends. Yet it is also this attachment of the patent system to market mechanisms that account for its disadvantages.

C. CLASSES OF INVENTIONS AND THE LOCI OF THE PATENT SYSTEM'S ADVANTAGES AND DISADVANTAGES

In a well-known paper in 1962, Kenneth Arrow divided inventions into two classes. In the first class are innovations which reduce production costs substantially, and in the second class are innovations which reduce costs in lesser amounts. The first class embraces innovations which lower cost so much that, if a monopolist was in control of the market, that monopolist would set the post-innovation profit-maximizing price below the level of the old unit production cost. The second class consists of other cost-reducing innovations.

This classification of inventions worked well for Arrow's paper, which sought to distinguish the profit generated by invention in a monopoly marketplace from that generated by invention in a competitive marketplace, and his classification has been followed by others. Nordhaus, for example, employed that classification, and called the first class "drastic" inventions. Arrow's classification also works for this Article. Drawing from (and somewhat modifying) traditional legal terminology, this Article calls these two classes of inventions "pioneer" inventions and "improvement" inventions.

\[\text{id}\]
\[\text{id, supra note 4, at 620-24.}\]
\[\text{id}\]
\[\text{id, supra note 4, at 620-24.}\]
\[\text{id, supra note 5, at 72-73.}\]
\[\text{Cf. Westinghouse v. Boyden Power Brake Co., 170 U.S. 537, 561-62 (1898), which held,}\]

This word [pioneer invention] . . . is commonly understood to denote a patent covering a function never before performed, a wholly novel device, or one of such novelty and importance as to mark a distinct step in the progress of the art, as distinguished from a mere improvement or perfection of what had gone before.

In using the term "pioneer invention" to refer to a major invention in the Arrow sense, see supra
The patent system probably operates in its least controversial mode in fostering improvement inventions. Here the ratio of deadweight loss to profit is minimized. Minimizing this ratio mutes controversy over the optimum length of the patent term in the context of improvement inventions. And fostering improvement inventions shows the operation of the patent system at its best. The benefits of the system’s decentralized incentive structure ensure that adequate attention is directed to improvements of technologies at levels that fall below the threshold of public visibility, but which, in the aggregate, contribute significantly to the improvement of society’s productive efficiencies. Probably most patent activity concerns with improvement inventions. If so, then most patent activity is concentrated where it raises few controversial issues about social costs and benefits.

The patent system’s most apparent disadvantages involve the deadweight losses that the system generates by conferring market power on patentees. These losses may be a part of a system that generates inventive activity, but they are, nonetheless, a social cost. Pioneer inventions are likely to generate higher ratios of deadweight loss to profit than improvement inventions. In some cases, the ratio of deadweight loss to profit might be very high. As a result, pioneer inventions better raise issues about the system’s social costs and benefits. Of course, the deadweight loss generated by pioneer inventions is also a measure of the social value created by these inventions. Society wants and needs pioneer inventions. The questions are whether patent terms are too long and whether these inventions can be generated with a lesser degree of deadweight loss?

note 4, at 620-24, is employing that term in a related, but slightly different, sense from that used by the courts.

See infra Part IV.A.

See, e.g., Keith E. Maskus, Intellectual Property Rights and Economic Development, 32 CASE W. RES. J. INT’L L. 471, 478-79 (2000) (“In the vast majority of cases, invention involves minor adaptations of existing technologies and products. The cumulative impacts of these small inventions can be critical for growth in knowledge and productive activity.”).

Id.

Generating deadweight loss is a widely recognized social disadvantage of the patent system. See, e.g., Jonathan M. Barnett, Private Protection of Patentable Goods, 25 CARDOZO L. REV. 1251, 1269 (2004) (referring to the deadweight loss as a significant social cost). Because the patent law confers exclusive right to make, use, and sell the invention upon the patentee, the patentee is likely to exercise whatever economic power these exclusive legal rights generate. Arrow’s analysis describes the relative economic powers of pioneer inventors and of improvement inventors. See infra Part IV.A.

See infra Part IV.A.

The more value that society places on an invention and the consequent more power possessed by the patentee to set price above marginal cost, the greater will be the deadweight loss. From this perspective, deadweight loss is a rough measure of the invention’s social value.
The public is probably most conscious of patentee market power over new pharmaceutical products. Because pharmaceuticals are one of the few places where a single patent covers an entire product, they may be less subject to pricing constraints than other inventions that are improvements to machines or processes and for which pre-existing technologies are ready substitutes. The media has reported extensive public concern over what are perceived as unduly high price levels for patented pharmaceuticals, a concern to which Congress has recently responded. Beyond these domestic welfare and distributional issues, however, the pricing of patented pharmaceutical products appears to create extensive deadweight losses in third world nations. These real and perceived disadvantages of the patent system, as it operates in the pharmaceutical industry, may be accompanied by some weakening of the informational advantages that the system draws from its close interaction with the market. The system's ability to harness market-supplied information, one of its major advantages, may constitute less of an advantage with certain kinds of pharmaceutical products where, in the area of critical and life-saving drugs, needs are widely recognized. Indeed, the patent system’s close interaction with the market explains why pharmaceutical companies do not develop drugs for the cure of diseases afflicting poor nations: Such products would not be profitable. None of these remarks are intended to say that the patent system does not work in this industry or that it works particularly badly. Neither are they intended to say that social costs outweigh benefits in generating new pharmaceuticals. Rather, these remarks merely point out that in this area the patent system's advantages appear weaker than they do in other areas. These apparent weaknesses in the way the system operates in

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47 See Burk & Lemley, supra note 9, at 1590, which states: In some industries, such as chemistry and pharmaceuticals, a single patent normally covers a single product. Much conventional wisdom in the patent system is built on the unstated assumption of such a one-to-one correspondence . . . . Such a correspondence is the exception rather than the rule, however. Machines of even moderate complexity are composed of many different pieces, and each of these components can itself be the subject of one or more patents.

See also Herbert Hovenkamp et al., Anticompetitive Settlement of Intellectual Property Disputes, 87 MINN. L. REV. 1719, 1738 (2003).


50 The incentives generated by the patent system stimulate potential inventors to learn about and to address technological and other problems afflicting highly specialized fields of endeavor. But the incentives of the patent system are not needed to bring to light the need for cures for diseases threatening the lives of large populations. See infra Part VI.
pharmaceutical markets are discussed below. This Article then discusses means for minimizing those weaknesses.

III. THE INCENTIVE EFFECTS FROM THE PERSPECTIVE OF THE INVENTOR: WHERE SOCIAL BENEFIT MEETS PRIVATE INCENTIVE

A firm contemplating research to develop a new product necessarily investigates whether the research is likely to succeed and whether the revenues that the product generates will be likely to cover its costs and produce a profit. The ordinary lag between the time when a firm introduces a new product and the time when its competitors bring rival products to market provides a window for the innovating firm to capture much of the economic value that it has created. That period of de facto exclusivity is sufficient to support modest research and development. The patent system provides legally protected exclusivity for the longer periods required to justify the larger investments that may be necessary to design highly innovative products.

Thus, a firm contemplating a large research investment considers first the chances that its research will succeed. Second, it considers the probabilities that it (rather than one of its rivals that may also be conducting research) will be able to obtain a patent on the product. Third, it assesses the amount of expected revenue that the product is likely to generate and the costs that it will incur in producing the product.

A. THE PROBABILITY OF SUCCESS

A potential innovator must, of course, balance the amount of its research and development costs and its probability of successfully developing the innovation against the value of the innovation. In addition, it must also weigh the risk that a rival will also succeed in developing the invention. Professor Robert Merges breaks the decision about committing funds to research into two stages. In the first stage, the inventor decides whether to undertake preliminary experimentation.

51 The discussion Part III and Part IV, infra, considers the value of the patented invention. The Article distinguishes between the aggregate social value of the invention and the private value to the inventor. In the next Part, the Article considers the social value of invention. Here, because of the interest in the incentive effects of the patent system, there is concern with the private value to the inventor.

52 Merges, Uncertainty and the Standard of Patentability, supra note 8, at 10-12.

53 Id. at 31.

54 See id. at 20-23.

55 Id. at 21.

56 Id.
on an invention.\textsuperscript{57} In the second stage, the inventor decides whether to develop the invention.\textsuperscript{58} As Merges points out, this model captures some of the complexity of the real world: The results of the preliminary experimentation in the first stages provide information that will recast the probabilities of success that the inventor weighs when deciding whether to proceed into the second stage.\textsuperscript{59} Indeed, an inventor is continually facing new decisions with increasing amounts of information as the project proceeds.\textsuperscript{60} Thus, Merges's analysis fits nicely with a third stage of the development process identified by Edmund Kitch.\textsuperscript{61} In Kitch's model, issuance of a patent is treated as tantamount to staking out an area for commercial development.\textsuperscript{62} In this post-patent stage, the inventor has solved the basic technology problem and has won the race to the patent office. At this late stage, an inventor deciding whether to go forward must weigh the costs of commercial development against his estimate of commercial success.\textsuperscript{63}

Let us now consider the probability of success in the quest to develop the innovation. If only one firm is in the research race, then that firm undertakes the research if the value of the anticipated product multiplied by the probability of successfully developing it is greater than the cost of the required investment in research and development (R&D).\textsuperscript{64} But if two firms decide to undertake investment in similar R&D, the dimensions of the problem change. If one firm develops the product and the second firm does not, the successful firm acquires the entire value of the product.\textsuperscript{65} But it is possible that both firms may succeed
technologically but only one of them wins the race to the patent office and thereby captures the potential economic value of the product. Indeed, regardless of how many firms succeed technologically, only one will receive the patent.66

The expected value of product development must account for both situations. Since only one firm can win the patent race, the probability of succeeding overall, that is, the probability of both developing the technology and receiving the patent, is the multiple of the two probabilities (the probability of developing the technology multiplied by the probability of receiving the patent).67 Accordingly, the ex ante expected profit for each firm is discounted by both probabilities. Of course, any number of firms may enter the research and innovation race. If we assume that each of the successful innovators has an equal chance to obtain a patent, then the expected value of the patent becomes the value of the innovation divided by the number of successful innovators.68 As the number of firms focusing their efforts on developing the same innovation increases, the chance of success for any one firm decreases. Indeed, as the number of firms in the patent race increases, the expected value of the invention to any one of them approaches zero.69
B. RETURNS DISCOUNTED TO PRESENT VALUE

The expected profit that is salient to the inventor is, of course, the discounted present value of the expected future returns. As a result, the more distant the future revenues, the lower is the inventor's contribution to the incentive structure of the patent system.

1. Incentives and Discounted Future Revenues. Because the expected profit is realized over a period that begins only after the invention is fit for commercial exploitation, the comparison of expected profit to investment—as noted above—necessarily is a comparison of present costs with future earnings. Earnings are necessarily weighted less than the research costs that generate them because earnings must be discounted to present value while the latter do not.

Moreover, the anticipated returns must be adjusted in several ways. Part III.A, supra, noted that returns must be adjusted for the estimated probabilities of technological success, as well as for the probabilities that technological success may be rendered moot by others winning the race to the patent office.

This section focuses upon the value of the anticipated returns. At the stage at which the investment commitment is made, the present value of the anticipated returns is at its lowest. Since the research and development work has not yet begun, the period in which the anticipated returns are generated is still some time away. The inventor receives no returns until the invention is produced and in a form for commercial use. Thus if the research and development period takes three years, the first returns will not begin until then. In that case, the first year’s anticipated returns must be discounted for that three-year wait. And, of course, the returns generated in each year of the patent term must be discounted accordingly. Thus, if the patent application is filed three years after the commencement of research and the product is immediately marketed, the returns to the investor (viewed from the date of his investment) from each year of the twenty-year patent term would have to be discounted from three to twenty-three years.

Kitch's focus upon patent rights as means of staking out a technology for commercial development calls attention to the fact that the early years of the patent term may not be usable for commercial exploitation. However long this post-patent period of development extends, it consumes some of the protected

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70 The present value of anticipated returns is lowest at the time investment is committed to research because the dates on which the returns will be realized are at their most distant and are discounted to their maximum extent at that time.

71 See Pindyck & Rubinfeld, supra note 29, at 534-35.

72 Id.

73 See Kitch, supra note 6.
patent period, narrowing further the period of return on investment.\textsuperscript{74} Modifying the above example to take account of a period of development, there might be a three-year period of research followed by the filing of a patent application, which is then followed, say, by a two-year period of development. Since the twenty-year patent term begins with the filing of the patent application, the two-year development period in the example reduces the commercially relevant protected term to eighteen years. So, in such a case, the first return would be a full five years distant from the commencement of investment. This problem became acute in the pharmaceutical industry after Congress required new drugs to be effective as well as safe.\textsuperscript{75} The new effectiveness requirement added to the delay before manufacturers could market a patented drug, as more extensive testing was required before the FDA could approve marketing the drug. Congress then authorized extensions of the patent term to compensate for regulatory delay, but the extensions do not fully compensate for those delays.\textsuperscript{76}

Finally, it should be observed that potential customers may take time to recognize the value of a new product and adjust their purchases accordingly.\textsuperscript{77} A producer generally plans a promotional strategy with which to acquaint potential

\textsuperscript{74} This discussion is premised upon a simple three stage model. The first stage is Merges' stage of preliminary experimentation. See Merges, Uncertainty and the Standard of Patentability, supra note 8, at 21. The second stage collapses much of Merges's more elaborate model into a stage in which research is conducted directed to the generation of a patentable invention. In this second stage the risks are whether the technology can be developed at all and whether a rival will do it first. See infra notes 89, 92 and accompanying text. The third stage is the stage of commercial development, discussed by Kitch, that occupies the initial years of the patent term. See Kitch, supra note 6, at 271. Since the patentee receives no returns during the period of development, the period in which the patentee is able to exercise its patent rights to generate a return on its investment is narrowed to the patent period less the development period. If the development period were, say, five years, then only fifteen years of the standard twenty-year patent term would generate a return on the patentee's investment.


\textsuperscript{77} See, e.g., Jayanta Bhattacharya & William B. Vogt, A Simple Model of Pharmaceutical Price Dynamics, 46 J.L. & Econ. 599 (2003) (observing that for this reason, producers of new pharmaceuticals tend to sell at low prices during the early years of the patent term and to invest in advertising during that period).
purchasers to the characteristics of its new product. As a result, the sales volume of a new product may increase over a period of years. Revenue, accordingly, may be lower in the early years in which it is marketed than in later ones.

2. The Inventor's Perspective Again. Implicit in the discussion above are the economics underlying the decision of the inventor about whether to undertake an investment in innovation. The basic economic questions are whether the value of the patented invention is expected: (1) to exceed the cost of the investment, and (2) to produce a return superior to alternative investments. In making these comparisons, the prospective investor necessarily compares the present cost (the up-front investment) with future returns, which must be discounted both for their uncertainty and their future dates.

A stylized example will illustrate these matters. Suppose we estimate the chances of successfully developing a new product (let's call it a widget) at 80%. Then we should discount our projected profits by 80%. Suppose further that we know that three of our rivals are attempting to develop this product. The first to succeed will receive a patent and block the others from the widget market. Since we and our three rivals are starting out about the same time and with approximately the same resources, our chances of developing the product first would appear to be one in four, or 25%. Thus, on this assessment, we have a 25% of 80% chance of success, or an overall probability of success of 20%. On these probabilities, unless the expected return is extremely high and we are high-risk takers, we should probably look for an alternative line of research and development.

Let's add a new element. Our own prior research gives us an advantage unknown to the others. As a result, we have concluded that we have a 90% chance of developing the product first. Now our aggregate probability of success is 90% of 80%, or 72%. The project, of course, is risky, but if the expected returns are sufficiently high, then they can justify the risk. Those returns must be discounted to 72% of their expected value in order to compare them with our investment and alternative investments. Alternative investments, of course, also have to be discounted for risk.

Let's make some additional simple assumptions for illustrative purposes. We expect that our invention will generate revenues (in excess of production costs)

78 Id.
79 Id.
80 See Pindyck & Rubinfeld, supra note 29, at 542 (considering a possible investment in the light of alternative possible investments).
81 See, e.g., David Tenenbaum, Valuing Intellectual Property Assets, 19 No. 2 Computer & Internet Law 1, 1, 4 (2002) (observing the need to returns discount for future date and risk).
of $1,000,000 per year. Over a twenty-year patent term the total return would be $20,000,000. The \textit{ex ante} expected value of the patented invention, however, is substantially less than $20,000,000. Ignoring for the moment the time required for research and development, that $20,000,000 in future earnings must be discounted to present value. Let's assume that we recognize earnings at the end of each of the twenty years of the patent period. Then the $1,000,000 for the first year is discounted by the interest rate: $1,000,000/(1+r)$, where $r$ is the rate of interest. The $1,000,000 for the second year is discounted by the interest for years one and two: $1,000,000/(1+r)^2$, and so on. The present value of the $20,000,000 in future earnings thus is: $^82$

$$
\sum_{i=1}^{20} \frac{1,000,000}{(1+r)^i}
$$

At an interest rate of 5%, the $20,000,000 in future revenues would have a present value of $13,850,320. So the present value of these revenues is only about 69% of their nominal dollar amount. We also must discount the $13,850,320 for risk. Recalling that we had an estimated 72% probability of succeeding in actually acquiring the invention, the value of the expected invention is $9,972,230. That is not quite 50% of the total expected future $20,000,000, expressed in nominal dollars. If the investment required to develop the product is substantially less than the $9,972,230, then it would provide a positive profit.

Suppose the required investment is $5,000,000. Then, on these figures, the investment would generate a profit of $4,972,230 over a twenty-year period. The attractiveness of that return depends upon its alternatives. Five million dollars invested at 6% over a twenty-year period would produce $19,098,748, or a net profit of $14,098,748 in nominal dollars or $5,054,202 in present value. Thus in this case, the pursuit of the invention does not appear especially attractive as an investment. An alternative disposition of the $5,000,000 at 1% over the going interest rate would be more profitable.

Thus, the incentive structure of the patent system requires assessment of the expected return in the light of the investment necessary to generate that return.\textsuperscript{83} To make that assessment, the inventor must discount future revenues to present value and further discount for risk.\textsuperscript{84} Such discounting is standard practice for investors considering whether or not to undertake a particular investment or in

\textsuperscript{82} R.G.D. Allen, \textit{Mathematical Analysis for Economists} 232 (1938).

\textsuperscript{83} The processes of comparing expected return with investment is described, inter alia in Christopher P. Bowers, Comment, \textit{Courts, Contracts, and the Appropriate Discount Rate: A Quick Fix for the Legal Lottery}, 63 U. CHI. L. REV. 1099, 1123 (1996).

\textsuperscript{84} Id.
selecting a particular investment from a range of alternatives. Yet the patent system is dedicated to generating significant advances: No patent can be issued unless the invention is nonobvious, a phrase meaning beyond the knowledge and abilities of a competent professional in the field. The system itself thus courts the risk that the purported inventor will not exceed the capabilities of his or her peers. In the most successful inventions, the risk factor is reflected in the high profits which those inventions command. And the reliance of the patent system upon incentives generated by the twenty-year period of exclusive rights also exacerbates the difference between the return seen by observers (the dollar return at the moment of the observation) and the incentive to the inventor (that return discounted to its ex ante value). As shown below, these differences between the ex post and ex ante values are relevant in a variety of ways to the assessment of the system’s private and social costs and benefits.

IV. EXPLORING SOCIAL COSTS AND BENEFITS

A. THE ARROW ANALYSIS: DIFFERENT VALUES IN DIFFERENT MARKET STRUCTURES

Arrow (who divided inventions into two categories) concluded that for pioneer inventions, an innovator would set a royalty equal to a monopoly return. This would be true regardless of the industry market structure. Despite the monopoly return to the inventor, the public would incur an immediate benefit because the large cost savings would press prices downward, below their level prior to the invention. This benefit is easily seen in Figure 1 below. Let’s assume that the product was initially produced in a competitive market where the cost and price are represented by the line $PP$ and the output is $XX$. The invention reduces costs to the level of $c$. Now the inventor licenses the invention at a per unit royalty equal to the vertical distance between $c$ and $p$. Consumer

85 The Patent Act requires that an invention pass the threshold of obviousness. That is, the difference between the invention and the prior art must not be obvious to a person skilled in the art pertaining to the subject matter of the patent. 35 U.S.C. § 103 (2000).

86 See Bowers, supra note 83; see also David S. Evans & Richard Schmalensee, Economic Aspects of Payment Card Systems and Antitrust Policy Toward Joint Ventures, 63 ANTI TRUST L.J. 861, 877 (1995) (discussing the risk factor, investment in research, and returns viewed both ex post and ex ante).

87 See Evans & Schmalensee, supra note 86, at 877.

88 Arrow refers to cases in which the cost reduction is sufficiently drastic that the optimum monopoly price is less than the cost in the pre-invention period \([p' < \bar{d}]\). This Article refers to those cases as involving pioneer inventions. See supra Part II.c.

89 Id.

90 Thus, in Arrow’s description of this situation the monopoly price is below the pre-invention cost. Id.; see also supra note 88. A fortiori, the monopoly price would be below the preexisting price.
The second or "improvement" category requires some discussion. Arrow was interested in how market structure affected the incentives to innovate. Although his focus differs from that of the present Article, his analysis is useful for exploring the economic effects of an invention of the improvement type. Arrow observed that in the case of an improvement the inventor would set the royalty in the full amount of the per-unit cost savings, thereby capturing the entire cost savings for itself. But the revenues earned would differ depending upon the market structure in which the invention was employed. In a competitive market, the royalty would equal the unit cost savings multiplied by the industry output immediately prior to the deployment of the invention. In a monopoly
marketplace, the inventor's return would be less, because the value of the invention would be limited to the unit cost savings multiplied by the smaller monopoly output. The critical element in Arrow's analysis of improvement patents is the constraint that the preexisting technology exerts upon the patentee's pricing power. That constraint is examined below.

Figure 2 depicts the Arrow hypothesis in diagrammatic form. In the diagram, the monopolist's initial profit is represented by the rectangle formed by the horizontal line $p_{m1}$ on the top, the horizontal line $c$, on the bottom, the (vertical) 0 axis on the left side, and the vertical $X_{m1}$ intersect on the right side (or $X_1(p_{m1} - c)$). The monopolist's post-innovation profit is represented by the rectangle formed by the horizontal line $p_{m2}$ on the top, the horizontal line $c_2$ on the bottom, the (vertical) 0 axis on the left and the vertical $X_{m2}$ intersect on the right (or $X_1(p_{m2} - c_2)$). The increment to the monopolist's profits resulting from the innovation, accordingly, is the difference between these two amounts. The difference in monopoly profits is also shown in the area under the marginal-revenue curve (MR). The pre-innovation profits are represented by the area under the MR curve down to the initial cost curve $c$. The post-innovation profits are represented by the area under the MR curve down to the post-innovation cost curve $c_2$. The increment to the monopolist's profits from the innovation thus are represented in the diagram by the area under the MR curve between the two cost curves $c$ and $c_2$.

94 Id.
95 Id. Since the preexisting technology is available, the patentee owning the new technology cannot charge a royalty higher than the cost advantage that the new technology confers upon its users.
This way of representing the increment to the monopolist’s profits makes it easy to show Arrow’s point graphically. When the monopolist innovates, it can capture additional profits represented by the area between $c_1$ and $c_2$ that lies under the MR curve. But when a competitor firm innovates, it can capture additional profits represented by the area between $c_1$ and $c_2$ all the way out to the pre-innovation competitive output of $X_1$.

The preexisting technology, represented here by $c_1$, constrains the royalty that the patentee is able to charge. Improvements can range in significance all the way from one that approaches (but does not reach) the cost-savings of a pioneer invention, to the more common inventions that generate modest cost savings. In the context of linear demand and constant costs, all improvement inventions generate a lower ratio of deadweight loss to profit (and to total surplus) than do pioneer inventions. Restated, within the context of linear demand and constant cost, this class of inventions appears, prima facie, to generate a higher ratio of social benefit to social cost than does the class of pioneer inventions.

B. THE KAPLOW ANALYSIS

In a path-breaking analysis of the patent system and its connections to antitrust law, Harvard Law Professor Louis Kaplow brought a new analytical refinement to the evaluation of the patent system and its operation. Identifying the social benefits of the patent system as the innovations that it engenders, and the social costs of that system as the monopoly output restrictions which the system provides as incentives for innovative activity, Kaplow directed his attention to the system’s marginal benefits and costs. As Kaplow rightly indicated, a rational society would determine the level of innovation that it

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96 Figure 2, supra. The area under the marginal revenue curve (out to the point of output) represents all of the monopolist’s revenue. The area under its cost curve represents its costs. The difference in those areas is its profits. When the monopolist reduced its cost from $c_1$ to $c_2$, it lowered its costs and, because of those lower costs, increased its output. As a result, its profits increased. The increase in profits is represented by the difference between the area under its marginal revenue curve (out to the point of output) and the area under its new cost curve $c_2$. This profit increase is represented by the area described in text.

97 When the competitor innovates, it charges licenses a royalty equal to the cost savings on the pre-invention competitive-market output. This royalty base is larger than the base from which the monopolist’s calculates its savings from equivalent cost savings, because the monopolist has been restricting output in order to charge monopoly prices from the beginning.

98 Under this Article’s adoption of Arrow’s approach, inventions fall into two classes: pioneer inventions or improvement inventions.

99 Kaplow, supra note 7, at 1825-26.

100 Id. at 1823-25.
desired, and would then generate that innovation at the least cost.\textsuperscript{101} Ideally, society should limit the patent term to the point when the marginal social costs imposed by the patent system rise to the level of the marginal benefits that it generates.\textsuperscript{102}

In analyzing the patent system's marginal social costs and benefits, Kaplow hypothesized a one-year extension of the patent term.\textsuperscript{103} A one-year extension of the patent term would increase the reward of the patent and thus would probably generate more innovations.\textsuperscript{104} The additional innovations generated by that one-year extension would constitute the marginal benefit of such an extension.\textsuperscript{105} But a one-year extension of the patent term would also impose additional social costs: All of the patent monopolies which were about to expire now would continue for an additional year. The year extension would thus impose monopoly losses upon society which would not occur in the absence of the extension. The monopoly loss so imposed during the one-year extension would be the incremental, or marginal, cost of that one-year extension.\textsuperscript{106} Kaplow also worked backward to compare the costs and benefits which would result from reducing the patent term: What would be the social losses from the reduction in innovation which would result from a one-year reduction of the patent term?\textsuperscript{107} And what would be the social benefits (in the elimination of monopoly restrictions) which would result from such a one-year reduction of the patent term?\textsuperscript{108}

Kaplow forthrightly acknowledged that it is virtually impossible to determine either the value of new innovation or the monopoly loss from a hypothetical extension of the patent term.\textsuperscript{109} He believed, however, that the analytical format which he developed would be helpful in thinking about the issues. His marginal analysis is a major contribution. Earlier writers had not focused their attention on marginal costs and benefits. Kaplow's format, by considering marginal costs and benefits, moves analysis and evaluation of the operation of the patent system to a higher plane of conceptual clarity.

\textsuperscript{101} Id. at 1822, 1834.
\textsuperscript{102} Id. at 1825-27.
\textsuperscript{103} See also id. at 1830, 1840.
\textsuperscript{104} Id. at 1826.
\textsuperscript{105} Id.
\textsuperscript{106} Id.
\textsuperscript{107} Id. at 1824.
\textsuperscript{108} Id. at 1825.
\textsuperscript{109} Id. at 1833-34.
This Section will use this marginal analysis in assessing the operation of the patent system. As Kaplow pointed out, protecting an inventor's work for more years than necessary to stimulate his invention imposes a cost upon society in the form of a restricted output.\(^{110}\) Thus, some inventors would have produced their inventions even without a stimulus from the patent system. For other inventions, the costs of research and development, the risks of failure, and the risks of the marketplace would deter the necessary innovative effort without the stimulus of an exclusivity period provided by the patent system.\(^{111}\) Yet for some inventions, the necessary period of exclusivity might be very short.\(^{112}\) The stimulus necessary to generate other inventions might be longer, but still less than the actual patent term.\(^{113}\) For yet other inventions, exclusivity for the full patent term would be necessary to provide an adequate stimulus.\(^{114}\) Other potential inventions may well go uninvented because even the twenty-year patent term is too short to provide the requisite incentive.\(^{115}\)

Let's begin our analysis by assuming that some inventions would be produced without any period of exclusivity, some would be produced with a one-year period, others with a two-year period, others with a three-year period, and so on. Thus, we will assume that each year of the patent term produces an incremental stimulus to generate more inventions. More precisely, we assume that invention occurs in proportion to the investment in R&D. On these assumptions, more investment in R&D generates increased invention and the increase in invention is proportional to the increase in R&D investment. For purposes of the following discussion, invention is measured in terms of a value derived from the market: Inventions carry value determined by the demand for a patented invention, a value derived from its attractiveness as a consumption good or from its ability to produce new products or to lower production costs for preexisting products.

Let us assume that each year of the patent term provides the incremental incentive necessary to generate new inventions over and above the inventions generated by terms of lesser length. For purposes of exposition, we hypothesize that each year of the patent term generates such additional inventions that (in an unrestricted market) would generate an average of $1,000,000,000 per year over

\(^{110}\) Id. at 1825.

\(^{111}\) Kaplow, supra note 7, at 1826 n.29.

\(^{112}\) Id.

\(^{113}\) Id.

\(^{114}\) Id.

\(^{115}\) Id.
their useful lives. Note, however, that because these inventions will be covered by patents, their output will be restricted during the patent term.\textsuperscript{116} For the reasons set forth below, the annual social value represented by these inventions during the patent term will be assumed to be 75% of the amount that it would be in an unrestricted, competitive market. The monopoly restriction and concomitant social loss imposed by the patentee is thus assumed to be equal to 25% of the social value in a competitive market. Social value is the combination of producer and consumer surplus.

![Figure 3](image)

**FIGURE 3**

Figure 3 above represents the demand for a pioneer invention. The annual value contributed by the production of the product in a competitive market is symbolized by the area $DFG$. We assume that the product is patented, however, so that the patentee restricts production to $X$, producing producer surplus represented by the rectangle $EABF$, and a concomitant consumer surplus $DAE$. The aggregate social value of the product is thus represented by the area $DABF$, and the monopoly loss being the area $AGB$. Assuming a linear demand\textsuperscript{117} for the product and constant costs as in Figure 3, the monopoly loss is 25% of the total

\textsuperscript{116} Patentees are assumed to exercise the exclusive rights that the patent law confers upon them. Therefore, they will restrict output under their patented technology in order to maximize their profits.

\textsuperscript{117} This Article employs a linear model as an entry into its analysis of the patentee's situation. The use of linear analyses is common in other critiques of the patent system. See, e.g., Abramowicz, supra note 27, at 162-68; Douglas Gary Lichtman, Pricing Prozac: Why the Government Should Subsidize the Purchase of Patented Pharmaceuticals, 11 Harv. J.L. & Tech. 123, 130 (1997). Later, this assumption is dropped. See infra note 135 and accompanying text.
The triangle $AGB$ is equal to the triangle $DAE$ and is one half the area of the rectangle $EABF$.

**Table 1: Marginal Social Benefits and Costs: Naïve Version**

[figures in millions of dollars]

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<th>Year</th>
<th>PS (annual)</th>
<th>CS+PS (annual)</th>
<th>Monopoly Loss (annual)</th>
<th>Value of Invention</th>
<th>Marginal Benefit</th>
<th>Marginal Cost</th>
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In Table 1 above, we consider marginal social costs and benefits using the approach just outlined and add a number of additional assumptions. First, we continue the assumption that each year of the patent term generates new inventions whose production under competitive conditions would add $1,000,000,000 of social value (i.e., producer surplus plus consumer surplus) to the economy. And because these new inventions are patented, we continue to assume that the patentees impose monopoly restrictions on production, thus reducing the $1,000,000,000 of potential social benefit by 25% to $750,000,000. Next, we determine how to capitalize the social value of inventions. Here we make two observations. First, during the twenty-year patent term, the social value is the discounted sum of the combination of producer and consumer surplus. But the social value of the invention continues beyond the end of the patent term. The social value of the patent term is the discounted sum of each year’s consumer surplus—far is now enlarged when the patent rights expire. Together these two sums equal the capitalized value of the consumer surplus unrestricted by the exercise of patent rights. Using a 5% discount rate, the value of the inventions generated by each year of patent protection would thus be twenty times the earnings, or $20,000,000,000.

Alternatively, we could take a more conservative approach by drawing from the practice of investors in the securities markets. Historically, a conservative measure for the value of a stock was twelve times the annual per share earnings of the company. Following our conservative approach, we capitalize only the

\[ PS \] is producer surplus or profit. \[ CS \] is consumer surplus. This is the benefit that consumers receive when they are able to purchase a product at a price below their reservation price. Their reservation price is the highest price that they would be willing to pay for the product. Accordingly, the difference between the demand curve (that symbolizes consumers’ reservation prices and price) is consumer surplus. The Monopoly Loss is the “deadweight loss” or the loss that society incurs as a result of monopolist raising price to a supracompetitive level. At supracompetitive levels, some persons who would have been willing to purchase at prices equal to or higher than production cost but less than the price set by the monopolist are not served. The failure to serve customers who are willing to pay the cost of producing the product is a misallocation of social resources and a loss to society. The Marginal Benefit in the table describes the increment in value produced by the patent system each year. The Marginal Cost describes the value that is not generated each year as a result of that year’s patent protection.

Since the patentee can no longer restrict the use of the invention, there is no longer any deadweight loss. What has been profit and deadweight loss during the patent period now becomes consumer surplus.

Over forty years ago, one author suggested that the previously widely-followed earnings multiplier of ten for an industrial business was probably outdated, and that a ratio of fifteen or higher might be more appropriate. See David R. Herwitz, Allocation of Stock Between Services and Capital in the Organization of a Close Corporation, 75 Harv. L. Rev. 1098 (1962). Investors capitalize producer surplus. Since we are concerned with social value, we capitalize the combination of producer and consumer surplus but exclude the deadweight loss.

\[ ^{118} \text{PS is producer surplus or profit. CS is consumer surplus. This is the benefit that consumers receive when they are able to purchase a product at a price below their reservation price. Their reservation price is the highest price that they would be willing to pay for the product. Accordingly, the difference between the demand curve (that symbolizes consumers' reservation prices and price) is consumer surplus. The Monopoly Loss is the "deadweight loss" or the loss that society incurs as a result of monopolist raising price to a supracompetitive level. At supracompetitive levels, some persons who would have been willing to purchase at prices equal to or higher than production cost but less than the price set by the monopolist are not served. The failure to serve customers who are willing to pay the cost of producing the product is a misallocation of social resources and a loss to society. The Marginal Benefit in the table describes the increment in value produced by the patent system each year. The Marginal Cost describes the value that is not generated each year as a result of that year's patent protection.} \]

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combination of producer and consumer surplus (omitting the deadweight loss). Thus, we multiply the $750,000,000 (producer plus consumer surplus) by twelve to arrive at a capitalized social benefit of $9,000,000,000. We use this figure for social value in the analysis in Table 1 above.

On these assumptions, the patent restrictions applied to the inventions which would have been produced in the absence of the patent system produce unnecessary restrictions on those inventions for twenty years. For inventions which would have been stimulated with only a one-year patent term, the actual patent term produces unnecessary restrictions for nineteen years. For inventions which would have been stimulated with only a two-year patent term, the actual patent term produces unnecessary restrictions for eighteen years. Thus, each year of the patent term adds restrictions on the output of a new class of inventions, (i.e., those for whose generation a patent term ending a year earlier would have been sufficient, to the restrictions imposed by earlier years). The marginal social costs of patent restrictions thus rise with each year of the patent term.

We start with the most simple assumptions. Later, we will add some more complexity. Table 1, supra, is based upon the assumption that each year of the patent term generates inventions whose aggregate capitalized value is $9,000,000,000. On that assumption, the marginal benefit from each year of the patent term is a constant $9,000,000,000. The marginal costs of the patent system, on these assumptions, gradually rise from $250,000,000 to $5,000,000,000. On such assumptions, the patent term would have to be lengthened to thirty-six years before its marginal cost would rise to the level of its marginal benefits. If the patent system actually operates like the one hypothesized, there is little room for concern that the patent term is unduly long.

I suspect that for a range each year of the patent term generates an increasing marginal return. If so, over that range marginal benefit would substantially outpace marginal cost because new inventions would add their capitalized values to the computation of the marginal benefit, substantially outpacing growth in the aggregate monopoly restrictions. Ultimately, however, decreasing returns would likely set in. And, of course, a rapid shrinkage of marginal benefit after a rapid rise would maximize the chances that marginal cost would then meet marginal benefit.

121 Nordhaus appears to have assumed continually diminishing marginal returns to research investment. See Nordhaus, supra note 5, at 23, 73-75. Professor F.M. Scherer, commenting on Nordhaus, believes that it is more plausible to assume increasing returns to research, followed by decreasing returns. F.M. Scherer, Nordhaus' Theory of Optimal Patent Life: A Geometric Reinterpretation, 62 AM. ECON. REV. 422 (1972).
122 Nordhaus, supra note 5, at 23, 73-75.
D. *EX POST* AND *EX ANTE* VALUES

Note that the monopoly restriction impacts society now, at the time that the output restriction occurs. The monopoly restriction is properly measured, therefore, in the present at its full nominal dollar amount. Yet that monopoly restriction engenders an incentive to innovation only at its *ex ante* value. As the patent term increases in length, the difference between the deadweight loss (measured *ex post*) and the incentive effect (measured *ex ante*) grows.

Thus, as observed in Part I, *supra*, the *ex ante* value to the patentee of each additional year of the patent term declines over the life of the patent. This decline is the necessary result of discounting future returns to their present values. Because the *ex ante* value of the return generated by each year of the patent term declines each year of that term, then on our assumption that all other factors remain the same, the incentive effect of the patent term increases at a declining rate over the patent term. Each year of patent protection generates a lesser incentive to inventive activity than did the preceding year.

### Table 2: Marginal Social Benefits and Costs: Discounted Version

[figures in millions of dollars]

<table>
<thead>
<tr>
<th>Year</th>
<th>CS+PS (Annual)</th>
<th>Monopoly Loss</th>
<th>Value of Invention</th>
<th>Marginal Benefit</th>
<th>Marginal Cost</th>
<th>Net Marginal Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$750</td>
<td>$250</td>
<td>$9,000</td>
<td>$9,000</td>
<td>$250</td>
<td>$8,750</td>
</tr>
<tr>
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<td>$488</td>
<td>$8,083</td>
</tr>
<tr>
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<td>$227</td>
<td>$8,163</td>
<td>$8,163</td>
<td>$715</td>
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</tr>
<tr>
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<td>$7,775</td>
<td>$931</td>
<td>$6,844</td>
</tr>
<tr>
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<td>$206</td>
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<td>$6,268</td>
</tr>
<tr>
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<td>$7,052</td>
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</tr>
<tr>
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</tr>
<tr>
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<tr>
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<td>$5,801</td>
<td>$5,801</td>
<td>$2,027</td>
<td>$3,775</td>
</tr>
</tbody>
</table>

123 See Evans & Schmalensee, *supra* note 86, at 877 and accompanying text.
124 Thus future earnings generate incentives to invest only in the amount of their present values.
These considerations require modification of the analysis in Section C, supra. There it was assumed that each year of the patent term generates a constant amount of innovation. We now modify that analysis by discounting future returns to present values. This modification recognizes that throughout the patent term, each year of patent protection generates a progressively smaller increment to the incentive to inventive activity.

In order to discount future returns to present values, the selected discount rate must be determined. In the following example, the discount rate is 5%. Consider an invention that generates an income stream of $1.00 per year for the twenty-year patent term. Discounted to present value at the 5% rate, the income for each year falls from $1.00 in the first year to $.95 in the second year to $.91 for the third year, and ultimately to $.40 for the twentieth year. Since a dollar of expected revenue from each year of the patent term has a present value of less than the present value of a dollar from the year preceding, we assume that the second year of patent protection generates a lesser incentive to invest in research and development than the first year. The third year generates a still lesser incentive, and so on. On this reasoning, the second, third and subsequent years generate incentives of 95%, 91%, 86%, 82%, 78%, 75%, 71%, 68%, 64%, 61%, 58%, 56%, 53%, 51%, 48%, 46%, 44%, 42% and 40% of the incentive generated by the first year revenues. Accordingly, in the following example, we assume that each of the years of the patent term provokes investment that declines in these proportions. The figures in the “value of Invention” column of Table 2 therefore are also

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125 See supra notes 110-22 and accompanying text.
adjusted downwards to reflect the lesser inventive activity. If the assumptions underlying Table 2 accurately reflected reality, then the patent term would be almost optimal. One additional year would bring the patent term to its optimal length. Beyond that, additional years would produce negative net social values.

E. MAKING THE MODEL MORE COMPLEX

1. Modifying the “Constant Cost” Assumption. Let’s first consider dropping the constant-cost assumption employed in the preceding analysis. When marginal cost is rising, it intersects the demand curve more quickly than when marginal cost is constant. Thus, in cases involving pioneer inventions in which marginal cost is rising, the deadweight loss will be less than the 25% of potential benefits of the invention assumed above in Sections C and D of Part IV, supra. Of course, a declining marginal cost curve produces the opposite effect. A monopoly restriction in a situation of declining marginal cost produces a greater deadweight loss than in the situation of constant marginal costs. Yet economists commonly assume that a firm’s short-run marginal cost curve eventually rises, because in the short-run the firm is unable to adjust the proportions at which it deploys capital with labor. As a result, its short-run marginal cost curve takes on a U-shape. Moreover, a firm with a constantly declining marginal cost curve appears to be a natural monopoly. Since our focus is upon output restrictions generated by patents (rather than other causes), natural monopolies fall outside the domain of this Article. On the basis of these considerations, it seems appropriate now to let marginal costs either rise or remain constant. For ease of statement let’s assume that the aggregate yearly output produced under pioneer patents is produced by firms whose marginal cost curve is either flat or U-shaped.

If for each year most of the output value produced under pioneer patents is produced by firms with flat or U-shaped marginal cost curves, then the analysis presented in sections C and D above requires adjustment. While production under conditions of flat (or constant) marginal cost and linear demand would generate the results set forth above, production under U-shaped marginal cost curves would generate less deadweight loss. Thus, allowing production under the

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126 Because the demand curve declines to the right, it necessarily intersects sooner with a marginal-cost curve that is rising to meet it.

127 A declining marginal cost curve intersecting at the same point with the marginal revenue curve as a hypothetical constant marginal cost curve would add the area to the right of the intersection that is between the marginal cost curves and under the demand curve to the deadweight loss that would have been produced by the hypothetical constant marginal cost curve.

128 PINDYCK & RUBENFELD, supra note 29, at 210.

129 See, e.g., id. at 224, 226.

130 Id. at 350.
latter conditions into the model would increase the ratio of social benefit to social
cost.\textsuperscript{131}

2. Including Improvement and Component Inventions. The ratio of social benefit to
deadweight loss is higher in improvement inventions than in pioneer
inventions.\textsuperscript{132} Indeed, the ratio appears to grow as the cost savings generated by
the invention falls. The highest ratio of social benefit to deadweight loss is
associated with modest cost improvements, and the lowest ratios are associated
with inventions that approach the cost saving magnitude of a pioneer invention.\textsuperscript{133}
Since the number of commercially valuable improvement inventions probably
exceeds the number of pioneer inventions by far, the linear model would be made
somewhat more realistic by adjusting it to include improvement and component
inventions.\textsuperscript{134} The result of this modification would necessarily increase the
overall ratio of social benefit to deadweight loss generated by the patent system.

It follows that under conditions of linear demand, the ratio between marginal
social benefit and marginal social cost appears to be greater than the three-to-one
ratio considered in Section D. The larger ratio is due both to the addition of
improvement patents to the universe of pioneer patents first considered, and to
the addition of production processes involving ultimately rising (or U-shaped)
marginal cost curves.

3. Dropping the Assumption of Linear Demand. We can now drop the assumption
that the demand curve is linear. Some of the current legal literature employs
linear assumptions,\textsuperscript{135} but those assumptions oversimplify reality. Many actual
demand curves are probably convex to the origin.\textsuperscript{136} This would likely be true
especially where the product in question appealed to a broad public and, as price

\textsuperscript{131} If both a constant and risking marginal cost curve were to intersect with the marginal revenue
curve at the same point, the latter would produce a smaller deadweight loss but the same profit and
consumer surplus. Hence the ratio of social benefit to social cost would increase.

\textsuperscript{132} See supra note 98 and accompanying text.

\textsuperscript{133} See supra note 98 and accompanying text.

\textsuperscript{134} See Maskus, supra note 42, at 478-79 ("In the vast majority of cases, invention involves minor
adaptations of existing technologies and products. The cumulative impacts of these small inventions
can be critical for growth in knowledge and productive activity.").

\textsuperscript{135} See, e.g., Abramowicz, supra note 27, at 162-68 (criticizing Lichtman, supra note 117, at 130).
Lichtman, however, recognizes the critical role that his assumptions play in his analysis. Lichtman,
supra note 117, at 130.

\textsuperscript{136} This is likely to be true in the global market for pharmaceuticals where the market for many
products would expand enormously were prices lower. See, e.g., Theodore c. Bailey, Note, Innovation
U. ILL. J. TECH. & POL'Y 193, 196 (2001) (stating that 90% of people with HIV/AIDS are located
in developing nations that cannot afford current prices; in such nations the demand curve should
be extremely elastic).
dropped, became available to lower-income segments of the public.\textsuperscript{137} Dropping the preceding assumption of linearity, of course, substantially complicates the evaluation of the patent system’s social benefits and costs. Nonlinear curves come in an endless variety of shapes and positions. In addition, there is no reason to believe that all actual demand curves are continuous rather than kinked, wrinkled, broken, or otherwise discontinuous. But bringing nonlinear demand curves into the analysis is absolutely necessary because there is no reason to believe that actual demand curves are linear. Moreover, broadening the model may heighten appreciation of both social problems connected with the patent system and their potential solutions. Let’s take a few examples to see whether we can learn anything from them.

Many simple convex demand curves are of the form of a constant over $x$ raised to a power. Curves of this form exhibit unitary elasticity throughout their length where the exponent of $x$ is one, inelasticity where the exponent is greater than one, and elasticity where the exponent is less than one. Since monopolists maximize their profits by pricing in the elastic portions of their demand curves,\textsuperscript{138} demand curves of the form of $k/x^2$ (or $k/x^3$, $k/x^4$, and so on) are not interesting in a pure form, because they exhibit inelasticity throughout their length. If a second constant is added, however, so that the curve is of the form $k_1/x^2 + k_2$, the curve becomes elastic at higher values of $x$ and is asymptotic to $k_2$. An interesting aspect of this curve is that the associated marginal revenue curve rises throughout. As a result, a constant marginal cost is initially higher than marginal revenue. If it is higher than the asymptote, it will never intersect with the marginal revenue curve, and marginal cost would exceed marginal revenue at every level of output. As a result, there would be no output. But if a constant marginal cost curve is lower than the asymptote, it will eventually intersect with the rising marginal revenue curve.\textsuperscript{139} Beyond that point, marginal revenue will exceed marginal cost for all levels of output. In such a situation, there would be no monopoly restriction on output; a monopolist in this situation would produce to capacity. A curve of this type is illustrated in Figure 4 below.

\begin{footnotesize}
\begin{enumerate}
\item If large numbers of lower-income people are unable to buy a product at its current price but would buy it at lower prices, then at those lower prices the demand curve would show a curvature to the right.
\item A U-shaped marginal cost curve would, of course, also intersect with a rising marginal cost curve.
\end{enumerate}
\end{footnotesize}
We now take a demand curve of the form of a constant over the square (or other) root of $x$. In Figure 5 below, the demand curve is this form and the exponent is one-half: The curve takes the form of a constant over the square root of $x$ ($k/\sqrt{x}$ or $kx^{1/2}$). The marginal revenue curve corresponding to such a demand curve takes the form of $(1/2)(k/\sqrt{x})$ or $(1/2)(kx^{1/2})$.

In the circumstances illustrated by Figure 5, below, a pioneer inventor would favor a price—output policy determined by the intersection of its marginal cost and marginal revenue curves at point $E$. It would produce $X_m$ units of output and sell them at price $P$. It would earn a profit represented by the area $P-MC-E-A$, and the resulting deadweight loss would be represented by the area under the demand curve from $A$ to $B$ down to the marginal cost curve $MC-E-B$. 
In this circumstance (with a demand curve of the form \( k/\sqrt{x} \)) the deadweight loss is exactly equal to the seller's profits. The patent restriction thus appears more significant than it did in the case where the demand curve took a linear form. In the former case the deadweight loss was only one-half of the profits. Here the deadweight loss is equal to the entire amount of the profits. Still, the combination of profits and consumer surplus, generally known as total surplus, exceeds the deadweight loss. Downward shifts in the cost curve would increase total surplus, and because profit equals deadweight loss, would necessarily increase the absolute amount by which total surplus exceeds deadweight loss.

The earlier projections of the balance between the social benefits and costs of the patent system, made under assumptions of linear demand, do not fit these demand curves which exhibit elasticity throughout. The demand curves in this example (of the form of a constant over the square root of \( x \)) alter the ratio between benefits and costs. Inventions for which the demand takes this form would generate higher social costs than under the earlier analysis involving linear demands. Moreover, other demand curves of the same form but involving numerically higher denominators (such as the curve generated by a constant over the square root of \( 2x \) or \( k/\sqrt{2x} \)) produce an even higher ratio of deadweight loss to profit. Indeed, the curve of the form \( k/\sqrt{2x} \) follows the basic form of \( k/\sqrt{x} \) but it is located further to the left, thereby further reducing profit in relation to deadweight loss, so that the deadweight loss produced by monopoly pricing under such a demand is actually larger than profit. Curves in the form of \( k/\sqrt{x} \) or \((kx^{1/2})\), or variations on them or those involving smaller negative exponents, would generate even higher ratios of deadweight loss to profit. In short, the introduction of nonlinear demands shows that the potential deadweight loss generated by the patent system could be very large indeed.

4. Recapitulation and Assessment. Examination of the social costs and benefits of a patent system under the first set of highly simplified assumptions (all patentees possessed monopoly power and all demands were linear) shows that deadweight loss was limited to an amount equal to one-half of profit and one-third of total surplus. When that model is broadened to include improvement patents, the ratio of deadweight loss to social benefit is reduced. Examination of convex demands shows that demand curves of the form of \( k/\sqrt{x^2} + k_2 \) would not generate any deadweight loss at all: Either there would be no output (because marginal cost exceeded marginal revenue at all possible levels of output), or there would be output but no monopoly restriction (because marginal revenue would eventually exceed marginal cost throughout the range of possible production).

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140. See discussion of Figure 3, supra Part IV.c.
141. Because the ratio of deadweight loss to social benefit in improvement patents is reduced, the inclusion of improvement patents lowers the average ratio.
Yet demand curves of different shapes produce an opposite result: Examination of convex demand curves of the form of $k/\sqrt{x}$ shows that deadweight loss is larger in relation to total surplus than under linear demands, and that under many variations of the convex demand curve deadweight loss would actually exceed profit.

This examination of the possible shapes of demand curves thus reveals several matters. First, some types of demand curves (including both linear and some nonlinear) generate high ratios of positive welfare effects to deadweight losses. Second, some types of demand curves ($k_1/x^2 + k_2$) are incompatible with monopoly restrictions. Third, still other types of demand curves ($k/\sqrt{x}$) would provide the context for a single-price monopolist to generate very large deadweight losses. Fourth, improvement patents generate a lower ratio of deadweight loss to profit under any type of demand curve. The ratio of deadweight loss to profit and thus to aggregate welfare (i.e., total surplus) generated by improvement patents decreases with the production volume that preceded the introduction of the improvement.

These matters are significant for policymaking. In categories of patented inventions producing high ratios of deadweight loss to welfare (i.e., total surplus), marginal social cost meets marginal social benefit earlier than in those categories where the opposite is the case. A policy prescription seems to follow: Provide shorter patent terms for inventions with the highest ratios of deadweight loss and longer terms for inventions with lower ratios of deadweight loss. One problem such a prescription raises, however, is that while some judgments can be made about how to set relative lengths of patent terms among classes of invention, there is no baseline from which to set these relative terms. There is, moreover, a second problem with such a policy prescription that is discussed below: What do we know about the categories of invention that are likely to generate the highest ratios of deadweight loss to welfare?

The category of invention that is likely to produce the highest ratio of deadweight loss to welfare is a pioneer invention as we have defined it. Thus, the invention is a stand-alone product, rather than a component or improvement. The invention is likely to be a product that is desired by many people, but that many people are unable or unwilling to pay the monopoly price set by the patentee. In short, the demand for the product is a highly elastic one. The

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142 See supra Part II.C.
143 Deadweight loss results, of course, from demand for the product at prices higher than the marginal cost of producing it but less than the (super-competitive) price charged by the seller. As demand increases, so does the deadweight loss.
demand curve may be kinked below the monopoly price where it becomes highly elastic. Some pharmaceutical products are likely to meet this description.\textsuperscript{144}

The preceding discussion of patentee pricing producing high ratios of deadweight loss to welfare assumes that patentees set price at a single level for all purchasers. Thus the analysis has been focused upon the deadweight loss produced by a single-price monopolist. Yet it is in the circumstances giving rise to high ratios of deadweight loss to welfare that a monopolist has the greatest incentive to set a range of prices, with each price geared to a different market segment.\textsuperscript{145} Price discrimination by a patentee is discussed below. Here it is relevant merely to point out that patentees able to price discriminate among market segments may substantially reduce the deadweight losses that they would otherwise generate. The argument referred to above for reducing the patent terms of certain pioneer inventions, therefore, would not apply to these price-discriminating patentees.

V. PRICE DISCRIMINATION AND ITS BENEFITS

A. IN GENERAL

Deadweight loss falls as output increases beyond the single-price monopoly output. Such increases in output can result from price discrimination. Economists recognize that price discrimination carries the potential for increasing output in monopoly markets.\textsuperscript{146} A monopolist that practices so-called first-degree price discrimination (i.e., selling to each customer at the customer’s reservation price\textsuperscript{147}) would expand output until all customers with reservation prices above marginal cost were satisfied.\textsuperscript{148} In such a situation, output would be at the competitive level and there would be no deadweight loss.\textsuperscript{149} In so-called third-degree price discrimination, a monopolist sells the product at its most profitable price to each of several segmented markets. The monopolist maximizes the

\textsuperscript{144} See supra text accompanying note 47.
\textsuperscript{145} See PINDYCK & RUBINFELD, supra note 29, at 376-77 (explaining how price discrimination can enable a seller to appropriate consumer surplus and deadweight loss); see also Alden F. Abbott, Intellectual Property Licensing and Antitrust Policy: A Comparative Perspective, 34 LAW & POL’Y INT’L BUS. 801, 821 n.108 (2003) (observing that “[p]rice discrimination may allow distributional inefficiency (measured by deadweight loss) to be minimized by allowing the upstream firm to calibrate contract terms to take into account differences among downstream actors in willingness to pay).
\textsuperscript{146} See, e.g., PINDYCK & RUBINFELD, supra note 29, at 372-74; F.M. SCHEFFER & DAVID ROSS, INDUSTRIAL STRUCTURE & MARKET PERFORMANCE 494-96 (3d ed. 1990).
\textsuperscript{147} A reservation price is the highest price that a customer would be willing to pay for the product.
\textsuperscript{148} PINDYCK & RUBINFELD, supra note 29, at 371.
\textsuperscript{149} SCHEFFER & ROSS, supra note 146, at 495.
profits when its marginal revenues from each market are the same and are equal to its marginal cost. First-degree price discrimination always increases output. Third-degree price discrimination maximizes output when the demand curve in the more elastic market exhibits a greater convexity than the demand curve in the less elastic market.

As observed above, a monopolist's incentive to price discriminate increases as the deadweight loss from monopoly single-pricing increases. Since price discrimination carries the potential for expanding output and reducing deadweight loss when there are substantial differences in the elasticities among markets, a patent policy that encouraged price discrimination in those circumstances would possess considerable social merit. Because patent policy is probably too crude an instrument to reflect differences in demand elasticity, a socially optimum patent policy would just endorse all price discrimination by patentees.

B. DISCRIMINATION IN THE DOMESTIC MARKET

Despite its merits, the United States and other nations have not always looked favorably upon price discrimination. In 1914, Congress directed section two of the Clayton Act against large firms that used price discrimination to drive their rivals from the market. Later, in 1936, Congress expanded section two in the Robinson-Patman Act in order to protect small retailers from aggressive price-cutting by chain stores who were able to secure their supplies at discriminatorily-favorable prices. In a series of legislative acts extending from 1916 to the present, Congress has sought to prevent or constrain dumping, or price discrimination on an international scale. Yet price discrimination is a way not only for a seller

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150 Pindyck & Rubinfeld, supra note 29, at 377.
151 Id.
152 Scherer & Ross, supra note 146, at 496.
153 Two provisions of European Union competition law are directed against price discrimination. Article 85(1)(d) of the Treaty Establishing the European Economic Community identifies agreements that "apply dissimilar conditions to equivalent transactions with other trading parties, thereby placing them at a competitive disadvantage" as particularly suspect. Treaty Establishing the European Economic Community, Mar. 25, 1957, art. 85(1)(d), 298 U.N.T.S. 11. Similarly, Article 86(c) identifies the application of dissimilar conditions to equivalent transactions by a dominant firm as behavior which constitutes an abuse of its position. Id. art. 86(c).
possessing market power to increase its own profits, but also (under the conditions identified above) to mute the anti-social effects of its power by expanding its own output and concomitantly reducing deadweight loss. Price discrimination is widely practiced in the United States in a variety of forms.\textsuperscript{157}

As pointed out above, the welfare loss from monopoly pricing is generally highest when the monopolist sells to all customers at a single price.\textsuperscript{158} This welfare loss is aggravated where the ratio between deadweight loss and profit is high. Yet if the monopolist were able to sell to different segments of demand at prices geared to those segments, that welfare loss might be significantly reduced. This Article will now examine the pricing of pharmaceutical products.

To a significant degree, price discrimination appears to reduce deadweight loss in pharmaceuticals within the United States domestic market. Indeed, even at a time when price discrimination was most disfavored, Congress recognized its potential good. Within two years after it enacted the Robinson-Patman Act to protect small businesses from large chain-store competition, Congress enacted the Nonprofit Institutions Act in order to ensure the legality of price discrimination in favor of nonprofit institutions.\textsuperscript{159} A major channel of distribution of pharmaceutical products involves so-called closed door sales to hospitals and other health care institutions for the use of their patients.\textsuperscript{160} In addition, pharmaceuticals are sold for a variety of prices to, or under arrangements with, wholesale drug chains, health maintenance organizations, and insurance companies.\textsuperscript{161} A wide variety of theorists view bargaining by these and similar organizations as a route for driving down pharmaceutical prices.\textsuperscript{162}

\textsuperscript{157} Pindyck & Rubinfeld, supra note 29, at 376.

\textsuperscript{158} The monopolist can reduce the welfare loss when the monopolist replicates (as far as it is able) first-degree price discrimination and (when market segments exhibit significantly different elasticities) third-degree price discrimination. See supra notes 146-52 and accompanying text.


\textsuperscript{161} See, e.g., United States v. Ferro, 252 F.3d 964, 967 (8th Cir. 2001); In re Brand Name Prescription Drugs Antitrust Litig., 186 F.3d 781, 783 (7th Cir. 1999).

C. DISCRIMINATION IN THE GLOBAL MARKETS

On the international marketplace, prices often vary substantially from jurisdiction to jurisdiction, and this price variation (or discrimination) may reduce global deadweight loss. Indeed, prices of pharmaceutical products vary widely, for example, among the nations in North America and among the nations in Europe. Recent proposals to alleviate perceived high pharmaceutical prices in the United States by allowing purchases of pharmaceuticals in Canada for use within the United States have drawn attention to different pricing in different national markets. Pharmaceutical prices are lower in Canada than in the United States because Canada exerts control over pricing through its Patented Medicine Prices Review Board. Pharmaceutical prices in the United Kingdom are generally lower than in Germany and the Netherlands because the U.K. government maintains an effective ceiling on their prices. Indeed, government policies on controlling pharmaceutical prices have varied substantially over the years within the European Union, giving rise to widespread arbitrage.

Keying prices of pharmaceuticals to market demand in different national marketplaces would appear to be a means of both increasing the availability of these products to people that need them and to increase the profits of the pharmaceutical companies. The most obvious impediments to this approach are:


(1) the possibility of arbitrage diverting discounted products back to Western markets and undercutting Western prices, and (2) engendering resistance to Western pharmaceutical prices as knowledge of the discount prices provided to third world countries spreads in the West.\textsuperscript{168}

D. ENCOURAGING PRICE DISCRIMINATION IN GLOBAL MARKETS

The economic interest of pharmaceutical manufacturers motivates them to sell their products in ways that maximize profits, and price discrimination may further that goal. As observed above, as the deadweight loss increases relative to the single monopoly price, price discrimination becomes ever more attractive to the seller and is likely to significantly reduce the social loss that results from a monopolistically set single price.

Similar issues are present on the international marketplace. Large variations in wealth between the developed, developing and underdeveloped nations means that there are vast disparities in the purchasing powers of their publics. Pharmaceutical companies could benefit if they were capable of selling at a range of prices keyed to each sector of demand.\textsuperscript{169} A major impediment to the implementation of such a program, however, is the potential for arbitrage.\textsuperscript{170} In Europe, where governmental interventions in markets have forced prices to comparatively low levels in certain national markets, arbitrageurs have seized the opportunities of purchasing in the low priced markets and exporting into high priced markets.\textsuperscript{171} Probably a major impediment to pharmaceutical companies selling at low prices in the underdeveloped or developing world is the potential for arbitrage that such sales would engender. Arbitrageurs would be likely to purchase at third world prices for re-export to the West for sale at North American or European prices.

Many commentators interested in increasing the availability of pharmaceuticals to third world nations have directed their attention to the problem of potential arbitrage, and to the potential for arbitrage to discourage low-price sales in third


\textsuperscript{170} See, e.g., Hammer, supra note 163, at 888-92.

\textsuperscript{171} See cases cited supra note 167 and accompanying text.
Most of these commentators have focused their attention on the impact of the first sale or exhaustion doctrine and on how a doctrine of international exhaustion would facilitate arbitrage. They have also directed their attention to provisions of the World Trade Organization (WTO) Agreement that prevent (or appear to prevent) governments from interfering with arbitrage operations. They have argued that in order to effectively prevent arbitrage in such situations, governments must be enlisted in the task. Purely contractual restrictions between the exporting pharmaceutical company and its third world customer may be inadequate, these critics have contended, to provide the needed protection. Even the customs service or health ministries of third world nations may not be up to the task. Rather, according to these commentators, what is needed is multi-governmental cooperation that involves the governments of the exporting nation, the importing nation, and the governments of all the nations that are potential recipients of re-exports.

To what extent does the WTO regime impede arrangements that might otherwise facilitate the delivery of patented pharmaceuticals to third world nations? This question cannot be answered without considering both the text of the Treaty, the Doha Declaration, and related developments. Considered by itself, the WTO does appear to bar the cooperation among nations that could effectively prohibit arbitraging of pharmaceutical products, as the critics have contended. Article XI of the General Agreement on Tariffs and Trade (GATT), incorporated into the WTO Agreement, prohibits any party to the Agreement from imposing quantitative restrictions on imports or exports. Accordingly, a simple reading

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173 See Hammer, supra note 163, at 888-92; Attaran, supra note 172, at 872; see also Darren E. Donnelly, Comment, Parallel Trade and International Harmonization of the Exhaustion of Rights Doctrine, 13 SANTA CLARA COMPUTER & HIGH TECH. L.J. 445, 453 n.40, 511-12 (1997) (concerning the first-sale or exhaustion doctrine).
175 Id.
176 Id.
177 Id.
178 Id.
179 See id. at 880-81.
180 GATT, supra note 174:
No prohibitions or restrictions other than duties, taxes or other charges, whether made effective through quotas, import or export licenses or other measures, shall
of the literal language of Article XI would, as those commentators have suggested, appear to prohibit inter-governmental cooperation designed to prohibit exporting pharmaceuticals from poor nations or to bar importation into wealthier ones. Yet, there is much more to be said.

First, Article 31 of the TRIPS Agreement permits governments to impose compulsory licenses on patent holders in the case of a national emergency or other circumstances of extreme urgency. At the time of the anthrax scare in the United States, the U.S. government considered using this power to compel licenses on Cipro, a patented antidote to anthrax, from Bayer, the German patentee. So did Canada. The HIV/AIDS epidemic, and other epidemics in third world nations would appear to allow countries to use this Article 31 authority to impose compulsory licenses upon patented pharmaceuticals that provided needed treatments.

Article 31, however, was drafted without consideration of the fact that many poor nations lack pharmaceutical manufacturing capacity. Compulsory licensing does not help when there are no potential domestic manufacturing licensees. Accordingly, in November 2001, the ministers of the WTO member states, meeting at Doha, issued the Declaration on the TRIPS Agreement and Public Health (Doha Declaration). This Declaration stated that the TRIPS Agreement “should be interpreted and implemented in a manner supportive of WTO members’ right to protect public health and, in particular, to promote access to medicines for all.” The ministers also recognized that WTO member nations lacking pharmaceutical manufacturing capabilities might experience difficulties in attempting to use the compulsory licensing provisions of Article 31. In so doing, they implicitly recognized that Article 31 had been drafted without taking into account that some nations lacked the productive resources to take advantage

be instituted or maintained by any contracting party on the importation of any product of the territory of any other contracting party or on the exportation or sale for export of any product destined for the territory of any other contracting party.

181 At least one commentator has also argued that discount sales to third world markets would be vulnerable to attack as dumping. See Attaran, supra note 172, at 882. Attaran admits, however, the government of the recipient nation would be unlikely to challenge low-priced sales that benefited its own citizens, at least when there was no domestic pharmaceutical industry able to supply the domestic market and when other equally low-priced sources of the product were unavailable. Id.

182 TRIPS Agreement, supra note 2, art. 31.


186 Id. ¶ 4.

187 Id. ¶ 6.
of its provisions. Accordingly, the ministers instructed the council for TRIPS to recommend a solution to the General Council of the WTO. On August 31, 2003, the General Council issued its decision. The General Council decision effectively allows nations to import patented pharmaceuticals from abroad to deal with national health emergencies, even though those pharmaceuticals had not been produced with the permission of the patentee. In other words, compulsory licensing would effectively extend to suppliers from abroad when the nation experiencing the health emergency lacked its own manufacturing capability. Since many of the nations experiencing HIV/AIDS health emergencies lack their own pharmaceutical manufacturing capability, the Doha Declaration and its implementation under the General Council decision have significantly corrected the unintended rigidity of the TRIPS language. But the Doha Declaration and the General Council decision also shed light on the arbitraging issues discussed in this Article.

In approving the use of compulsory licenses for foreign suppliers, the General Council took steps to ensure that the entire production of the product produced under those licenses would be applied to the national health emergency and that none would be diverted to other markets. The Council mandated that “only the amount necessary to meet the needs of the eligible importing Member(s) may be manufactured under the license and the entirety of this production shall be exported to the Member(s) which has notified its needs to the Council for TRIPS.” The General Council decision also required the exporting member to inform the TRIPS Council about the identity of the licensee, “the product(s) for which the license has been granted, the quantity(ies) for which it has been granted, the country(ies) to which the product(s) is (are) to be supplied and the duration of the license.”

And, “in order to ensure that the products imported . . . are used for the public health purposes underlying their importation,” the decision requires eligible importing members to “take reasonable measures . . . to prevent re-exportation.” The decision also requires all members “to ensure the availability of effective legal means to prevent the importation into, and sale in, their territories of products . . . diverted to their markets inconsistently with” these provisions.

186 Id.
188 Id. ¶ 2(b).
189 Id. ¶ 4.
190 Id.
191 Id. ¶ 5.
Second, it is unclear why contractual and licensing restrictions would not afford a degree of protection against arbitrage. The exporting pharmaceutical company could require, as a term of the sales agreement, that the purchasing firms or other organizations receiving the pharmaceuticals in the importing nation agree not to re-export and to take reasonable steps to ensure that its distributees avoid re-export.\footnote{The Patent Act grants the authority to assign rights to limited geographical parts of the United States. 35 U.S.C. § 261 (2002). Territorially limited patent licenses abroad are also generally upheld. See, e.g., United States v. Westinghouse Elec. Corp., 648 F.2d 642, 647-48 (9th Cir. 1981). On the extent to which license restrictions can constrain the actions of purchasers from those licensees, see Gen. Talking Pictures Corp. v. W. Elec. Co., 304 U.S. 175, 37 U.S.P.Q. (BNA) 357 (1938).} It is also possible that patents underlying these products could be employed as a base for licensing restrictions that effectively barred re-export.

Third, patent law may, in some circumstances, provide assistance in curbing or impeding arbitrage. Its usefulness depends in part upon the patent exhaustion or first sale doctrine, and how that doctrine is implemented in the nations involved, or potentially involved, in arbitrage. As that doctrine is reflected in U.S. law, a patentee exhausts its rights over a particular unit of a patented product after it has sold that unit.\footnote{See Ronald L. Yin, Hardware and Software Licensing Issues for the 1990s, 19 HASTINGS INT’L & COMP. L. REV. 691, 697-99 (1996) (discussing international exhaustion).} Thereafter the purchaser is generally free to resell that unit, as the purchaser pleases. This doctrine is reflected in the patent law of most other nations, producing similar results.\footnote{See Case 267/95, Merck & Co. v. Primecrown Ltd., 1996 E.C.R. 1-6285, ¶ 133.} But nations differ on how they treat sales abroad. Some nations follow a doctrine of international exhaustion, under which a sale anywhere in the world exhausts the rights of the patent holder over the units sold.\footnote{See Case 267/95, Merck & Co. v. Primecrown Ltd., 1996 E.C.R. 1-6285, ¶ 133.} The purchaser is then free to resell the product anywhere, including resales within the domestic market of the patentee. Other nations limit their use of exhaustion to their domestic markets.\footnote{See, e.g., Adams v. Burke, 84 U.S. (17 Wall.) 453, 456 (1873); Curtiss Aeroplane & Motor Corp. v. United Aircraft En’g. Corp., 266 F. 71, 78 (2d Cir. 1920).} In these nations, a domestic sale would exhaust the patent holder’s rights over units sold in the domestic market, but a sale abroad would not give the purchaser a right to resell in the domestic market. In the past, U.S. courts tended to apply exhaustion to unrestricted sales abroad by a U.S. patentee or a party in privity with a U.S. patentee.\footnote{See Case 267/95, Merck & Co. v. Primecrown Ltd., 1996 E.C.R. 1-6285, ¶ 133.} Recently, however, the Federal Circuit has ruled that for exhaustion to apply, “the authorized first sale must have occurred under the United States patent,” a view that appears to embrace a domestic, rather than international, view of
exhaustion.\textsuperscript{200} Even under the traditional approach, international exhaustion was of limited scope: When foreign sales of a patented product are conditioned upon their exclusion from the United States, courts have barred their importation.\textsuperscript{201} In addition, the cases have generally refused to apply international exhaustion to the detriment of a rights holder under a U.S. patent where the foreign sales were made without the latter's consent.\textsuperscript{202} The European Union follows a policy under which sales within any member state of the Union exhaust a patent holder's rights.\textsuperscript{203} After such a sale, the units sold may be resold anywhere within the Union. A sale outside of the Union, however, does not confer on the purchaser a right to resell within the Union.\textsuperscript{204} Differentially priced sales within different member states of the Union are vulnerable to arbitrage but it is not clear whether low priced sales of patented products outside the European Union create a potential for export back into the Union. To the extent that arbitrageurs sought to re-export pharmaceuticals to nations that followed a doctrine of international exhaustion, patent law would not provide a means for making such re-export unlawful. Although commentators focus considerable attention on the first sale doctrine and issues of international exhaustion, these legal issues are not necessarily the key to preventing arbitrage.

Fourth, the patent law itself contemplates the imposition of territorial limitations. While the law speaks to territorially limited assignments of rights within the United States,\textsuperscript{205} it is also clear that a patentee may grant territorially limited licenses.\textsuperscript{206} Of course, once a licensee makes a lawful and unconditional sale to a third party, the third party can deal freely with the unit that it has purchased. If the sale takes place abroad, then the ability of the third party to export to the United States raises issues of exhaustion. But if the patentee conditions the right of the licensee to sell for use solely within the jurisdiction in

\begin{footnotes}
\footnotetext{200}{Jazz Photo Corp. v. Int'l Trade Comm'n, 264 F.3d 1094, 1105, 59 U.S.P.Q.2d (BNA) 1907, 1914 (Fed. Cir. 2001).}
\footnotetext{201}{See Dickerson v. Tinling, 84 F. 192, 194-95 (8th Cir. 1897); Dickerson v. Matheson, 57 F. 524, 527 (2d Cir 1893).}
\footnotetext{203}{Case 267/95 Merck & Co. v. Primercrown Ltd., 1996 E.C.R. I-6285.}
\footnotetext{204}{See Case 270/80, Polydor Ltd. v. Harlequin Record Shops Ltd., 1982 E.C.R. 329 (concerning copyright infringement, and suggesting how EU authorities would treat international exhaustion issue involving patent).}
\footnotetext{206}{See Prima Tek II LLC v. A-Roo Co., 222 F.3d 1372, 1377, 55 U.S.P.Q.2d (BNA) 1742, 1745 (Fed. Cir. 2000) ("Section 261 recognizes, and courts have long held, that an exclusive, territorial license is equivalent to an assignment.").}
\end{footnotes}
which the licensee is located, then a sale by the licensee so conditioned does not convey unrestricted title to the purchaser. 207

In a case in which a United States patentee delivers goods to a distributor located in a particular third world nation for distribution to users within that nation, the legal analysis would be similar. The goods would be delivered to the distributor conditioned on its selling only to local users. 208 Sales beyond the mandate of the license would be unlawful, and would not confer first-sale rights on the purchaser, at least not to those aware of the license limitations. 209

Finally, a rather obvious means for a pharmaceutical company to sell its products at low prices in a poor nation while impeding potential arbitrage would be to limit the volume of sales to estimates of local demand. 210 The principal problem would lie in obtaining accurate estimates. But the companies' own marketing experiences both in the target market and in other similar markets may prove helpful. In addition, governments in the target markets would probably be willing to assist in the estimates of local demand. In cases where the importer was a government or government-controlled distributor, advance estimates of demand might be unnecessary. In these cases, the governmental interest would lie in ensuring that manufacturers routed the purchased drugs to the patients who needed them, and, in order to ensure the delivery of drugs in the future, to take steps to discourage arbitrage. Patent law would support this scenario indirectly, since by ensuring that the patentee is the only source of the product, it ensures the effectiveness of the patentee's limitation on export volumes.

VI. CORRECTING THE WEAKNESSES OF THE PATENT SYSTEM

The most apparent weakness of the patent system in performing its function of fostering invention lies in the deadweight losses that this system generates. Generally, these deadweight losses are a modest price for encouraging invention. Indeed, since there is no deadweight loss at all without the development of both: (1) a new product, and (2) one for which there is a demand, these losses are a measure of technology growth. To the extent that the exclusivity conferred on a patentee is necessary to generate an invention, the resulting deadweight loss is not a social loss at all. Yet as discussed above, to the extent that exclusivity is

208 Id.
209 Id.
210 See, e.g., Case C-2/01, Bayer AG v. Comm'n of the European Cmtries. (Jan. 6, 2004) (stating that a pharmaceutical company lawfully limited its sales to estimates of local demand in order to forestall arbitrage).
unnecessary (as, for example, by extending longer than necessary), it can become a social cost.

The pharmaceutical industry provides an example of where deadweight losses may be large when measured on a global scale. Thus the pharmaceutical industry may be more of a candidate for revealing the weaknesses of the patent system than other industries. It is possible that the usefulness of the market for supplying information about needs to prospective inventors is at its lowest in the sector of the pharmaceutical industry that is concerned with the development of remedies for widespread life-threatening disease. It is a matter of common knowledge that cures are needed for diseases afflicting large populations. Thus, the close interaction between the patent system and the market pharmaceutical industry may be less socially advantageous in this sector of the pharmaceutical industry than in other industries: Here, market-based information is less needed, and the patent system's market-based incentives carry a potential for generating unduly high deadweight losses.\footnote{The pharmaceutical industry also reveals other dysfunctions connected with the patent system. As observed in Part I of this Article, prices of patented pharmaceuticals reflect the exclusive rights that the patent system confers upon their patentees. See \textit{supra} note 13 and accompanying text. Consumers complain that these prices are unduly high, but exclusive patent rights are designed to produce such prices. If those prices are high, that is the result that the patent system contemplates. High prices generate the incentives necessary to stimulate inventive activity. Yet when the government responds to consumer dissatisfaction by subsidizing purchases of patented pharmaceuticals, the prices of these products will tend to rise. Government subsidization of consumers increases demand and thus price. This subsidy to consumers ultimately results in a subsidy to the pharmaceutical producers. If, as is likely, the amended Medicare Act generates higher pharmaceutical prices in the United States, the international problem is likely to be exacerbated unless the patentees sell at discounted prices in poor countries. See \textit{Medicare Prescription Drug, Improvement, and Modernization Act of 2003}, Pub. L. No. 108-173, 117 Stat. 2066 (2003). Purchasers in poor countries now complain that they are priced out of the market. When U.S. prices rise further, the gap between U.S. prices and affordable third world prices will increase. As argued above, however, the gap between U.S. and third world prices need not deprive third world publics of patented pharmaceuticals, so long as the patentees are willing to set prices in third world markets targeted to the demand within each market. See \textit{supra} note 169 and accompanying text.}

These considerations raise the question of whether another form of financing for developing of lifesaving pharmaceutical products would be desirable. Public funding of such development, if successful, would generate the larger aggregate welfare since there would be no patents and hence no deadweight losses. But, to raise the question of public funding is also to raise the question of who would ultimately pay for that public funding. That question, in turn, leaves unanswered the question of who pays for the development of pharmaceutical products today. The answer to the latter question is that although pharmaceuticals are paid for by the publics of Western nations, the bulk of the financial contribution comes from
Prices are higher in the United States than elsewhere. Moreover, although the U.S. government does not pay list prices for pharmaceutical products, it nonetheless subsidizes them in its Medicaid program and, under recently enacted legislation, will now subsidize them in its Medicare program. In short, the U.S. public, through purchase prices, insurance premiums, and taxes, pays a disproportionate part of the research and development cost for new pharmaceutical products.

To raise the possibility of public funding for lifesaving pharmaceutical products also raises the question of whether that public funding should be shared by all or most of the world's nations. The entire world benefits, or potentially benefits, from pharmaceutical research. Some formula, perhaps keyed to each nation's gross domestic product or to its per capita income might produce both a more equitably shared source of financing and a major advance in global welfare. The result, of course, would be that Western nations would make the largest contributions. This result mimics the present system in which U.S. consumers pay the highest prices, Canadian and European consumers pay lower prices, and the lowest prices are paid by consumers in those poor countries where the pharmaceutical companies sell at discount prices. This financing arrangement, however, would have the advantage of transparency, open bargaining, and an agreed-upon distribution of the burden. The extent to which other Western nations free ride upon U.S. consumers' support of research and development would probably fall. The public funding of research would dispense with patent rights and the deadweight losses that accompany their exercise. Global welfare would advance substantially. Discontent in the third world over patent policies that prevented or impeded their publics from treatments available elsewhere would be reduced. And a by-product of this reduced discontent would be the strengthening of TRIPS.

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214 Although U.S. consumers and taxpayers bear the burden of supporting pharmaceutical research, existing U.S. policy may confer certain advantages on American producers. See The Trouble with Cheap Drugs, Economist, Jan. 31, 2004, at 59-60.