To speed innovation and increase human welfare, law should provide a framework for open competition among innovators with high profits for the winners. High profits especially come from the innovators’ market power, which is the power to affect prices. The first firm to develop and market an innovation often enjoys market power temporarily (the “first mover’s advantage”), which is a form of natural monopoly. Secrecy often extends the innovator’s market power by slowing the discovery’s dissemination to competitors. Patents and copyright that shield innovators from competition create market power by legal fiat. These three sources of market power -- natural monopoly, private information, and legal fiat -- especially relate to three bodies of law: antitrust, trade secrets, and intellectual property. This chapter concerns the third source of market power for innovators -- intellectual property law.

Article 1 Section 8 of the U.S. constitution reads:

“The Congress shall have power…To promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries…”

The “useful arts” mentioned in Article 1 Section 8 form a heterogeneous collection of activities. To measure “progress” requires combining the activities into an index. A comprehensive measure of economic growth is often the best index of progress in the useful arts. Thus Article 1 section 8 authorizes Congress to promote economic growth through intellectual property law.

Congress asserted its constitutional power by enacting Title 35 Sections 100-105 of the United States Code. The constitution and much of the code is general and abstract. Regulations and court decisions increase the precision and certainty of these laws. In the U.S. where courts justify their interpretations by reference to prior court interpretations, much intellectual prop-

property law is “judge-made”. Economic growth provides a useful standard for interpreting and critiquing intellectual property law made by Congress and courts. The separation from Chapter 4 and fertility principle from Chapter 5 contribute to interpretation and critique, especially where innovations can grow exponentially.

This chapter applies the separation and fertility principles to innovations that can grow exponentially, so the effects of growth on human welfare overtake other effects. Patented inventions can grow exponentially. So can some copyrighted expressions such as computer programs, as well as some innovations covered by special statutes.\(^2\) In contrast, cultural expressions (novels, songs, plays) evolve and develop, but these changes do not constitute exponential growth on a generally accepted measure such as cost-benefit analysis or market value. Compared to economic growth, any attempt to measure progress in artistic expression immediately encounters deep disagreements over cultural values.

The patent or copyright for inventing a machine, creating a molecule, extracting a vaccine, or writing a computer program can be weak or strong. The separation principle distinguishes infringement by innovators from infringement by consumers or producers. Patent protection should be strong against infringers who consume the invention or produce with it. According to the fertility principle, patent protection should be weak or absent against users who innovate with it in the usual cases. In exceptional cases, however, patents should be strong against other innovators where the patented invention is more fertile than the innovation for which it is used.

**Strength**

We will develop the theory and application of the optimal strength of intellectual property law. The strength of intellectual property rights depends on three attributes: duration, breadth, and remedy. The duration of a patent can be measured in years. Thus U.S. patent duration is 20 years from the date of filing the patent application.\(^3\) When filing, the applicant and her patent attorney make claims about the innovation’s breadth. The patent office and

\(^2\) The Semiconductor Chip Protection Act of 1984, which legally protects the layouts of integrated circuits, exemplifies such special statues.

\(^3\) Before 1995, U.S. patent duration was 17 years from the date the patent issued.
the courts ultimately decide the validity of these claims. Breadth is easier to order than to measure. Thus a patent covering rain gear is broader than a patent covering umbrellas, and a patent covering umbrellas is broader than a patent covering automatically opening umbrellas. While one patent can be broader or narrower than another, there is no natural measure of the difference in breadth.4

Taken together, the duration and breadth of an intellectual property right define its scope. Acting within the scope of a patent or copyright without a license from the owner infringes it. Law usually provides a remedy for infringement. For past infringements, the owner can usually sue to recover compensatory damages. Higher damages (“super-compensatory”) are allowed sometimes. For future infringement, the owner can usually enjoin the infringing conduct.5

4 Patent breadth resembles the alphabet. Letters A through N encompasses more letters than A through M, but there is no natural measure of the distance between M and N. Similarly, no natural measure exists to answer the question, “Is the difference in breadth between a patent on rain gear and a patent on umbrellas larger or smaller the difference in breadth between a patent on umbrellas and a patent on automatically opening umbrellas?” In this respect, patent breadth contrasts with height. One person is taller than another and the difference can be measured in centimeters.

5 Note that money measures damages like years measure duration, whereas breadth orders (but does not measure) injunctions like patent claims order their breadth.
In addition to increasing the strength of individual patents, the patent system as a whole can strengthen against unpatented activities. Figure 6.1 divides future innovations into “ownable” and “unownable.” A new computer chip is ownable (patentable) and a new metaphor in the English language is unownable (no patent, no copyright). The strength of all patents indicates the patent system’s reach, as illustrated by the boundary between ownable and unownable innovations in Figure 6.1. Thus shifting the boundary in Figure 6.1 from R to R increases ownable innovations and decreases unownable innovations. To illustrate, U.S. patent law increased its reach when inventors were allowed to patent business processes for the first time, such as Amazon’s “one-click” ordering from its online catalogue. Expanding patent law’s reach fences in more of the common land of innovation.

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6 This is a picture, not a graph, because the breadth of innovations has no natural measure. See the discussion in this chapter of the difference between an ordering and an index.

7 Increases in the scope of a particular patent do not necessarily increase the scope of patents as a whole. Rather, the scope of a particular patent can increase by decreasing the scope of another patent. Instead of fencing more of the common land of innovation, the fence between patent holders moves to the advantage of one of them and to the disadvantage of the other, as with the boundary between α and β in Figure 6.1.
Besides strengthening the patent system against unpatented activities, patent law can strengthen one patent by weakening another. The space of innovations represented by the small circle in Figure 6.1 is subdivided into $\alpha$ and $\beta$. Assume that firm A invents $\alpha$ and firm B subsequently invents $\beta$. A claims that $\alpha$ and $\beta$ are a single invention and A files for a patent covering both of them. Later B files for a patent for $\beta$ and claims that $\beta$ is a different invention from $\alpha$. The patent office must decide whether to award a broad patent to A that covers $\alpha$ and $\beta$, or to award a narrow patent to A that covers $\alpha$ and a narrow patent to B that covers $\beta$. For a given space of inventions, the state can generally give few broad patents or many narrow patents, rather like a city planner can divide undeveloped land into a few large lots or many small lots.\(^8\)

# How Strong?

What reach and strength (breadth, duration, and remedy) of intellectual property rights maximizes innovation? The answer is remarkably simple. Maximizing innovation requires transferring resources from consumption and production to innovating. According to the separation principle (Chapter 4), an innovator should have a strong patent against others copying the innovation to sell to consumers, such as a smart phone application. An innovator should also have a strong patent against others producing consumer goods by using the innovation, such as industrial robots that manufacture cars. Applied to the strength of intellectual property, the separation principle asserts that the innovator’s rights against others consuming it or producing with it should be strong -- broad and long with a generous remedy for infringement.\(^9\)

Besides producing and consuming, some innovations need prior innovations like a carriage needs wheels. When a prior innovation is owned, the owner usually has market power against a subsequent innovator who needs a license

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\(^8\) Once lots are surveyed in a new town, owners can sell a lot but not half of a lot. The owner who cannot sell half of a lot can lease it for use by someone else. Much the same is true for selling patents. An owner cannot sell half of a patent, but an owner can contract for someone else to use half of it. Some theorists think that divisibility is the essential difference between property rights and contract rights. See Thomas A. Merrill & Henry Smith, “Optimal Standardization in the Law of Property: The Numerus Clausus Principle,” 110 Yale Law Journal (2000).

\(^9\) Economists may wish to compare broad patents and broad taxes. Economists favor broad taxes because the demand for broad categories of goods is less elastic than the demand for narrow categories of good, so the deadweight loss is smaller. Similarly, the demand for broad patents is less elastic the demand for narrow patents, so the deadweight loss is smaller and the transfer from buyers to sellers is larger.
to use it. Market power of innovators against each other imposes a dead-
weight loss on all of them, which slows innovation and growth. This fact
argues that innovators should have weak intellectual property rights against
each other, or none at all.

Chapter 4 described four forms of deadweight loss and their likely extent.
Creating market power for an innovator causes a large deadweight loss when
the patented good has close substitutes (high elasticity of demand),\(^\text{10}\) few
obstacles to resale (no price discrimination),\(^\text{11}\) the innovation is complex and
opaque (incomplete information for buyers),\(^\text{12}\) and many buyers purchase
small amounts of the good.\(^\text{13}\) These conditions argue that innovators should
have weak intellectual property rights against each other, or none at all.

To apply the separation principle, lawmakers and courts must distinguish the
uses of an innovation into consuming, producing, and innovating. In many
cases, the distinction requires non-technical judgments of the kind that
courts routinely make without statistics or mathematical theories. Common
sense usually suffices, but difficulties arise at the boundaries of these three ac-
tivities. In hard cases, economists can assist by drawing on their long history
of distinguishing these three activities. Economists can also assist by predict-
ing the effect of different distinctions on the goal underlying the separation
principle: maximizing innovation.

Legal application of the separation principle can mimic licensing practices by
some firms owning fundamental inventions like computer platforms. Apple
allows developers of applications to use the iPhone platform for free, whereas
consumers must pay a fee for using many of the resulting applications. Thus
Apple separates innovation from consuming, and asserts weak rights innovat-

\(^{10}\) Goods are substitutes when having more of one makes a person demand less of the other.
When a good has close substitutes, raising its price (while keeping other prices constant) causes
buyers to switch to the substitute. Switching costs are a deadweight loss.

\(^{11}\) With few obstacles to resale, the owner cannot charge different prices to different buyers for
the same innovation. Price discrimination is impossible. The more the seller can discriminate
among buyers, the less the buyers will switch in response to a price increase, so the deadweight loss of
switching falls. This is an application of the proposition found in microeconomics textbooks that a
perfectly discriminating monopolist is efficient.

\(^{12}\) As a good becomes more complicated and opaque, the amount of bargaining increases, and so
do the search costs of determining whether an innovation is already patented.

\(^{13}\) Transactions costs of purchases often have economies of scale. Consequently, the transaction
cost of market exchange is higher with many buyers make small purchases than when few buyers
make large purchases.
ing and strong rights against consuming. Similarly, Sun Microsystems developed the Java programming language in the 1990s and made it available for free to developers under a general-purpose license.\textsuperscript{14} Developers use Java to write programs that they sell to consumers.\textsuperscript{15} Thus Java is free for innovators and costly for consumers of its applications.

As explained, the overtaking principle and the deadweight loss from monopoly argue for weak intellectual property rights of innovators against each other. However, an argument in the opposite direction applies when innovations differ significantly in fertility. By definition, \textit{costless} transfers (no deadweight loss) from less to more fertile innovations increase the rate of innovation and growth. Stronger intellectual property rights for more fertile innovations transfer wealth away from less fertile innovations. In transactions among innovators, relatively greater fertility favors relatively stronger intellectual property rights.

As explained, deadweight losses argue against market power for innovators against each other, and greater fertility argues in favor of market power for some innovators against others. Maximum growth requires balancing these considerations. \textit{The fertility principle asserts that the ideal balance is struck when further strengthening of property rights of fertile innovations causes growth to decrease from greater deadweight loss by the same amount as it increases from greater fertility.} Equivalently, the innovator’s rights are ideally strong against others using it for less fertile innovations when further weakening increases growth from lower deadweight loss by the same amount as it decreases growth from lower fertility.

\section*{Applications}

To maximize progress in the useful arts, intellectual property law should apply the separation and fertility principles. The separation principle favors giving innovators strong rights — broad, long, and with a generous remedy for infringement -- against others consuming the innovation or producing

\textsuperscript{14} A reverse of this pattern sometimes occurs. Thus when the owner of a platform for running computer games allows consumers to use it for free and charges developers who want to use it to create new games to sell to consumers.

\textsuperscript{15} Legal disputes subsequently arose when Microsoft modified java to run exclusively on its Windows program, thus necessitating the use of Windows to run programs written in the modified java language.
with it. The fertility principle usually favors giving innovators weak rights or no rights against others using the innovation to make subsequent innovations. In unusual case of especially fertile innovations, an innovator’s rights against others using the innovation to make subsequent innovations should balance incentives for fertile innovations and the deadweight loss from stronger property rights. We will apply this general theory to intellectual property’s strength as indicated by reach, breadth, duration, and remedy.

**Reach: Invention or Discovery**

The boundary between owned and unowned innovations defines the intellectual property system’s reach as depicted in Figure 6.1. Courts and regulators have attempted to draw the boundary in various ways. One line of cases distinguishes inventing and discovering. To be patentable in U.S. law, an innovation must be an invention, but inventions often involve discoveries about nature. A fault-line of legal dispute concerns the difference between patentable inventions and unpatentable discoveries about nature.

To illustrate, the inventors of the telegraph in the 19th century attempted to patent the use of the electromagnetic spectrum to transmit messages. In *O’Reilly v. Morse*, the U.S. Supreme Court decided that the telegraph’s inventors could patent a particular machine to transmit messages by using the electromagnetic spectrum, but not all ways of doing so. The electromagnetic spectrum is unpatentable, like the laws of nature and observations of physical phenomena.\(^{(16)}\) A similar conclusion concerns DNA sequencing. Does the first person to observe a DNA sequence acquire the exclusive right to observe it? In *Myriad Genetics* (2013) the U.S. Supreme Court unanimously decided “No”. Inventions can be patented, but not discoveries of natural laws and facts.

How does this legal distinction square with the separation and fertility principles? The separation principle favors strong patent protection over static activities (consuming and producing) and weak or no patent protection over dynamic activities (innovating). The telegraph was the first device to use the electromagnetic spectrum to transmit messages, and many others followed, including telephones and computers. The patent for the telegraph gave its inventor’s temporary market power over transmitting messages by using the electromagnetic spectrum.

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\(^{(16)}\) The court recently sustained this view in *Bilski* (2010).
electromagnetic spectrum. The patent was strong against telegraph transmissions, which mostly concern consumption and production. However, the patent was absent against subsequent inventions that transmit message by using the electromagnetic spectrum like telephones. So the breadth of the patent for the telegraph was consistent with the separation principle and it created strong incentives to innovate, not obstacles to it.

The separation and fertility principles broadly favor the patentability of inventions and the non-patentability of discoveries of natural laws and facts. Easy cases can follow common-sense distinctions, and hard cases can look to evidence about locating the boundary to maximize economic growth. An example of a hard case concerns whether diagnostic devices in medicine are inventions or observations of nature. Diagnostic devices are used to treat patients (consumption) and to conduct medical research (innovation). The separation and fertility principles commend a different standard of “infringement” for medical treatment and medical research.

To speed innovation, the separation and fertility principles argue for patent coverage of patient treatments, which implies that unlicensed use of a diagnostic device to treat a patient infringes the patent. The patent will increase the cost of treatment, and patients will lose from higher prices in the short run, but, according to the overtaking theorem in Chapter 1, patients will gain more from faster innovation in diagnostic devices. The conclusion is different for research as opposed to treatment. To speed innovation, the fertility principle argues against patent coverage for research, which implies that unlicensed use of a diagnostic devices to make medical innovations does not infringe the patent. The law follows these prescriptions imperfectly. In *Prometheus* (2012) the U.S. Supreme Court disallowed the patenting of diagnostic devices (and also surgical methods) without distinguishing between treatment and research. In pharmaceuticals, however, the law follows the separation principle and allows a “research exemption,” as we will discuss shortly.

The preceding discussion of “reach” mostly concerns the difference between inventing and discovering. To be patentable in U.S. law, an innovation must be an invention, not a discovery of a natural phenomenon. In addition, it must be useful. For most patent applications, the authorities presume that the invention is useful without weighing the arguments. In unusual cases
that weigh the arguments, some commentators doubt that an invention has utility if its only use is to generate more inventions. This reasoning is confused. A fertile innovation promotes “progress” in the “useful arts” even if it is not used in consumption or production. Progress in the useful arts is the constitutionally recognized purpose of intellectual property law. Thus fertility is a constitutionally recognized form of utility, not a suspect category.

Besides being useful, U.S. patent law requires an invention to be new. An invention is new if it is unknown to the public and not obvious. The most important disputes about novelty concern whether one innovation is sufficiently different from another to justify a separate patent. The breadth of patents is our next topic.

**Breadth**

In Figure 6.1 the patent authorities could issue one broad patent to A that encompasses both α and β, or a narrow patent to A for α and a narrow patent to B for β. Are α and β sufficiently similar to justify one patent, or are they sufficiently different to require two patents? Common sense understanding of it and engineering facts give the answer in most cases, but not in the hard ones. Resolving hard cases requires connecting legal rules to their purposes. The constitutional purpose of intellectual property law in the U.S. is promoting progress in the useful arts, which economic innovation measures.

Connecting patent breadth and growth requires understanding how economists measure similarity in goods. Economists regard two goods as similar if they are substitutes in markets, which implies that people will buy whichever one is cheaper, and not buy the dearer one (high cross-elasticity of demand). The breadth of patents affects innovation partly through the substitutability of goods. If α and β are close substitutes for each other, and if no close substitutes exist for them, then one broad patent will create a monopoly and two narrow patents will create a duopoly. Compared to duopoly, a monopoly can charge at least as high prices and extract at least as much wealth from buyers. So one broad patent for A covering α and β transfers at least as

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17 Duopolists sometimes cooperate perfectly with each other, or they merge. In that case, they maximize their joint profits and earn the same profits as a monopolist. More often, however, duopolists cooperate imperfectly with each other and do not monopolize their joint profits. So the profits of a monopolist are at least as high as a duopolist for the same product.
much wealth from buyers to the owner A as two narrow patents transfer to the owners A and B.

When goods are substitutes, their use determines whether transferring wealth from buyers to sellers increases or decreases incentives for innovation. If innovations $\alpha$ and $\beta$ mostly have static uses (-consuming and producing), then one broad patent will transfer more wealth from static to dynamic activities than two narrow patents, which increases the incentive to innovate. Thus the separation principle favors broad patents for innovations that substitute in consumption or production. Conversely, if innovations $\alpha$ and $\beta$ are substitutes and they mostly have dynamic uses (innovating), issuing two narrow patents will impose less deadweight loss on innovating, which increases the incentive to innovate.

In hard cases, the connection between similarity as measured by substitutability and incentives for innovation can often provide definite answers about the optimal patent breadth. The separation principle favors broad patents for substitutes in consumption and production. The fertility principle usually favors narrow patents for substitutes in innovation. However, in the exceptional case the fertility principle favors broad patents for very fertile substitutes in innovation.

Demand for two goods is independent if the price of one does not affect how much people will pay for the other (zero cross price elasticity). Independent goods are dissimilar economically. Intellectual property law cannot increase the market power or profitability of innovating by issuing broad patents encompassing independent inventions. Thus when demand for $\alpha$ is independent of demand for $\beta$, owning the patent on $\beta$ does not increase the profitability of owning the patent on $\alpha$. Since independent goods are dissimilar, broad patents do not increase the incentive to innovate. The breadth of intellectual property makes little difference to market power created by patents for independent innovations. The patent authorities should issue narrow patents for inventions of independent goods.

Table 6.1 summarizes these conclusions about use, substitution, and preferred patent breadth.
Table 6.1. Preferred Patent Breadth

<table>
<thead>
<tr>
<th>Use</th>
<th>Substitutability</th>
<th>Close substitutes</th>
<th>Independent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>strong patent</td>
<td>weak patent</td>
</tr>
<tr>
<td>consuming or</td>
<td>(broad preferred to narrow)</td>
<td></td>
<td>(narrow preferred to broad)</td>
</tr>
<tr>
<td>producing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>innovating, usual case</td>
<td>weak patent</td>
<td>weak patent</td>
<td>weak patent</td>
</tr>
<tr>
<td></td>
<td>(narrow preferred to broad)</td>
<td></td>
<td>(narrow preferred to broad)</td>
</tr>
<tr>
<td>innovating, very fertile case</td>
<td>strong patent</td>
<td>strong patent</td>
<td>weak patent</td>
</tr>
<tr>
<td></td>
<td>(broad preferred to narrow)</td>
<td></td>
<td>(narrow preferred to broad)</td>
</tr>
</tbody>
</table>

This reasoning applies to a series of suits that Apple brought against Samsung beginning in 2011 for infringement of design patents for the iPhone and iPad. For smart phones and tablets, Apple was the original innovator and Samsung was the imitator. Samsung’s strategy was to build close substitutes to the originals and to make small improvements. By imitating, Samsung saved development costs, so Samsung built substitutes at lower cost and sold them to consumers at lower prices. Consequently, Samsung’s share of the smartphone market increased at Apple’s expense.18

The legal question is whether Samsung infringed Apple’s patents. Table 6.1 provides an answer by relating preferred patent breadth of substitutes to their use. In so far as Samsung mostly used Apple’s innovations to make consumer goods, the separation principle favors strong protection. Strong protection will reward innovation and speed progress in the useful arts. In so far as Apple’s innovations were fundamental and Samsung’s innovations were derivative, the fertility principle also favors strong protection of Apple’s patents against Samsung. Again, strong protection will reward fertile innovation and speed progress in the useful arts. However, in so far as Samsung mostly used Apple’s innovation to make its own innovations of similar fertility, the fertility principle favors weak protection of Apple’s patents against Samsung. Weak protection will reduce the deadweight loss on innovation and speed progress in the useful arts.

Samsung’s liability to Apple ideally depends on the extent to which Samsung’s smart phones and tablets embody its own fertile innovations. Samsung’s de-

vices appear to use Apple’s designs mostly to increase consumer sales, and Samsung’s innovations appear to be derivative. If these appearances are the deeper truth, then Apple’s patent protection should be strong against Samsung. Liability of Samsung to Apple will promote faster growth in the future by causing Samsung to devote more of its formidable technological prowess to fundamental inventions and less to imitations.

We have discussed the alignment between patent breadth and the separation principle. For the pharmaceutical industry, an important exception to U.S. patent law aligns them closely. Firms that develop a new drug need regulatory approval before marketing it in the U.S. To gain regulatory approval, the drug’s owner must prove that it is effective and safe. Proof often requires research on other chemically related drugs, including rivals for the same market. The owner of a drug has reason to refuse to license its use by a rival. A legal exemption (“Hatch-Waxman”) allows firms to use patented drugs for research on regulatory compliance without a license from the patent’s owner. Instead of obtaining permission to license the patented drug at the price demanded by the owner, the innovator can use the drug and pay a royalty set by legal authorities. In the language of property rights, the innovator can “take” the patentee’s property right by paying an “objective price” set by the court, rather than having to pay the “subjective price” demanded by the patent’s owner.

The research exemption for pharmaceuticals discriminates between using an innovation for innovating and using it for consumption or production, as prescribed by the separation principle. The research exemption for pharmaceuticals should ideally generalize and extend to other industries. Unfortunately, a recent case on research by universities went in the opposite direction.19

**Duration**

Next, apply the separation and fertility principles to the duration of a patent. The horizontal axis in Figure 6.2 indicates the length of patents in years, and the vertical axis indicates the rate of innovation. The curves in Figure 6.2 depict some possible relationships between the rate of innovation and patent length. For curve A, the rate of innovation is an increasing function of

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19 Universities were traditionally exempted from the legal requirement to license patented inventions for use in research in laboratories. This traditional research exemption was eliminated in …
patent length. Curve A depicts an industry where innovators sell mostly to consumers and producers, such as pharmaceutical drugs. For a curve like A, optimal patent length is infinite for patents against consuming and producing an innovation.\textsuperscript{20}

For curve C, the rate of innovation is a decreasing function of patent length. Curve C depicts an industry where innovators of similar fertility sell mostly to each other. In Curve C the dominant effect of longer patents is to transfer wealth among dynamic users without regard to fertility. The deadweight loss from the transfers slows innovation.

Curve B depicts the intermediate case in between the pure cases of Curve A and Curve C. In the intermediate case, strengthening weak intellectual property rights increase the rate of innovation at first, but a point is reached where further strengthening decreases innovation. In Figure 6.2, the optimal patent duration of patents is internal, not infinite as for curve A or zero as for curve C. In the intermediate case, moderately strong intellectual property rights maximize the rate of innovation.

\textsuperscript{20} Landes and Posner advocate patents of infinite length, which we favor for patents against consuming and producing, but not for patents against innovating. CITE;
Curves A, B, and C in Figure 6.2 depict three possible relationships that often exist between the rate of innovation and the duration of intellectual property rights. (We will not discuss other possible shapes.) For curves with these shapes, a simple rule leads to the maximum: Starting from 0, increase the strength of intellectual property rights so long as venture profits increase. The maximum occurs at infinity for curve A, zero for curve C, and an interior point for curve B.

The ideal patent system grants patents of different length according to the product’s growth profile as in Figure 6.2. German patent authorities issue “petty” patents of short duration for minor inventions, and “full” patents of longer duration for major inventions. In contrast, American patent law issues full patents for all patented inventions. Does the German or American patent regime come closer to this ideal? For inventions mostly sold for producing and consuming, full patents will transfer more wealth from static to the dynamic uses. Consequently, American patent law is closer to the ideal than German patent law for innovations mostly used for consuming and producing. In contrast, for innovations mostly sold for innovating, the ideal law issues strong patents to fertile inventions and weak patents to sterile

21 Curve B is a concave function with a unique maximum. Another possibility is a convex function with two local maxima, one for weak intellectual property rights and one for strong intellectual property rights. Another possibility is multiple equilibria. For analyzing many activities, economists assume a concave function with a unique maximum.
inventions. A stronger patent for fertile innovations and a weaker patent for sterile innovations transfer wealth from the latter to the former in accordance with the fertility principle. In so far as German patent authorities issue “full” patents to fertile inventions and “petty” patents to sterile inventions, German patent law is closer to the ideal than American law for innovations mostly used for innovating.

The international default standard for patent duration, which the U.S. has adopted, is twenty years from the date of the application for a patent. Quantitative research on the optimal duration of intellectual property rights has barely begun. No compelling evidence indicates whether the pace of innovation would increase from lengthening or shortening the duration, or from distinguishing between petty patents and full patents. According to U.S. law, copyright endures for the creator’s life plus 70 years.22 Many scholars believe that this is far too long. The shadow of dead writings apparently inhibits creativity. A U.S. statute on semiconductor protection possibly has a better rule. The Semiconductor Chip Protection Act of 1984 (or SCPA) legally protects the layouts of integrated circuits for 10 years from registration.23

**Optimal Remedy**

Patent law provides damages for past infringements. Three benchmarks for damages are compensation, disgorgement, and treble damages. Compensation ideally puts the victim in the same position as if the infringement had not occurred. For firms, this requires transferring profits from the injurer to the victim until the victim’s profits equal what they would have been but for the infringement. Disgorgement ideally puts the injurer in the same position as if the infringement had not occurred. For firms this requires transfer-

22 In October, 1998, Congress passed the Sonny Bono Copyright Term Extension Act, which lengthens copyright protection for works created on or after January 1, 1978, to the life of the author plus 70 years, and extends existing copyrights “created for hire and owned by corporations” to 95 years. Before the change, the 1976 Copyright Act had given protection for the author’s life plus 50 years. Whatever other reasons there may be for the Copyright Term Extension Act, one justification is that it brings U.S. practice into conformity with Western European practice.

23 The three dimensions of strength of intellectual property protection for the layouts of integrated circuits, which the law calls a chip’s “mask”, mix standards from patents and copyright. Breadth is determined by the substantial similarity” test of copyright law, duration is 10 years from registration, and the available remedies correspond generally to copyright and patent law. Protection covers all embodiments of the chip’s layout, but does not cover the chip’s functionality that patents law protects or the information on chips that copyright law protects (if they are protected at all). If the defendant asserts reverse engineering as a defense and provides “probative evidence” of it, then the standard shifts from “substantially similar” to “substantially identical.”
ring profits from the injurer to the victim until the injurer’s profits equal what they would have been but for the infringement. Treble damages simply mean three times compensation.

For infringement of intellectual property rights, compensation is the usual remedy in U.S. law. Disgorgement is seldom available except when infringement of an intellectual property right involves breach of a fiduciary duty or unjust enrichment. When the law allows the disgorgement remedy, the victim can choose between compensation and disgorgement. Treble damages are the remedy in U.S. patent law for willful infringement of intellectual property rights.

The following inequalities order these remedies by the usual size of damages, or, equivalently, by their strength:

\[ \text{treble damages} \geq \text{choice of compensation or disgorgement} \geq \text{compensation}. \]

In addition to damages for past harm, the owner can often obtain an injunction against future infringements. This possibility gives the owner a choice: either prevents future infringements by enjoining them before they occur, or deter future infringements by obtaining damages after they occur. If the law allows the owner to defend his patent with an effective injunction, then others must desist from using it or pay the owner’s asking fee for a license.

However, the law does not always give the owner a choice between injunction and damages. Sometimes the law allows damages but not injunction. If the owner defends his patent by suing for damages, then, instead of licensing, others may infringe and pay a price set by the court, not the owner’s asking price. Thus in eBay v. Merc, the U.S. Supreme Court held that when a

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24 In addition to patent law, U.S. firms have an additional remedy against infringing imports. The U.S. firm can bring a case before the U.S. International Trade Commission asking it to ban the import of all infringing goods. This powerful remedy against foreign infringement allegedly leads to abuse by firms shielding themselves from foreign competition. See K. William Watson, Still a Protectionist Trade Remedy: The Case for Repealing Section 337, No. 708 POLICY ANALYSIS (CATO INSTITUTE) (2012).

25 Legal scholars say that property rights cannot be taken without paying the owner’s subjective price, whereas the law allows other rights to be taken by paying an objective price. An implication of this fact is that sellers will not sell property for less than it is worth to them, and buyers will not buy property for more than it is worth them. Consequently, voluntary sales move property from people who value it less to people who value it more, which yields a surplus that can benefit buyer and seller. By creating surpluses, sales allocate resources to their most productive uses and reward innovators.
Ver. 1.4 - Chapter 6. Separation and Fertility in Intellectual Property Law

patented invention is a small component in a large product, compensatory damages can compensate sufficiently for future use of the patented good, and no injunction will be given by the courts. Consequently, the owner receives compensation instead of getting paid whatever she asks. The decision effectively compels the owner of a patent on a small component in a large product to license its use at a price close to compensatory damages.

The owner’s right to choose between damages and an injunction is at least as strong a remedy as the right to damages without any choice of an injunction. The following inequality orders these two remedies by strength:

compensation or injunction > compensation.

The preceding inequalities characterize different remedies for infringement by their strength. To maximize growth, how strong should the remedy be? The separation principle distinguishes between static (consumption and production) and dynamic (innovation) activities. Infringements for static uses should have strong remedies, in order to transfer more resources from static to dynamic activities and increase the pace of innovation. For past infringements by consumers and producers, the separation principle favors treble damages instead of a choice between disgorgement or compensation, and it favors a choice between disgorgement or compensation instead of compensation without a choice. For future infringements by consumers and producers, the separation principle favors the choice of compensation or an injunction instead of compensation without a choice.

The fertility principle distinguishes between the usual innovations and very fertile innovations. Infringements for dynamic uses involving the usual innovations should have weak remedies in order to reduce the excess burden on innovators. Consequently, the fertility principle usually ranks remedies the opposite of the separation principle. For past infringements by innovators, compensation without a choice is preferred to a choice between disgorgement or compensation, and a choice between disgorgement or compensation is preferred to treble damages. For future infringements by innovators, the fertility principle favors compensation without a choice instead of the choice of compensation or an injunction. In contrast to the usual cases, unusual cases concern infringements of patents for fundamental innovations that are
very fertile. Here the fertility principle ranks remedies the same as the separation principle.

Table 6.2 summarizes these conclusions about the preferred remedy for economic growth.

**Table 6.2. Preferred Strength of Remedy for Infringement (“P”)**

<table>
<thead>
<tr>
<th>Infringing Use</th>
<th>Time of Infringements</th>
<th>past infringements</th>
<th>future infringements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>strong treble P compensation</td>
<td>strong injunction P compensation</td>
</tr>
<tr>
<td>consuming or producing</td>
<td></td>
<td>weak compensation P choice P treble</td>
<td>weak compensation P injunction</td>
</tr>
<tr>
<td>innovating, usual case</td>
<td></td>
<td>strong treble P choice P compensation</td>
<td>strong injunction P compensation</td>
</tr>
<tr>
<td>innovating, very fertile case</td>
<td></td>
<td>strong treble P choice P compensation</td>
<td>strong injunction P compensation</td>
</tr>
</tbody>
</table>

Table 6.2 compares compensatory damages to the strength of two other remedies. Compensatory damages also differ in strength according to their basis of computation. Production costs and development costs often figure as elements in compensation for infringement. Compensation can include the cost of the invention’s production and development, which suggests this ordering of compensatory damage measures for patent infringement:

production and development costs ≥ development costs ≥ no compensation.

The same reasoning as in Table 6.2 motivates the relationship between the infringing use and the preferred measure of compensatory damages that Table 6.3 depicts.

**Table 6.3. Preferred (“P”) Damages for Infringement**

<table>
<thead>
<tr>
<th>Infringing Use</th>
<th>Damages for infringement</th>
</tr>
</thead>
<tbody>
<tr>
<td>consuming or producing</td>
<td>high production &amp; development P development P nil</td>
</tr>
<tr>
<td>innovating, usual case</td>
<td>low nil P development P production &amp; development</td>
</tr>
<tr>
<td>innovating, very fertile case</td>
<td>high production &amp; development P development P nil</td>
</tr>
</tbody>
</table>
To illustrate the use of the tables, return to the case of eBay v. Merc, where the court held that compensatory damages can compensate sufficiently for infringing a patent on a small component in a large product. This decision is apparently consistent with Table 6.2, which indicates that a patent owner should receive compensatory damages for infringement by innovators in the usual case. The “usual case” involves an innovator’s infringement of a patent with low or average fertility, and a “small component in a large product” presumably has low or average fertility. Furthermore, Table 6.3 indicates that compensatory damages should preferably exclude development costs or extraordinary profits. (Notice that the rule of compensatory damages replicates the cost structure in a patent pool, which eliminates market power and deadweight loss.26) In the exceptional case where one patented innovation is much more fertile than others, however, Table 6.2 requires a strong remedy – injunction or high damages.

**Thickets and Holdup**

Bell Labs developed the computer operating system Unix in the 1960s. Subsequently, many different programmers created variants of Unix, including the version powering Apple computers (BSD developed at the University of California at Berkeley). Chapter 5 described circular transactions among innovators as an “innovation thicket.” In an innovation ticket, everyone needs the innovations of others in order to make their own innovations, as with variants of Unix. We will apply Tables 6.1, 6.2, and 6.3 to patent thickets.

Unix is “unowned” or “open access” or “in the public domain.” Its users are unrestricted by patent or copyright, although it is trademarked.27 Since no one privately owns Unix, using it does not require negotiating with anyone. If someone owned Unix, however, anyone who wanted to improve it would have to license its use. Negotiating a license takes time and effort, which reduces profits and slows innovation. An innovation thicket contains so many circular transactions that bargaining over property rights slows growth. Innovations in a thicket ideally remain in the public domain where anyone can use them freely, like Unix. If not in the public domain, then innovations in a

26 In a patent pool, anyone is free to produce and use another’s patented good, without paying a license fee. So anyone selling its patented good to another member of the pool must charge a price that does not exceed the good’s production cost. If courts award compensation for production and not development among innovators in a patent pool, costs replicate a patent pool.
27 Only users conforming to certain specifications can apply the name “Unix”.

6.20
thicket should, according to the fertility principle, receive weak patent rights (narrow breadth in Table 6.1, weak remedy in Table 6.2, low damages in Table 6.3). In the unusual case of a pioneering patent in a thicket, however, its high fertility warrants strong patent rights (wide breadth in Table 6.1, strong remedy in Table 6.2, high damages in Table 6.3).

Three different kinds of private transactions among innovators can sometimes overcome the patent thicket problem. Large firms often accumulate a rich patent portfolio. When firm A needs to use a patent in B’s portfolio, sometimes B needs to use a patent in A’s portfolio, so they can negotiate cross licenses. Or, instead of waiting until the need arises, cross licensing can be negotiated in advance. Each member of a patent pool agrees in advance to cross-license its patents for a given technology to everyone else. Or, instead of forming a pool, owners of complimentary patents can merge into a single firm that holds all of the patents required to develop an innovation.

Each of these solutions – cross licensing, pools, and mergers -- has limited success in solving the patent hold out problem. In practice, firms cross license or pool a small fraction of patents, and small firms often resist merging for fear that size will impede creativity. Private transactions among individuals often fail so solve the challenge of innovation thickets because of the problem that game theory explains. If innovations in a thicket are patented, then each venture to develop an innovation needs licenses from several other innovators. When several patent owners have the power to withhold licenses that are necessary to develop an innovation, then the each of them can effectively veto the venture. Given multiple vetoes over a venture, every veto holder must consent for the venture to proceed. If everyone with veto power consents except for one, the last hold out can demand most of the venture’s value in exchange for his consent. Since a patent holder gains by consenting last, no one wants to consent first. As the number of patent-holders with veto power increases, the probability increases that someone will hold out for a higher license fee.

28 A subsequent chapter on contracts discusses cross licensing and pools.
29 A subsequent chapter on antitrust discusses mergers among innovators.
30 Each firm wants to give the pool its least valuable patents, and each firm wants to use the most valuable innovations of others in the pool. This is the problem of adverse selection.
31 Merging dilutes the concentration of ownership needed to solve the double trust problem, as mentioned in Chapter 3 and examined further in a subsequent chapter on antitrust.
Behind this bargaining story lies a technical fact. When distributing the value of a joint product, the usual rule in economics is for each participant to receive his marginal product. The marginal product of a participant in a cooperative venture equals the increase in the venture’s value when he participates in it (holding the participation of others constant). In a patent thicket, many people own essential patents for further innovation. Consequently, the holdout’s marginal product is large, possibly equal to the venture’s entire value or nearly so. Furthermore, anyone can hold out who owns an essential patent for the venture. In these circumstances, the sum of the marginal products of the contributors to the venture exceeds the venture’s total value. The venture does not have enough value for each contributor to receive his marginal product. Demands that are reasonable individually are unreasonable collectively. If the participants negotiate and each one demands his marginal product, the venture is doomed. (For the same reason, marginal product provides no basis for computing compensatory damages or reasonable fees.)

Given its intractability, private actors need law’s help to solve the holdout problem. Law can help by weakening patents among innovators in a thicket. Narrowing a patent’s breadth weakens its market power and lowers the price that a license commands. In Apple v. Motorola, Judge Posner recently followed this prescription by dismissing Apple’s infringement claims. Law can also help to solve the holdout problem by weakening the remedy for patent infringement. As mentioned above, in eBay v. Merc, the U.S. Supreme Court held that the weaker remedy – damages instead of injunctions – applies to small components in a complex innovation.

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32 This is usually equivalent to the decrease in the venture's value when he stops participating in it (holding the participation of others constant).
33 In more technical language, increasing returns to the scale of a coalition implies that the sum of the marginal contributions of each member exceeds the coalition’s total product, and the game’s “core is empty”.
34 Damages for using another’s property often equal the marginal product that the owner lost when the infringer used his property (compensatory damages), or else damages equal the marginal product that the trespasser got from using another’s property (disgorgement damages). In a thicket, “compensatory damages” or a “reasonable fee” for using a patented good without a license cannot refer to its marginal product, because the sum of the marginal products exceeds the total product. Marginal productivity theory is unreasonable for computing damages from infringement or negotiating shares in cross-licenses.
Middlemen and Trolls

“Middlemen” refers to intermediaries who buy goods for resale. Throughout history, people have viewed middlemen with suspicion because they make money without making goods. Confusion abounds about their economic role. Do they increase or decrease prices to consumers? Do they create cartels or match buyers and sellers? The same confusion infects discussions about patent middlemen, who buy patents to enforce them, not to produce or innovate. According to the Norwegian fairy tale of the “Three Billy Goats Gruff”, a troll living under a bridge gobbled up pedestrians who tried to cross. Similarly, some law firms gobble up patents and sue others who need them for production or innovation. “Patent troll” is the derogatory term for “patent middlemen.”

Name calling aside, law requires analysis of patent middlemen. After a business venture develops and patents an innovation, the innovation must be marketed to users and enforced against infringers. Innovating, marketing, and enforcing are different specialties that different people can perform. With respect to enforcement, the innovator can directly defend her patent or she can indirectly defend by selling the right to collect damages to someone else. Thus firm A invents and patents $\alpha$. A can enforce the patent on $\alpha$, or A can sell $\alpha$ to B, or A can sell to B only the right to sue and collect damages from infringers of $\alpha$.

By facilitating middlemen, the law gives patent owners more enforcement choices. Innovators tend to choose the most profitable form of enforcing patents, whether by themselves or others. More enforcement choices strengthen the patent owner’s rights de facto, but not de jure. Stronger patent rights can stimulate or stifle innovation, as previous discussions show. According to the separation principle, increasing a patent’s strength against consumers and producers stimulates innovation. By prosecuting infringers who use an invention to produce consumer goods, patent middlemen transfer resour-

35 Middlemen often save buyers and sellers the cost of finding each other, but they sometimes form cartels to separate buyers and sellers, and to extract higher prices. Thus middlemen try to prevent buyers from obtaining information about sellers from any source but themselves. To illustrate, the American Bar Association historically prohibited its members from advertising their specialties, including printing a specialty on a business card. Consequently, a person who needed, say, a patent attorney often had to ask the family attorney for a reference. This restriction on information generated referral fees for lawyers. Such predatory practices by middlemen cause hostility and resentment among those who must pay for it. The U.S. courts eventually struck down such legal rules as violations of “commercial free speech”.

6.23
es from consuming to innovating, which speeds progress in the useful arts. To increase progress in the useful arts, law should facilitate sales of patent rights to middlemen for innovations used in consumption or production. Conversely, increasing a patent’s strength imposes a deadweight loss on innovators in the usual case. By prosecuting infringers who use an invention to innovate, patent middlemen impose a deadweight loss on innovators, which slows progress in the useful arts. To increase progress in the useful arts, law should inhibit sales of patent rights to middlemen for innovations used in innovation. In the usual case of a very fertile patent, however, law should facilitate sales of patent rights to middleman. Perhaps the derogatory word “troll” should be reserved for patent middlemen who stifle innovation.

**Conclusion**

Intellectual property law, which includes patents and copyright law, establishes the ownership of innovations by people. It conveys a bundle of rights to creators as determined by rules. The normative question of growth economics is, “Which ownership rules maximize innovation?” In order to increase the pace of innovation, ownership rules should open competition to innovate and increase the winner’s profits. This chapter poses the question, “Which ownership rules maximize profits among ventures in open competition to innovate?” Answering the normative question of growth economics requires comparing two opposite effects of stronger intellectual property rights. The first effect is a transfer from static activities (consumption and production) to dynamic activities (innovation), which increases the profitability and pace of innovation. According to the overtaking theorem explained in Chapter 1, transfers from static activities to dynamic activities increase the welfare of people. So the first effect favors strong intellectual property against infringement by consumers and producers. The second effect is the dead-weight loss of licensing dynamic activities, which decrease the profitability and pace of innovation. So the second effect favors weak intellectual property rights against infringement by innovators.