The Economics of Patents and Copyright

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Foreword: A Primer for Free

Economics is a powerful instrument to understand the current controversial issues on intellectual property: e.g., the extension of patents to software and business models, the lengthening of copyright protection, the compulsory licensing of pharmaceutical products or the legal suits against music downloaders.

Economics is also a powerful instrument to improve public policy. It helps to design the appropriate reform to adapt intellectual property law to the 21st century.

That is why we wrote this book and decided to deliver it for free.

Our aim is not to defend an opinion – otherwise we would have written an essay or a manifesto instead of a textbook. We want to shed the light of economic analysis on major patent and copyright issues and, therefore, help our readers to make up their own minds. We thus describe and discuss the rationale of intellectual property law, its economic advantages and drawbacks and how to fine-tune them. Consistent with this approach, the book has been written to reach a wide public of both economists and non economist readers. In particular, it should also help lawyers, engineers and scientists to become more familiar with economic analysis of intellectual property.

We have chosen to use the internet to share our conviction on usefulness of economics to the larger number of people. As we argue in one of our chapters, the development of the world-wide-web along with the digitalization of contents - text, music, or video - have opened new possibilities of diffusion which we have decided to experience with this book. Virtual books, as any digital content, can be copied and transmitted nearly for free. This may be a nightmare for those authors and producers who lose the economic incentives to invest in new creations. This may also be a unique opportunity for those – like us – whose prime aim is to diffuse knowledge and information.

In return for free access to this book, we expect two benefits: useful feedback and further diffusion. A digital book can easily be updated and evolve as readers express new needs. We will thus welcome any suggestion (to meniere@cerna.ensmp.fr) that would be worth adding to the book. We especially encourage graduate students and instructors using this textbook to suggest addenda and exercises. We also encourage you to post the weblink to our book (www.cerna.ensmp.fr/PrimerForFree.html) on your website. This is exactly how the internet is useful! So enjoy the reading, and please diffuse this book!

Paris, July 2004

The Economics of Patents and Copyright

The Economics of Patents and Copyright

François Lévêque
Yann Ménière

Should intellectual property protection be tightened or relaxed? Should we side with Kazaa, which fled to Vanuatu to set up shop, or the major record labels that had Napster wound up? Should computer programs be patentable, and should Microsoft be allowed not to disclose information on Windows' interfaces, and either way jeopardize the development of freeware? Should pharmaceutical companies be compelled to license their products at low price, or should they benefit from better protection to encourage them to find new molecules?

On the one hand, piracy and counterfeiting are spreading, which reduces the incentives to create and invent. On the other hand, intellectual property law is being reinforced, which will ultimately restrict the diffusion of creative work and the use of innovations. What is the right balance?

This book aims to use economic analysis to highlight the particular arguments as well as the general issue.

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Introduction

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This book aims to show the contribution that economic analysis can make to this debate.

Intellectual property is a recent field of study for economists. Most research in this area began in the 1960s and focused on patents and their contribution to technological progress. Since then, the study of intellectual property has gradually expanded beyond the circle of innovation specialists. Economists from all horizons are now taking an interest in the subject. The overview proposed in this book therefore covers a wide variety of economic aspects. It includes ideas from antitrust economics and industrial

organization.

This book is nevertheless intended for non-economists, particularly law students. It has been designed with them in mind, by alternating general sections with more detailed analysis, and by providing the description of models in insets separate from the main text.

At the same time, the economic analysis offers readers with no legal knowledge a basis for understanding intellectual property law.

Intellectual property encompasses different types of rights – patents, copyrights and the sui generis rights that protect plant varieties, semiconductor chips and databases. All these rights obey common economic principles. This book seeks to outline these general principles and provide a more detailed analysis of the specific features of copyrights and patents.

The book is comprised of five chapters. The first is an explanatory chapter. It presents the basic economic ideas behind intellectual property to the lay reader. It explains how temporary and exclusive intellectual property rights reflect the specific characteristics of information. It also describes how the allocation of intellectual property rights facilitates trade and enables ideas and creations to be exploited by those that value them most.

The second and third chapters deal with patents. Chapter 2 has a normative slant and Chapter 3 a positive one. Chapter 2 examines ways to fine-tune patent scope in order to maximize welfare, by determining the optimal research effort, duration, breadth and depth of a patent. Chapter 3, on the reform and use of patents, offers readers a more tangible view of intellectual property. It analyses and discusses the way in which patents have been strengthened, harmonized and extended to new categories of inventions and points up the consequences on innovation and the behavior of firms.

The fourth chapter analyses copyright and its specific features. It first presents the negative effects of piracy, which, according to economic theory, justify the existence of copyright. It then looks at institutions based on copyright. The chapter includes descriptive sections, which illustrate the theoretical explanations of copyright and outline the questions copyright raises today.

The fifth chapter looks at the interface between intellectual property law and competition law. It covers both patents and copyright, and integrates legal aspects. It first broaches the question from a general point of view, to

determine whether the two bodies of law are contradictory or complementary. It then emphasizes the anticompetitive effects of intellectual property rights, through an examination of license agreements.

Readers will note that the book does not address trademark law. Together with patents and copyright, trademarks are indeed an area of intellectual property law. But law and economics diverge on their analysis. For economists [Landes and Posner, 1987], trademarks respond to a different problem than other intellectual property rights: they are a way of signaling the quality of goods and services to consumers. The analytical tools used to study trademarks are therefore quite different than those applied to other forms of intellectual property. Trademark law has therefore been excluded from this study.

The authors have also made the deliberate choice of emphasizing the role of intellectual property in facilitating trade and division of labor. By reducing transaction costs, the legal system of protection for works of the intellect facilitates the exploitation of inventions and creations by those who value them most. This role is more often overlooked than that of providing incentives to innovate. It is nevertheless as – if not more – essential from an economic viewpoint.

I/The Basic Economics of Intellectual Property Law

Intellectual property applies to all types of creative work. Through a system of exclusive and transferable rights, its legal framework protects trademarks, technical innovations, databases, literary works, musical compositions, films and even plant varieties. Each of these categories is covered by specific legislation, which lawyers group under the heading of intellectual property law. From an economic perspective, intellectual property law responds to two requirements: to provide incentives for innovators and to facilitate trade.

Striking a balance between incentive and access

Why does the law protect inventions and artistic works? The lawyer's answer is that intellectual property law seeks to encourage innovation and creation, while enabling access. This basic principle is highlighted by economic analysis, which assimilates works of the intellect to the production of information, although this presents two problems in terms of allocation of resources [Arrow, 1962].

Firstly, information is a non-excludable good. This means that it is impossible to exclude an individual from using the good even if he does not contribute to the cost of producing it. For example, a publisher cannot stop the same book from being loaned and read by several people. Similarly, a

newspaper journalist cannot prevent an original piece of information she reveals from being repeated by colleagues. The practical problem posed by these goods is a lack of incentive for entrepreneurs to produce them. From the outset, they know they will have difficulty being paid and covering their costs. From the point of view of the community, there is a loss in welfare, because goods for which there is a market will not be produced.

Secondly, information is a non-rival good. When an individual consumes information, it does not reduce the quantity available to other people. For example, watching a football game on television does not prevent other viewers from consuming the same program. Non-rivalry can be seen as the opposite of congestion. The enjoyment of watching a football game is not diminished by the presence of a large number of other viewers around the world. In other words, the marginal cost of serving an additional consumer is zero. Consequently, when a producer charges for his service, consumption of the good is needlessly rationed. Consumers whose willingness to pay is lower than the going price are excluded from using the good, although they would have benefited from it at no cost to anyone. Social welfare is not maximized.

By offering an exclusive right for a limited period, intellectual property law addresses these two problems sequentially. Initially, the legal mechanism of protection makes the good excludable. Users are required to pay for the services offered, through royalties. Subsequently, when the work passes into the public domain, all consumers can access it free of charge. Intellectual property law thus attempts to strike a balance between the incentive to create and innovate, and the diffusion of the results obtained. This contradiction between incentive and use translates into economic language as a trade-off between dynamic and static efficiency.

By addressing the problems of non-excludability and non-rivalry of

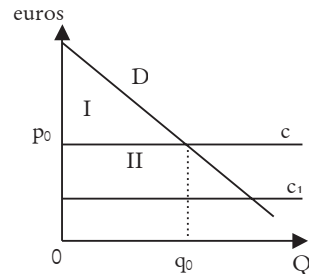
Static efficiency versus dynamic efficiency

Intellectual property law attempts to strike a balance between two economic efficiency objectives. To achieve static efficiency, allocation of resources should maximize surplus. Surplus consists of producer profit – measured by the area between the price and the marginal cost – and consumer gain – measured by the area between the demand curve and the price.

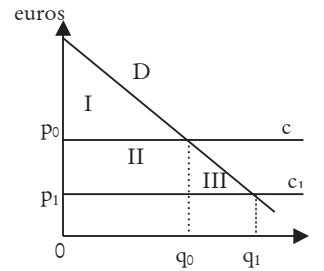
Dynamic efficiency refers to the improvement and renewal of production techniques and goods over time. It is the result of investment in R&D, design and creation.

The figure below shows the effect of patent protection. The innovation here reduces the costs of a manufacturing process from c_0 to c_1. Before the invention, the quantity of goods produced q_0 is sold at a price of $p_0 = c_0$. We assume a perfectly competitive market and therefore a producer profit of zero. The total surplus is therefore the consumer surplus, equal to the area of triangle I. During the lifetime of the patent, the quantity of goods produced is always q_0 and the price p_0. But the total surplus has increased by the area of rectangle II, which represents the savings generated by the innovation. This producer surplus is appropriated by the inventor through license revenue, set at $r = c_0 - c_1$ per unit of output. The other companies continue to make zero profit because they receive revenue of p_0 x q_0 for expenditure of $(c_1 + r)$, i.e., p_0q_0. Similarly, the consumer surplus does not change. At this stage, therefore, the inventor is the only winner. When the patent passes into the public domain, the price falls to $p_1 = c_1$ and the quantity produced rises to q_1. The total surplus increases by the area of triangle III, because new consumers have access to the good. Because of the reduction in price, the consumer surplus increases from area I to area (I + II + III) while the inventor's profit falls to zero. Consumers are now the only winners.

During protection:



After protection expires



To recapitulate: before the invention, the total surplus is equal to area I; during protection, it is equal to I + II; after the patent expires, it is equal to I + II + III. This means that society is better off if an invention is produced, and even better off if the patent has expired. This suggests that it would be preferable to move straight from the invention phase to the public domain and bypass the protection phase. However, the problem that arises there is that without the protection phase, the invention will not be produced: since the inventor knows that the market price will fall to P_1 and he will not be able to recover his R&D expenses, he therefore has no incentive to make the investment.

In other words, protection generates a deadweight loss to society (area of triangle III), but this is the sacrifice required to encourage artists and inventors to make the effort.

information sequentially, patents and copyright are necessarily imperfect mechanisms. During the period of protection, the rationing of consumption generates a deadweight loss for society. Once a work passes into the public domain, the deadweight loss disappears, but the innovators lose their royalties, which may prevent innovations of benefit to society from being produced. Let us consider, for example, an invention with a cost of 70, a value to society of 100, from which the company can derive annual revenue of 3 per year. The invention is socially useful because its value is higher than its cost. However, if the property right lasts for 20 years, it is not profitable for the company to make the corresponding investment in R&D. In other words, to limit the problem of non-excludability, the period of legal protection must be infinite, whereas to eliminate the problem of non-rivalry it must be zero.

● Alternatives

If granting an exclusive right for a limited period is an imperfect mechanism, why use it? What alternative instruments exist? One is that governments can fund artistic and technical works; and the other is that inventors can keep their discoveries secret.

With a good that is both non-excludable and non-rival (this is a pure

public good), the canonical economic prescription [Samuelson, 1954] is subsidization. This mechanism involves reimbursing the company for its expenditure – which eliminates the deficit and therefore the problem of a lack of incentive to produce – and offering free access to the good or service – which avoids the deadweight loss and therefore corrects the problem of sub-optimal rationing. Examples of this solution, in which production is funded by taxpayers rather than users, are national defense and urban street lighting. In the arts, subsidization exists in the form of patronage, which has enabled major works of art to be produced [Plant, 1934]. In the field of knowledge and science, the equivalent is public research. Subsidization is implemented via endowments to public facilities, bound to broad objectives (e.g., the multi-year funding contracts between the U.S. government and NASA) or via grants to associations or companies contracted to produce according to precise specifications (e.g., National Science Foundation and National Institutes of Health). More rarely, prizes are awarded to individuals who develop a particular innovation. An example of this is the reward Edward Jenner received from the British parliament for developing a smallpox vaccine [MacLeod, 1988]. In contrast, this solution is widespread in the artistic – particularly literary – sphere. These awards are not only designed as an incentive for creators. They also play a role of quality indicator for consumers.

However, the subsidization alternative is not without shortcomings in terms of both static and dynamic efficiency. Deadweight loss is eliminated at the expense of taxation on other goods, which introduces distortions in other compartments of the economy. In other words, public funding is not free. Furthermore, unless the government has accurate knowledge of the costs and benefits of research, the amount of subsidies will be mismatched to the social value of the innovations. This means that research endowments or grants tend to either under or overcompensate innovation.

A term-by-term comparison of exclusive rights and subsidization [Gallini and Scotchmer, 2001] therefore does not enable us to say that one instrument is better than the other in the absolute. Their relative merits depend on circumstances, in particular on the information available to the government.

Be that as it may, state intervention – in the form of public funding or even protection by intellectual property law – is not always essential to

creation. Another possible strategy for firms is to use secrecy to protect a process (e.g., Michelin radial tires) or formula (e.g., Coca Cola). As long as an innovation is kept secret, it cannot be copied by competitors and the company can appropriate the profits it generates. There is no need to introduce a complex legal mechanism to address the problem of non-excludability, since there is none! By definition, secrecy implies physical barriers to exclude free riders. Conversely, even when kept secret, information is still a non-rival good. Not diffusing it generates a cost to society. Even if an innovation can be protected by secrecy, a patent is valuable to society because of the disclosure requirement it entails. In effect, patent law requires applicants to describe their invention in sufficient detail for it to be reproduced by a skilled person or team. Once this information has been made public, it can be used by others to extend the frontiers of knowledge. Patents thus foster technical progress. Inventors can also gain from opting for a patent instead of a trade secret because a patent also protects against innovations realized independently. If Michelin's radial tire process or the Coca Cola formula were to be developed by an ingenious competitor, the corporations headquartered in Clermont-Ferrand and Atlanta would lose their exclusivity, whereas a patent would have protected them against such rival inventions.

Trade secrecy is obviously of no avail when the information created is incorporated into the new product on the market. This is typically the case of literary and artistic works, but also applies to animal breeds and plant varieties. Innovations in industrial techniques, such as semi conductor chips, can also be accessed by reverse engineering.

● Exclusive rights and market power

The intellectual property system gives an exclusive right to inventors and creators over the work produced. This does not mean that they automatically obtain a monopoly over the market. A new product or cheaper process can be developed in different ways. For example, human insulin, which is superior to pig insulin for treating diabetes, can be produced either by using enzymes to eliminate an amino acid from pig insulin or by genetically modified bacteria. Neither of the patents awarded for these inventions gave the applicants — Novo and Genentech — a monopoly over the insulin market. Similarly, in the

literary sphere, although every book is unique, if the price of a book goes up, consumers will switch to a similar but cheaper alternative. Because of such substitution, the market from the point of view of competition is usually larger than the market for the work itself. Now let us look more closely at the connection between exclusive rights and monopoly.

Economic theory draws a distinction between drastic and nondrastic innovations. In the case of a drastic innovation, intellectual property gives a monopoly over the market, whereas in the case of a nondrastic innovation, it simply gives market-power (or monopoly power — the two terms are used interchangeably). A drastic innovation is one that reduces the cost of production or improves the quality of a product to such an extent that the new monopoly price is lower than the competitors' production cost. The company that holds the property right no longer has to worry about competition. It can behave like a monopolist that seeks to maximize its profit without fearing other entrants. Conversely, if the innovation is nondrastic, the innovator's monopoly price remains higher than the competitors' cost. To exclude its rivals, the innovator must set a lower price than in the case of drastic innovation. Because this price is still higher than the marginal cost, however, the company enjoys market power, i.e., it can charge a higher price than the competitive price for a significant length of time.

To examine the link between intellectual property rights and monopoly, we need to ask which market structure is most conducive to innovation: monopoly or perfect competition? This question has been debated by economists for a long time. In his work on innovation and patents, Arrow [1962] attempted to point out the contradiction in Schumpeter's argument that large firms organized into monopolies offer the best chance of continuous innovation [Schumpeter, 1943]. The demonstration of the superiority of competition by the founder of economic analysis of intellectual property is easy to understand. Before an invention, a company in a competitive market simply recoups its costs, without generating any profit. The company will therefore appropriate the full profit generated by the invention. A monopoly's starting position is different, because it already makes a profit. Innovation only offers it higher monopoly revenue. Because its gain (i.e., the monopoly profit after the invention minus the monopoly profit before the invention) is lower than that of the competitor, the

monopoly firm has less incentive to innovate. However, this reasoning ignores competition between companies to conquer markets. The incentives are different if the monopoly knows that a competitor can enter its market by inventing and patenting a less expensive process or a similar new product. In this case, the two companies will launch into a race to patent. If the incumbent fails to win, it will lose its income and its investments, whereas if the entrant comes second, it will lose only its R&D expenditures. Here the incentive to innovate is stronger for the monopolist, even if the patent it obtains remains a sleeping patent [Gilbert & Newberry, 1982].

Property rights to facilitate trade

Intellectual property and physical property share some economic functions. The incentive role of patents and copyrights that we have just seen is no different than the general role of property in terms of dynamic efficiency. Imagine a society with no real property law or land tenure rules. A farmer clears a plot of land, fertilizes it and sows it, only to have a neighbor take the crop when it is ripe for harvest. Since the farmer has no title, either to the land or to the harvest, he has no possibility of seeking redress. After several thwarted attempts to farm, he will give up and switch to a different activity with a shorter investment cycle.
We will see how the general role of property in the regulation of trade also applies to intangible goods.

● Property rights and static efficiency

Intellectual property law grants exclusive, transferable rights. From an economic point of view, transferability is just as important as exclusivity because it ensures that the asset is used by the party who values it most. Let's take the example of an integrated movie studio that makes a hit movie. Commercial exploitation of the movie in the studio's own movie theaters would generate net discounted revenue of 100. A rival exhibitor with a larger network of theaters could generate revenue of 120. It is therefore in the former's interest to sell its right to the latter at a price above 100 and in the

latter's interest to buy it at a price below 120. The companies could agree, for instance, to split the mutual gain of 20 in the deal by making the transaction at a price of 110. If the first company had not been able to transfer its rights, allocation of resources would not have been optimal and social wealth – limited here to two agents – would not have been maximized. Similarly, an innovating company that is less efficient at developing its invention has an interest in selling or licensing its patent to a more efficient company.

Negotiating transfers of property rights and its effects on efficiency is the subject of an economic theorem, known as the Coase Theorem [Coase, 1960; Stigler, 1966]. Ronald Coase argues that negotiation results in allocative efficiency as long as property rights are clearly defined and there are no other obstacles to the deal. Furthermore, resource allocation is efficient regardless of the initial allocation of property rights. In a hypothetical world where rights on inventions and creations are precisely defined and where it does not cost anything to draft, sign and execute contracts, innovations would always be used by those who value them most, regardless of who made them in the first place. In other words, leaving aside incentive issues, if transaction costs are zero, the allocation of the initial rights on innovations does not affect the wealth created. Whether the first innovator is granted a broad right – e.g., an exclusive right on the production of all recombined proteins or on all movies about the conquest of the Far West – or a narrow right – e.g., on human insulin produced from genetically modified bacteria or on the first western The Great Train Robbery – makes no difference in terms of static efficiency. In such a perfect world, every new word or idea could be assigned a property right and an owner and every user would have to pay to be able to use them.

However, in the economic system, it is relevant to assume that these transactions have costs: property rights are not always clearly defined; drafting a sales or license contract requires time and expertise; and ensuring that parties comply with their commitments necessitates a system of monitoring and penalties. The decisive factor is whether the transaction costs are higher or lower than the gain of the transaction. Let's suppose that in the previous example of the studio and exhibitor, the transaction can only be performed at a cost of 21. This changes everything. The parties would lose 1 from the deal. They therefore have no interest in making it and the property

right will remain in the hands of the less efficient company. If the transaction cost is less than 20, the deal will go ahead, but the parties' gain will be smaller. If the cost is 19, they will only have a gain of 1 to share.

The public authority has two complementary means of action to promote efficiency when transaction costs are positive. It can either grant the property right to the party best able to develop it from the outset, or it can seek to facilitate transfers of rights by reducing transaction costs. For example, intellectual property law provides for nontechnical ideas and theories to remain in the public domain. This exemption obviates the need to negotiate with an owner every time a phrase is pronounced or an idea is expressed. Another example is that European and U.S. legislation authorizes associations of authors and composers to negotiate and collect rights revenue from radio stations and concert organizers on behalf of their members. Similarly, in the area of joint innovations, companies can group their patents into a pool, which in turn issues a single license to users. For instance, the MPEG2 standard, which is used to compress video data, began as a grouping of eight companies that owned around 100 patents. By authorizing such groupings, the public authority helps reduce transaction costs by removing the need for every user to negotiate with every owner of a piece of intellectual property. By reducing the number of contracts, these collective mechanisms reduce transaction costs.

- Delimiting intellectual property rights

Introducing property rights is not enough to facilitate trade, however. A precise definition of those rights is also essential. When ownership of a good is not clearly defined, it becomes more difficult to trade. If the buyer does not know exactly what he is buying, he cannot correctly set a ceiling price. The seller can lie about the merchandise to obtain a higher price. Despite the mutual gain in the deal, the negotiation is likely to stall.

We can visualize works of the mind as forming a finite space of elements [Friedman, 2000]. Intellectual property law divides this space into two main zones. The first zone consists of creations to come and past creations that are now in the public domain. This zone – by far the larger of the two – is an undivided whole. It can be used collectively and free of charge.

It is the equivalent of the common, where all of the villagers' livestock could graze freely. The second zone is private and encompasses contemporary, protectable inventions and creations. It is parceled out like fenced arable land. Every plot can be rented, sold or opened for passage in exchange for a toll. But how are the plots delimited? For artistic creations, the boundaries of each plot are relatively easy to identify. The entire work is protected against literal copying. Note, however, that in the United Kingdom, under the right to parody, a work can be pastiched or caricatured, which leaves room for criticism. In similar vein, in France, reproduction of extracts that do not exceed a few paragraphs is authorized without need to seek prior approval from the author. It is thus easy for a new author to know whether or not he is infringing a neighbor's property.

The delimitation of property in the case of inventions is much more cumbersome than for farmland or artistic works. The boundaries of ideas are not as clear – cut as plots of land or artistic expressions. Furthermore, the definition of the scope of an invention is left up to the inventor himself. Applicants must append a list of claims to the description of their inventions. For example, in his patent on the telegraph, Samuel Morse laid claim not only to the specific device that he had developed, but to all uses of electromagnetic power for transmitting signs or letters at any distance. In the space of works of the mind, the American inventor attempted to stake out a concession that would include not only the telegraph, but also semaphore, the fax and even television! The latitude given to inventors calls to mind the prospecting permits issued during the gold rush (Kitch, 1977). In the Great North of America, pioneers who discovered signs of a gold deposit had to stake out their claim themselves. The delimitation of the territory of patents is guided by rules, however. The legal requirements of novelty (i.e., the invention must not have existed previously), nonobviousness (i.e., the invention must not be readily apparent to a person skilled in the relevant field) and technical feasibility (i.e., the invention must be technically applicable) limit the possibilities of making claims. But the maximum limits they set remain very imprecise. This uncertainty over the limits of a patent can also discourage more efficient companies from purchasing the right. Conversely, it can prompt the acquisition of a license as a precautionary measure, since the purchaser does not know whether his process infringes the competitor's patent or not. .

Defining rights and its consequences: a comparison of patents and copyright

In terms of the balance between incentive and use, there is no difference between patents and copyrights. The definition of their respective scope, however, generates higher transaction costs for patents than for copyrights. The difficulty of defining an invention makes the delimitation of the patented property imprecise, thus increasing filing costs. The inventor must stake out his territory by submitting claims to the patent office. None of this is required for copyright. The application procedures, if there are any, are reduced to a minimum, with the patent office acting as a mere recording chamber. The general boundaries of the property are those of the work itself. These are specified ex post by a judge in the event of litigation. Copyright's greater clarity also explains why it is rarely violated unintentionally. By contrast, an inventor can easily infringe a patent without realizing it. To avoid doing so, he must undertake costly prior research on existing protection in his technical field and analyze the validity of the claims of key patents. No such undertaking is required for a copyright application, since an independent creation does not infringe another's property. Research of this kind would even be counterproductive, because it could cast doubt on the work's independence. Lastly, the cost of monitoring and prosecuting infringements is also higher for patents than for copyright. This is due not only to the imprecise limits of patents, but also to the greater ease of detecting industrial piracy in the case of copyright. Infringements by rival firms generally take the form of a publication and are therefore easily observed, contrary to the imitation of patented processes, for example.

Patents are also more conducive to strategic behavior than copyrights. The protection of a literary or artistic work only fences off an infinitesimal part of the space of creations. Filing a copyright reduces only fractionally the opportunities for other writers, musicians or painters. By contrast, patents offer much broader protection. By being the first to patent, an inventor can block competitors, by forcing them to switch to a different line of research or pay for a license. The patent triggers a race between inventors in which the winner takes all. Moreover, if the initial patent is sufficiently broad, it can also block subsequent innovations, which might improve or complement the first invention. In other words, the patent offers prospects of monopoly rent, which rival companies vie for.

- Detecting and punishing infringements

A property right only has value if it is enforced. To ensure that it is, a whole arsenal of rules and judicial institutions is required. It is generally left to holders of patents, copyrights and trademarks to monitor and detect offenses. In the event of infringement, a dispute can be taken to court. In the United States, there are around 100 patent trials a year. This figure is much smaller than the number of infringements reported, because most intellectual property disputes are settled out of court. This disproportion is explained by the costs and timeframes of litigation. For U.S. patents, the number of complaints is 16 times higher than the number of court cases [Lemley, 2001].

According to the economic theory of crime [Becker, 1968], in order to be dissuasive, a fine must take into account the probability of detection. The idea is that a potential economic criminal will abide by the law as long as the benefit he derives from his crime is lower than the penalty multiplied by the likelihood of being caught. This is particularly low for intellectual property because infringement is often difficult to establish. To detect the use of a patented process by a competitor, one needs to enter his factory; to catch a small-time infringer who copies software to sell it to friends and family would take a policeman in every house. Consequently the level of penalties should be extremely high. However, this is not usually the case. In a modern democratic system, it is not easy to impose a heavy fine or a jail sentence for photocopying a book or recording a cassette for sale (Watt, 2000).

The implementation costs of intellectual property law are high and directly incurred by the parties, which hinders trade. Given that the right he acquires will be difficult to defend, the buyer revises his valuation down,

which can cancel out the mutual gain and end up preventing the transaction. Ex post transaction costs thus have the same effect as costs generated before a contract is signed. They can prevent the exploitation of rights by the most efficient companies.

- The tragedy of the anticommons

The parceling out of intellectual property is an impediment to trade, which economists have termed "tragedy of the anticommons" [Heller and Eisenberg, 1998]. This expression describes a situation in which several individuals own rights of exclusion. By exercising those rights, they restrict access and therefore use of common resources.

Let's take the example of a technology based on two patents held by two different inventors. To use the technology, companies must obtain a license from each inventor. This double negotiation increases the transaction costs for the purchaser, compared with a situation in which he would only have to deal with a single owner. However, the tragedy of the anticommons goes beyond this. It stems from the fact that the two inventors set the prices of their licenses separately. If one inventor lowers his price, he will sell more licenses because the cost of access to the technology for consumers will fall. But this additional demand will also benefit the other inventor even though he has made no sacrifice on his unit margin. When the benefit of a reduction in price is only partly appropriated by the person who decided it, neither has an incentive to fully play that card. As a result, the total price of the technology will be higher than the price that a single owner would have charged. Consequently, the technology will be underutilized.

When one owner is better than two

Take a song produced by a lyricist and a composer (or a technology built out of two inventions). Every consumer of the song (or the technology) must obtain a license from both creators to have access to the good. Let's suppose that consumers' consent to pay is distributed uniformly along a [0.1] continuum between. P_1 and P_2 are the prices charged by the rights holders. All consumers whose consent to pay is higher than $P_1 + P_2$ will request a license from each owner. Owing to the distribution of preferences, demand for licenses is equal to $1 - (P_1+P_2)$. The profit of right holder 1 can be written as $P_1[(1 - (P_1 + P_2)]$ and that of right holder 2 as $P_2 [(1 - (P_1 - P_2)]$. The profit of the former will be maximum when the derivative cancels out, or $2 P_1+ P_2 = 1$; similarly, the profit of the latter will be maximum at $2 P_2+P1 = 1$. The solution of this system of equations leads to $P_1= P_2 = 1/3$. The price of the good for the consumer will therefore be 2/3. Let's imagine now that there is only one owner of the song or technology who sets a price of P. His profit is written as $P(1 - P)$, and the derivative is equal to $1 - 2 P$. It now cancels out for the value $P = 1/2$. In other words, when the exclusive rights are in the hands of one person, the price of the good will be set at a lower level and more consumers will have access to it. Note that a concentration of rights is also favorable to owners. When there are two owners, each makes a profit of 1/9, i.e., a total profit of 2/9, whereas with one owner, his profit is 1/4, which is more than 2/9.

The previous result makes sense if we consider that when there are several holders of a right of access, each applying a margin, the good is more expensive. This only applies in a monopoly, however. If the rights holders are subject to perfect competition, the price of the licenses is equal to marginal cost and profit is zero.

The superiority of a single monopoly over a chain of several monopolies was demonstrated by Augustin Cournot as early as 1838. Using the example of copper and zinc, the two raw components of brass, he established that two separate vertical monopolies were more disadvantageous for society than one.

The underutilization of technical or artistic resources as a result of parceled intellectual property is often compared to the overexploitation of natural resources when access is free. This situation was first described as the "tragedy of the commons" by Garrett Hardin in 1968, using the example of

fish stocks. When a fisherman catches fish of reproductive age, he reduces future fish stocks. The fisherman's action penalizes all fishermen, including himself. But, unlike other fishermen, he offsets the damage to himself with a benefit that he alone appropriates – a higher catch – so his net situation improves. Every fisherman is tempted to adopt this freeriding behavior, which leads to the depletion of the natural resource and a tragedy of the commons.

The difference between the two tragedies lies in the favorable or unfavorable effect of the actions on other users. When the owner of an exclusive access right lowers his price, he generates a positive externality – his decision benefits other owners of complementary licenses. Conversely, when the user of a natural resource increases his level of extraction, he generates a negative externality – his action causes damage to other users of the common good. The two cases are symmetrical [Buchanan and Yoon, 2000]. One leads to overexploitation, the other to underutilization. This also illustrates the general economic rule, according to which the level of production is not optimal when there are externalities.

Intellectual property law has created a system of exclusive, temporary, transferable rights. The first two characteristics reflect the specific properties of information. They represent a compromise between dynamic efficiency to favor innovation and static efficiency to promote use by the greatest number. Transferability is another aspect of property. By permitting trade and reducing transaction costs, the laws protecting works of the mind facilitate the use of inventions and creations by those who value them most.

The two aspects are complementary. When the costs of selling a license fall, because of more clearly defined rights for example, the inventor or creator can hope to obtain a higher profit. This strengthens incentives to innovate.

These two aspects are also a yardstick for discussion in the following chapters of ways to implement and reform intellectual property law. Is the compromise reached between incentive and use the most satisfactory in terms of social welfare? Are allocation and enforcement of intellectual property rights achieved at the least cost to society?

II/Patents and Efficiency

The economic principle underlying patents is to give inventors a temporary monopoly over their discoveries, in order to encourage innovation. The implementation of this principle is not so simple, however. What sort of rights should be given to innovators? How should they be defined? Patents can indeed differ widely in duration and scope. Determining the right design requires understanding how these different characteristics affect the economy. This is what economic analysis of patents aims to do.

Patents and the benefit of innovation

The net social benefit of an innovation is the difference between the welfare it brings to society, and its cost, particularly in the R&D investment. Any innovation whose net social benefit is positive should be produced. By allowing innovators to reap the benefits of their innovations, patents come close to that objective, but do not attain it. Indeed, patents are behind various mechanisms that cause net social benefit to diverge from net private benefit, depending on the decision of the innovator. Designing an optimal patent therefore consists in seeking the best compromise between these different effects. The first part of the chapter offers an overview of these mechanisms, which are recapitulated in the table on next page.

The effect of patents on the net benefit of an innovation

	Private	Public
Benefit	Temporary monopoly	Knowledge externalities
Cost	Investment in R&D	Duplication of investment Deadweight loss

● Patents and innovation surplus

The distortions caused by the innovator's monopoly affect the amount and the distribution of the surplus generated by the innovation. The monopoly is in a position to set a higher price than if it were in competition. By doing so, it excludes some consumers, who would buy the innovation if it were sold at competition price. This deadweight loss reduces the total surplus created by the innovation – at least during the lifetime of the patent.

Furthermore, the profit collected by the innovator is lower than the social value of the innovation. If the monopoly based its price solely on those consumers willing to pay the most for the innovation, it would discourage all other consumers. The monopoly must therefore set a lower price and give consumers some of the surplus. This consumer surplus is higher when consumers react sharply to a change in price, i.e., when demand is highly elastic.

Thus the mechanism designed to remunerate the inventor of an innovation reduces the net social value of the innovation and only allows the innovator to appropriate some of the remaining value. This limitation on the privatization of the benefit of the innovation should be put in perspective, however. It is not necessary for the innovator to appropriate the total surplus created by the innovation. To ensure that the innovation will be produced, it is sufficient for him to recoup his investment in R&D.

● Knowledge externalities and the role of patents

If, by giving rise to a monopoly, the patent reduces the social surplus created by the innovation, it can also increase that surplus in another way,

namely by favoring the diffusion of knowledge. An innovation can be defined as a set of new information. Information is a highly specific type of good. It is by nature non rival, because it is not destroyed when it is consumed. A mathematical theorem, for example, does not deteriorate with use. Non rivalry, combined with free access and use (i.e., non-exclusivity), is key to the knowledge externalities created by innovations. The information that makes up an innovation can be used without limit, by everyone. These are positive externalities, because they contribute to social welfare.

Knowledge externalities play a particularly important role in the research sector, where R&D activities build on the results of past innovations. This is the meaning of Isaac Newton's famous quote "if I have seen further it is by standing on the shoulders of giants." And it is in part because Albert Einstein knew and wanted to surpass Newton's theory of gravity that he developed the theory of relativity. Similarly, a team of engineers in charge of developing a new type of internal combustion engine does not have to reinvent everything from scratch; they can draw on all the existing patents relating to internal combustion engines.

Although the information about an innovation is non rival, it must be accessible to create an externality. In the absence of a patent, this condition is not automatic. Indeed, ownership of a product does not necessarily imply provision of information about the technology. Often the innovation can only be accessed by reverse engineering the product. This means taking it apart in order to understand how it works. This method works well for some technologies, such as semiconductor chips, because their printed circuit boards are clearly visible. It may be much more time-consuming and costly in other cases. For example, it is extremely difficult to find the source code-the program-of a piece of software from its object code-the translation of the source code into machine language, which is the only code that can be accessed from the commercialized version of the software.

In this regard, another justification for patents is the requirement for filers to publish information about their innovations. This makes the knowledge contained in innovations accessible at no cost. Apart from being an incentive to invest in R&D, the temporary monopoly is thus also an incentive for firms to divulge the knowledge produced. This function of patent systems is concretized in patent office databases, which offer free access to all

existing patents. In this specific case, patents are thus a factor in the diffusion of information. They increase the social return of the innovation, without diminishing the private return for the innovator.

● Negative effects of patent races

The impact of the monopoly conferred by patents on the amount and allocation of surplus or on knowledge externalities concerns the benefits of innovations. But patents also have an influence on their cost. The monopoly they grant can create a situation in which only one of several firms that have undertaken investments in R&D will appropriate all the profits generated by an innovation. This "winner takes all" situation triggers patent races, with the result that the future value of an innovation is squandered on R&D investments.

A simple model of a patent race

The depletion of the value of an innovation by a race to patent can be illustrated by a simple model where $p(n)$ is the probability that the innovation will be produced when n firms have undertaken investments in R&D. Every additional investment increases the probability that the innovation will be produced, but less than the previous investment. Therefore is $p(n)$ increasing and concave. If n firms have taken part in the race and the innovation is realised, each firm has one chance in n of obtaining the patent. Consequently, if the innovation has a value of v (the same to simplify for the innovator and for society) and the cost of an R&D investment is c, the expected profit of a firm that enters the race is:

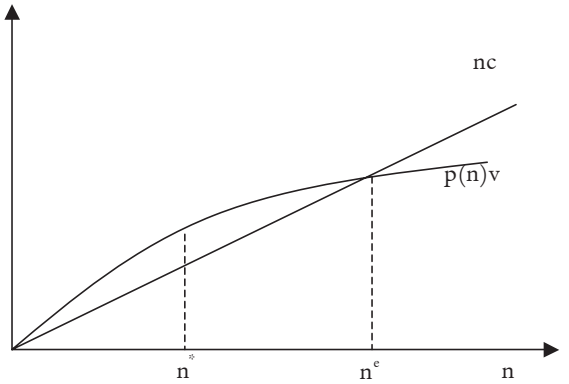
$$E(n) = \frac{p(n)}{n} v - c \qquad (1)$$

Firms will enter the race as long as the expected profit is positive $(E(n) > 0)$. As the increase in the number of firms reduces the expected profit, the total number n^e of firms participating in the race will finally be the one that verifies $E(n^e) = 0$. It can easily be verified that the social benefit for the race – i.e., the difference between the expected benefit for society and the sum of investments undertaken – is zero.

Indeed, $E(n^e) = 0$ means, from (1), that:

$$p(n^e)\, v - n^e c = 0$$

This simple model explains the dissipation of the innovation rent by the patent race.



A graph version of the model shows why this race is suboptimal. The graph represents the expected benefit (private and public) $p(n)v$ of the innovation as a function of the total investment effort n, and the social cost of that investment effort, nc, also a function of n. The socially optimal investment effort is one that maximizes the difference between the expected social benefit ($p(n)v$ curve) and the corresponding total R&D cost (line nc). On the graph, this is shown as level n^* . But the ability for firms to enter the patent race freely leads to point n^e, where the total cost equals the expected profit. We observe that $n^e > n^*$. Thus the number of firms participating in the race is always higher than the number that maximizes welfare. The excessive investments undertaken by firms waste the benefit that society derives from the innovation.

Patent races can be considered as a particular case of the more general problem of the tragedy of the commons. The prospect of producing an innovation encourages too many firms to attempt to obtain the patent. In the end, these firms will have undertaken combined R&D investments above what would have been sufficient to produce the innovation. In other words,

the collective investment effort is higher than the optimal effort. It does not maximize the social return of the innovation, defined as the difference between its expected profit and its cost.

The phenomenon of patent races can take another form. For all firms to enter the race freely, they must be informed that there is an innovation to be made [O'Donoghue et al., 1998]. Unless the opportunity to develop an innovation is public knowledge, the race will be limited to the firms that have the relevant information. This is also the case where a fixed number of already established firms are the only ones to have knowledge about a technological lead to explore and the technical and financial resources to conduct that exploration. For example, it is likely that only major oil companies will invest in developing new deep sea drilling techniques. This does not eliminate the race or excessive level of investment, however. In the absence of new entrants, the competitors in place will make stronger efforts. The higher the expected returns, the more the oil majors will invest in research.

These discrepancies between the social return of patents and their private return – the only one that motivates innovators – prompts us to take a detailed look at the characteristics of patents. How does the duration of a patent influence the differences between social and private costs? Can the scope of a patent affect deadweight loss? Do knowledge externalities always escape from the control of the patent owner?

Optimal patent duration

The duration of a patent is undoubtedly the most direct way that legislators have of controlling the scope of rights granted to innovators. Patents currently last for 20 years. Extending that duration would amount to granting additional profits to innovators and thus increasing their incentives to innovate. So why don't patents last indefinitely? For an innovation to be produced, the profits generated by the patent must cover R&D costs. By guaranteeing maximum profit to the innovator, an infinite monopoly would make it possible to recoup even bigger investments, which would mean more innovations. So why is the incentive power of patents restrained by a time

limit? The problem is that long patents also have a cost, stemming from the discount rate, the "cost of time," and from the deadweight loss generated by the monopoly.

- Why is patent duration limited?

The discount rate is the first limit on the efficiency of long patents, because it erodes the incentive power of profits that are a long way off in the future. An innovator compares his future profits to the R&D investment he must undertake in order to produce an innovation. For the decision to innovate to be profitable, the money invested in research must generate at least as much profit as it would if it were invested elsewhere, such as in an interest-bearing bank account. The more distant in time the expected profit from the innovation, the less able it is to compete with the cumulative interest that a bank account would generate.

The value of a patent

A patent is not a full property right, because it does not last as long as the good that it protects. Its validity is limited to 20 years, whereas the information it protects will never disappear. A patent is nevertheless an asset, which can be bought and sold at a certain price.

What is the right price, i.e., the correct value of the patent asset? The price must allow the owner to sell the patent without losing money. It must also enable the buyer to acquire the patent without losing money. It must therefore be an accurate reflection of the monopoly profits generated by the patent. More precisely, it must factor in all the future revenues generated by the patent, weighted for their distance in time. Indeed, the same sum of money will have a different value, depending on whether it is collected today or at a future date, because in the intervening time it can earn interest. For example, $100 invested at 10% interest today will be worth $110 (=100*1,10) in a year's time. Conversely, income of $100 that will be generated by a patent in a year's time is worth only $90.90 (=100/1,10) today. Likewise, $100 in two years' time is worth $82.60

today, or (100/1,10)/1,10=100/1,10². The value of a patent is calculated according to this principle of discounting, where every future profit flow is expressed as a present value, also called discounted value.

Let's suppose for example that a patent lasts T years, that the rate of interest is r, and that each year t the patent generates a profit of π_t. The value V of the patent at the time it is granted (at the beginning of T years) is therefore:

$$V = \sum_{t=1}^{T} \frac{\pi_t}{(1+r)^t}$$

We can see that the value of the patent depends negatively on the rate of interest r. This stems from the fact that the higher the interest rate, the smaller the present value of future profits. The value of the patent also depends positively on its duration T. The longer the patent, the more profit can be accumulated. Conversely, the value of the patent diminishes as it approaches term. It is of course zero when $T=0$.

The fact that profits distant in time have less incentive power for the innovator is a first justification for limiting the length of patents. Profit removed in time is less effective at offsetting the social cost of a long patent. This cost results from monopoly pricing. Given this deadweight loss, it is costly for society to extend this monopoly beyond the duration necessary to reimburse the innovator. Extending the duration of patents uniformly thus generates both a benefit and a cost for society. On the one hand, it allows investment-intensive innovations to be financed. On the other, the owners of patents on less costly innovations are needlessly subsidized via an extension of their monopolies.

This tradeoff was first expressed by Nordhaus [1969] to explain the finite duration of patents. He uses a model, a highly simplified version of which is reproduced here, to calculate the optimal duration of a patent. To reach this conclusion, Nordhaus assumes that as the profits of innovations increase, their R&D costs increase even more – i.e., an assumption of diminishing returns of R&D. In that light, beyond a certain patent duration, the social welfare generated by more costly new innovations no longer offsets the loss induced by the extension of existing monopolies.

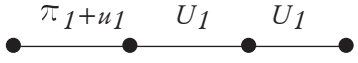
The principle of Nordhaus's model

Nordhaus's model [1969] is used to determine the optimal duration of a patent. This inset presents a simplified version of the model, which illustrates the main idea.

Let us imagine that the lifetime of an innovation is divided into three equal periods. Two innovations can be produced at the beginning of the first period, at R&D costs of $c_1=10$ for the first innovation and $c_2=30$ for the second. If innovation 1 is protected by a patent, it generates a profit of $\pi_t=10$ and a utility of $u_1=2$ for consumers in each period. In the absence of a monopoly, competition will increase the total surplus, and consumers reap the full benefit. As a result, consumer utility becomes $U_1 = 20 > \pi_1 + u_1$. Innovation 2 is more costly and has a higher value. If it is protected by a patent, it is assumed to generate $\pi_2=12$ for the innovator and for $u_2=4$ consumers. Without patent protection, it therefore generates $U_2 = 24 > \pi_2 + u_2$ for consumers.

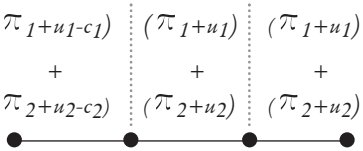
The problem for legislators is to set a patent duration that is long enough for both innovations to be produced. One monopoly period is enough to recoup the investment in innovation 1, for $c_1 = \pi_1 * 1$ year. However, three monopoly periods are required to cover innovation 2, since $c_2 = \pi_3 * 3$ years. The duration of the patent should therefore be three periods. However, the total surplus over all the periods is higher when the patent lasts only one period, even though this means that only innovation 1 will be produced. This is because a longer patent, while it enables innovation 2 to be produced, is not neutral on innovation 1 : it prolongs its exploitation needlessly by two monopoly periods. This negative effect is here greater than the positive effect of producing new innovations.

The patent lasts for one period:



W(1) = 2 + 20 + 20 = 42

The patent lasts for three periods:



W(3) = -22 + 28 + 28 = 34

The result is that a short patent generates more welfare than a long patent: W(3)<W(1). A short patent is therefore preferable, even though it does not enable all the innovations to be produced.

● Adjusting duration through patent renewal mechanisms

Nordhaus's argument can be generalized: the problem is that there is only one uniform duration for innovations of differing values and costs. Specifically, patents are of equal length regardless of the economic agents involved even though the R&D investments required to develop a patentable innovation vary widely from one sector to another. For example, it is much easier to develop a new toaster than a new drug. Elasticities of demand, and therefore deadweight loss induced by a monopoly, are also highly variable. If the market power of a monopoly is higher in the pharmaceuticals sector than in chemicals, it would be logical, in the light of Nordhaus's argument, to compensate that power with a shorter patent duration in pharmaceuticals.

Modern patent systems provide for a way to counter the uniform length of patents. A renewal mechanism allows firms to modify the duration of their patents at the margin. At regular intervals, they can choose to extend the duration of their patent, up to a maximum term, in exchange for a fee, the amount of which increases over time. In France, for instance, fewer than 50% of patents are maintained beyond 10 years [Schankerman, 1998], and fewer than 7% are extended to their maximum term [Pakes, 1986]. Is this solution socially efficient [Scotchmer, 1999]? The older a patent, the higher the expected profit from an additional year of monopoly must be to offset the renewal fee. Consequently, protection will only be extended on innovations with a higher value. Renewal is therefore useful insofar as these innovations are also the most costly.

To conclude, economic analysis thus provides a key argument in favor of limiting patent duration: it is preferable to forgo the creation of the most costly innovations in order to expand consumer access to less costly innovations. Looking at economic effects also highlights the way fee-based patent renewal systems work: the particular effect of taxing innovators who

want to extend their patents is that innovations are selected according to their value.

Optimal patent breadth

The concept of patent breadth measures the use that the innovator can make of the patent vis-à-vis his competitors. A narrow patent does not provide sufficient protection against infringement; a broad patent effectively dissuades competitors from imitating the innovation. Patent duration is set by law and is unambiguous. By contrast, patent breadth is defined only indirectly by law, and is often interpreted from an economic viewpoint by the courts as a last resort. The question of the best way to define patent breadth remains open. By favoring the owner over the competition, a broad patent reinforces the incentives to innovate. Does this mean that patent length and breadth are equivalent variables of public action? Is there an optimal breadth?

● The relationship between patent breadth and the legal definition of a patent

Patent breadth is not a legal concept. It is therefore important to clarify the relationship between the economic concept and legal practice.

A patent consists of two parts: a description of the innovation and a list of claims. It is these claims that delimit the rights conferred by the patent, and therefore its breadth. To ensure that the claims are not excessive, they must be consistent with the description of the innovation. However, the law stipulates that an innovation is only patentable if its description meets three criteria. The precise definition of these criteria varies from country to country, but is substantively the same. For example, the European Patent Office's patentability criteria for an innovation are novelty, inventive step, and industrial applicability. Breadth is thus initially determined by a patent office examiner, who applies the three criteria and evaluates the consistency between the claims and the description of the innovation.

A firm armed with a patent can impose its legal monopoly by suing a

competitor for infringement on the basis of the claims of the patent. However, competitors often defend themselves by challenging the validity of the patent in the light of the patentability criteria. Thus, after the patent office examiner, a judge can confirm, invalidate or redefine the breadth of a patent. In addition to patentability criteria, case law and the doctrines that ensue from it are thus another way to define breadth. The U.S. "doctrine of equivalents" is an important example, which supports an increase in patent breadth. It evaluates the breadth of a patent by interpreting the spirit, rather than the letter, of the claims.

Keys to understanding the concept of patent breadth

The description of a few patents can assist our intuitive understanding of breadth. The examples presented here are borrowed from Merges and Nelson [1990].

In 1895, Thomas Edison challenged the validity of a very broad patent for materials used in light bulb filaments. The patentees had found that carbonized paper worked as an effective light-emitting conductor in light bulbs. Based on this invention, they filed a patent claiming the right to use all carbonized fibrous or textile material as an incandescing conductor. Edison won the case because the claims exceeded what the patented invention made it possible to produce technically. In particular, they did not say which carbonized materials could be used successfully as incandescing conductors. This example illustrates the requirement of a link between the description of the invention and the claims.

The next example is an illustration of the doctrine of equivalents. International Nickel obtained a patent that covered a cast ferrous alloy. The patent described the addition to molten iron of a "small but effective" quantity of magnesium, fixed by the patent at "about 0.04%" as a minimum. International Nickel accused Ford Motor Company of infringement when Ford began making a nodular iron, even though Ford's iron contained under 0.02% magnesium. Although this technique was outside of the literal scope of the claim, it was judged to be an equivalent substance, and thus to infringe the patent.

Having specified the links between breadth and the legal definition of a patent, we can come back to our question: is breadth a comparable incentive instrument to length for innovators? More precisely, to provide a given level of incentive, is it better to grant innovators short broad patents or long narrow patents? This question has sparked numerous works of economic theory, which have provided elements for a complete analysis.

● Breadth and market power

One way to evaluate the breadth of a patent is in terms of the power it confers on the product market [Gilbert and Shapiro, 1990]. In this case, a broad patent reinforces the innovator's monopoly by providing better protection against infringement. In particular, it offers a way of excluding from the market more products that differ from the patented product but that are substitutes for it [Klemperer, 1990]. For example, Howard Head, the inventor of the oversized tennis racket, holds a patent that gives him a monopoly on rackets with a strung surface of between 85 and 130 square inches. Because there are no fallback solutions, consumers are captive and the patent owner can thus charge the highest prices and increase his profits. The strategy adopted by Texas Instruments in 1986 is another illustration of this [Hall and Ziedonis, 2001]. After successfully asserting its patents in court during 1985-1986, TI used this confirmation of the breadth of its patents to charge higher royalties to the firms using its technology.

Broadening a patent to strengthen the innovator's monopoly increases the deadweight loss and consequently reduces total welfare. In comparison, the neutrality of patent length on market power makes it an easy tool to use. Increasing the length extends the monopoly over time. However, the market power and deadweight loss it creates at a given time remain constant. Choosing between patent length and breadth amounts to comparing the social cost of extending the monopoly over time to that of reinforcing the monopoly during the fixed duration of the patent. In their first model designed to determine optimal breadth, Gilbert and Shapiro showed that deadweight loss increased at a faster rate with breadth than with length. This led them to conclude that an infinite-lived narrow patent was preferable to a short-lived broad patent to provide a given level of incentive.

- Breadth measured by the cost of imitation

Evaluating patent breadth in terms of market power makes it easier to understand its effect on competition. However, this overlooks the effects of breadth on research effort. Where do potential rival products come from? What does it cost to create them? To answer these questions correctly, we need to apply a more precise definition of breadth, in terms of technology. Indeed, the wording of a patent designates a technology rather than the services it renders. A patent thus leaves room for other innovators to compete with the innovation by using different technologies so that their products cannot be considered imitations. In other words, competitors can circumvent a patent and offer products that can be substituted for the innovation.

What is the effect of breadth on their strategies? If patent breadth is interpreted in terms of technology, the broader the patent, the more difficult it will be to imitate the technology or offer an alternative. Gallini [1992] proposes a definition of breadth that explains its effect on competitors. Breadth can be measured by the R&D cost required to imitate a patented innovation without infringing the patent.

In that case, the patent no longer gives the innovator a monopoly over a market. Rather, it defines the conditions under which the innovator must share the market. Because the innovation can be freely accessed once the patent expires, it is only possible to make a profit in the market during the validity of the patent. The longer the patent, the more incentive imitators have to invest in the creation of alternative technologies. By contrast, a broad patent makes it costly for imitators to enter the market. In other words, a long patent attracts imitators by giving them the time to recover the cost of their imitation, whereas a broad patent dissuades imitators by increasing the cost of imitation.

What are the social consequences of patent design? A long patent creates competition by encouraging imitation. Although limited to the innovator and the imitators, this competition benefits consumers. However, the imitation also has a cost for society. The R&D expenditure undertaken by the imitators is useless, because an equivalent technology – the patented technology – has already been developed.

In a model that takes these different effects into account, Gallini

reached the opposite conclusion to Gilbert and Shapiro, by showing that a short, broad patent is generally preferable. In other words, according to Gallini, it is better to have a strong monopoly for a short period than an oligopoly for a longer period with the needless imitation costs it generates. A simple model helps us understand the logic of this result.

The principle of Gallini's model [1992]

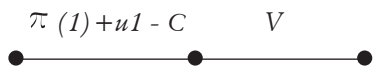
Let us imagine an innovation with a lifetime that can be divided into two periods. If the innovation is distributed free of charge, it creates a surplus of $V=40$, which fully benefits consumers. If there is a monopoly and no imitation, the total surplus $S(1)=25$ consists of the monopoly profit $\pi(1)=20$ and the consumer utility $u(1)=5$. If there is one imitation, the market becomes a duopoly. The total surplus is then $S(2)=30$, divided between a profit of $\pi(2)=10$ per firm, and a utility of $u(2)=10$ for consumers. Lastly, if there are two imitations, the total surplus becomes $(3)=35$, i.e., $\pi(3)=5$ for each firm and $u(3)=20$ for consumers. We verify that $V>S(3)>S(2)>S(1)$, which corresponds to the fact that the deadweight loss increases as competition decreases.

The problem for regulators is to design the optimal patent. This can be done by choosing the patent duration: one or two periods. It can also be done by choosing the breadth, i.e., the cost of R&D, noted as C, required to produce the innovation or an imitation.

One possibility is to design a short patent (one period) that is sufficiently broad to prevent any imitation. The R&D cost must be higher than 10, i.e., higher than any imitator's profit during the validity of the patent. Let us assume it is 11. In this case, the first innovator would enjoy a monopoly profit, which would be sufficient for the innovation to be produced.

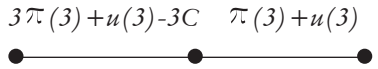
The alternative consists in designing a long patent (two periods) that is sufficiently narrow to allow imitation. Let us consider that the imitation cost is less than 10, say 9. In this case, two imitations will be produced.

Patent is short (one period) and broad (C=11):



W(1) = 14 + 40 = 54

Patent is long (two periods) and narrow (C=9):



W(2) = 8 + 35 = 43

Therefore W(1) >W(2)

The total surplus is higher if the patent is broad and short. This result can be ascribed to two main factors. Firstly, the long patent prolongs the deadweight loss over an additional period. But, more importantly, the prospect of reduced competition during the lifetime of the patent attracts imitators. However, although their entry on the market lowers the monopoly price practiced by the innovator, it also uselessly multiplies R&D investments. Imitation therefore causes useless duplications of investment, which do not necessarily offset its positive effect on competition.

● From technology to market

An approach to breadth from the angle of technology is useful because it sticks closely to the legal definition of the patent and highlights the dynamics of innovation and imitation. It is nevertheless still incomplete, because it does not take the patent owner's ability to grant licenses into account. Licensing offers the patent holder a way of voluntarily sharing the market with potential imitators, rather than letting them invest in their own alternative technologies [Gallini, 1984]. What are the consequences of license agreements on R&D strategies and consequently on optimal breadth?

By granting licenses on his technology, the patent holder creates new competitors on his market. His monopoly profit is therefore diminished, but to a limited extent, because he can appropriate the profit generated by the competitors he created through license royalties. What can be gained from diminishing one's market power in this way? Creating licensed competitors is in fact a way to lower the price while maintaining control of the market. The patent owner can grant licenses until the market price becomes dissuasive for

imitators. This will occur when the expected profit of an imitator, at the level of competition prevailing on the market, is insufficient for him to recover his R&D investment.

The cost of imitation is therefore a determining factor. If imitation is very costly, the patent owner does not need to grant licenses – he can take the full profit from his monopoly. Conversely, if imitation is easily affordable, the patent owner is compelled to forgo part of his profit by granting licenses, in order to dissuade imitators. This case is favorable to social welfare. It enables society to benefit from a competitive price, by saving on redundant R&D investments. The only problem is to ensure sufficient profit to encourage the first innovator. Maurer and Scotchmer [1998] showed that this condition is met when the cost of an imitation is sufficiently close to the cost of the first innovation. They draw the conclusion that patents should penalize imitators, but not good-faith inventors who have produced a competing innovation by their own means.

This result is particularly interesting as it also responds to the problem of patent races. Indeed, the prize for the winner of the race, i.e., the profit reaped by the innovator, is not as great if the patent owner is forced to license his innovation in order to dissuade imitators. This makes a race less attractive, which in turn reduces redundant investments. A narrow patent can thus save imitation costs and limit the excessive costs of patent races.

Models of breadth

	Gilbert & Shapiro [1990]	Gallini [1992]	Maurer & Scotchmer [1998]
Product market	yes	yes	yes
Cost of imitation	-	yes	yes
Licenses	-	-	yes
Optimal patent	long and narrow	short and broad	long and narrow

Should we conclude that length must prevail over breadth in the design of the optimal patent? This seems reasonable... as long as it is applied reasonably! The arguments presented so far relate to the protection provided by patents against imitation and competing innovations. Breadth can be measured as the difference between the competing innovations and the patented innovation. This definition of breadth has its limits, however. Indeed, an important aspect of breadth has been deliberately ignored until now. A patent owner can protect himself against competing innovations that differ from his own. But he may also be confronted with another form of innovation that, without necessarily representing a threat, represents an improvement on his own invention. The technological extension of innovations raises a new question about patent breadth: does intellectual property apply also to the posterity of an innovation? The originality and implications of this question merit separate analysis.

The efficiency of patents in the case of cumulative innovations

Protection of R&D investments is not the only purpose of patents. They also facilitate the diffusion of knowledge externalities, as was shown in the first part of this chapter. The publication of patents makes scientific knowledge public, which can benefit other researchers. It can also assist future research indirectly, for example by helping to better define a question that remains open. But publication can also open the gates for research that is directly linked to the initial innovation and that would not have been undertaken otherwise. The pioneer patent filed by George Selden in 1895 is an example. Selden's patent, which described for the first time an automobile powered by an internal combustion engine, spurred many innovations aimed at improving on it. This eventually led to the modern engines used today. In another field, the Cohen-Boyer patent application filed in 1973 was a similar event. The patent describes gene coding of proteins and its publication opened up a vast field of research in genetic biology. Innovations that result from other innovations are termed "cumulative". Cumulative innovations are common in information technology and biotechnology. Without necessarily

replacing the initial innovation, they use and reproduce it. Should they be considered as infringements?

- What is a cumulative innovation?

The sequential link between cumulative innovations can take different forms. One category of cumulative innovations consists of innovations that improve the quality of an existing product, for example, the addition of a new element to increase the resistance of an alloy. Another category is innovations that reduce the cost of a production process, for example the discovery of a catalyst that can speed up production of a chemical product. A third type of cumulative innovation is the discovery of new applications of an invention. The idea of using a steam machine-originally designed to power factories-to drive a ship is an example of this type of cumulative innovation. Finally, cumulativity is characteristic of research tools, which are innovations that are used to produce other innovations.

- Sharing incentives and holdup

When several innovations depend on one another, the exploitation of the technological prospect often requires the involvement of several different actors. The development of a drug, for example, is the culmination of several discoveries, involving a number of research teams, both fundamental and applied. How should the profits generated by the drug be shared? Should a patent be given to each innovator, or should the first innovator be given all the rights on later innovations? Although the ultimate success of the research is in everyone's interest, an inadequate distribution of the rights among the different successive innovators risks nipping it in the bud. A rational agent will think twice before undertaking research if the commercial exploitation of the result depends on the holder of a previous patent. This is the classic economic problem of holdup.

Holdup can be explained using a simple model borrowed from Green and Scotchmer [1995]. In the model there are two cumulative innovations. Taken in isolation, the first innovation has a value of v_1. It can only be produced by firm A, at an R&D cost of c_1 . The second innovation can only be

produced by firm B, and only if the first already exists. It has a value of v_2 and requires an R&D investment of c_2. We assume that $v_1 + v_2 - c_1 - c_2 > 0$. It is therefore socially desirable for both innovations to be produced. How can patenting be used to achieve this result?

One possibility is to grant a patent for each innovation. This solution only works, however, if the value of the first innovation is sufficient to cover its cost. Conversely, if $v_1 - c_1 < 0$, it will not be profitable for firm A to invest. In this case, since the first innovation is not produced, the second will not be produced either.

Therefore, should firm A be given the rights to the posterity of its innovation? That would mean that firm B has no guarantee of recovering its investment. Once firm B has invested, it could only make a profit from its innovation with the agreement of firm A. It is therefore at the mercy of the conditions imposed by firm A, which has every interest in appropriating the total profit of the second innovation, or v_2. Knowing that it cannot recover its investment, firm B will not invest. Lastly, if $v_1 - c_1 < 0$, since firm B will not invest, firm A has no interest in investing either. Thus, by allowing holdup, which discourages investment, a broad patent covering later developments of an innovation is less efficient than several narrow patents.

● Cumulative technologies

Major new technologies such as information technology and biotechnology are highly cumulative in nature. Software source codes consist of elementary programming "bricks," which can be used in different software programs. They are also written in program languages that comply with protocols — such as TCP-IP for Internet applications — which are themselves innovations. This strong cumulativity explains why the application of intellectual property to software has raised concerns among many programmers, who have been worried about working under the constant threat of an infringement suit.

Cumulativity in biotechnologies relies on the essential role played by research tools, which are products of fundamental research. The issue is whether these tools are patentable or not. If they are, the research they enable is controlled by the owners of the corresponding patents and contributes to

funding the tools. If they are not, they can be used by everyone. Aside from the incentive to innovate, patenting is thus mainly a choice about the organization of research. The discovery of monoclonal antibodies provides an interesting example. In 1975, two researchers, Kohler and Milstein, succeeded in using cells to create antibody "bio-factories". They did not patent their invention, although it won them a Nobel prize. As their discovery had many commercial applications, it was rapidly developed. Hybritech was the first to use it to make diagnostic kits, and filed a patent on the kits. The patent, upheld by the courts, enabled the company to exclude competitors that had produced similar kits in the meantime. In that case, exclusivity of research on a huge technological lead was granted to a single firm, even though the major innovation had been discovered by others.

Whether in information technology or biotechnology, semiconductors or aeronautics, the cumulative nature of some categories of innovation thus raises specific intellectual property problems. Because these innovations are technologically dependent on one another, it is no longer possible to seek optimal incentives by considering each innovation in isolation.

● Cumulative innovations and the optimal patent

What is the optimal patent when innovations are cumulative? One position is to advocate a "deep" patent, which covers all the innovations that follow an initial discovery. By granting the first innovator exclusivity over a technological lead, the patent gives him the power to organize research efficiently [Kitch, 1977]. The threat of litigation for infringement avoids patent races and the excessive investments that go with them. In addition, because the patent is published, other firms can identify new applications, which they can propose to the patent owner. The owner has every interest in licensing the technology or creating research partnerships, when he can benefit from them.

However, the furthering of research by other firms comes up against the problem of holdup. To avoid this problem, the owner of the patent and the other firms must enter agreements ex ante, for example by setting up a joint company. These agreements lay down the terms under which profits from the innovation will be shared before the investment is made. This is not easy because the parties must agree at a stage when the results are still highly

uncertain. In addition, past experience seems to show that deep patents tend to impede innovation [Merges and Nelson, 1990]. For example, in the electric light bulb industry, technical progress was severely slowed for the duration of Edison's patent on the use of carbon filament as a light source. The same thing happened in aeronautics, after the Wright brothers' patented their system for stabilizing and controlling airplanes.

The opposite position is not to apply intellectual property when innovations are cumulative. Innovators are thus put into direct competition, which reduces their incentive to invest. In return, however, they can draw freely on all the existing innovations and innovate in turn without having to worry about infringing a patent. Bessen and Maskin [2000] argue that for innovators, the loss in revenue due to increased competition is offset by the long-term gain of being able to share the available technologies. Open Source software (or "freeware") is an example that approaches this form of organization. In many other respects, however, it is a completely original model of innovation and cannot easily be transposed to other sectors. More generally, the debate on the optimal depth of patents remains open, because it is difficult to define clear solutions on the basis of the arguments to date.

Open Source software and cumulative innovation

The development of Open Source software (also called freely redistributable software or freeware), of which the Linux operating system is the most famous example, is a case of cumulative innovation in the absence of intellectual property. As its name indicates, freeware is available free of charge. But that is not its only feature. The source codes (program texts) can also be accessed by anyone. Users can adapt the software to suit their needs and propose changes or additions, on condition that they make these freely available to everyone. In this sense, freeware licenses are viral in nature – freeware can only be further developed in the form of freeware.

Innovation in freeware relies on an original form of organization. The constant changes made by programmers require a coordination effort to ensure the consistency of the whole. In a firm, coordination depends on hierarchical relationships in programming teams. In the absence of a formal hierarchy, freeware programmers are grouped around charismatic leaders, generally the creators of the software, who have the moral authority to impose their decisions [Lerner and Tirole, 2000].

Another difference is the level of incentive for the programmers, which determines the pace of innovation. Apart from altruism, the main authors of freeware are motivated by career goals or technical challenges. Freeware also changes the direction of technical progress. The innovation process is unusual in that the innovators are consumers who remedy their own needs [Von Hippel, 2002]. Because they have a greater awareness of the problems to be resolved, they tend to innovate faster than firms and pay more attention to the quality of their technical solutions. But this system also has disadvantages. Freeware is often designed for users with advanced computer skills. Functions of little interest to programmers, such as user interfaces, are often of lower quality than in proprietary software. To offset the shortage of incentives, some freeware licenses allow protection by copyright of some innovations at the end of the chain.

This chapter aimed to evaluate the main parameters of patent design – length, breadth and depth – on the basis of a simple criterion: social welfare. This method helps define the elements of an optimal patent. A patent of limited duration creates more welfare than a patent of infinite duration. Between the two ends of this reasoning – patent design and its effect on welfare – are economic agents. Indeed, the final effect of patent design depends on the reactions of agents and their consequences. The merit of narrow patents only appears in the light of the threat represented by imitators and the strategies the patent owner can adopt to counter them. The innovator has every interest in licensing in order to discourage imitators, which also saves useless investment in imitation and reduces the deadweight loss by creating competition. Similarly, the efficiency of protection of cumulative innovations depends crucially on the relationship between successive innovators – on their willingness to create a joint research and development company, for example.

III/Reform and Use of Patents

Over the past 20 years, patents have come to play an increasingly prominent role in OECD economies [OECD, 2004], which in many respects have become "knowledge economies". The number of patent grants has risen sharply, more than tripling in the USA between 1980 and 2001, whereas it was practically stable over the previous two decades. Over the same period, innovation has also expanded rapidly. Is there a link between these two trends?

Harmonization and strengthening of patent law

Since the early 1980s, the United States and Europe have strengthened patent law, sought to harmonize it internationally, and extended its coverage to new areas.

- Intellectual property reforms in the United States and Europe

Until the late 1970s, the U.S. authorities and courts were generally wary of patents. The reforms introduced in the United States since then denote a change in attitude. The Patent and Trademark Act of 1980, known as Bayh-Dole, permits universities and other nonprofit organizations to patent discoveries made in their laboratories. The Act also encourages them to transfer patented technologies to the private sector. In particular, they are

entitled to grant exclusive licenses, which transposes the economic logic of patents to public research. In 1982 the Court of Appeals for the Federal Circuit was established to harmonize patent law nationwide. The other effect of the new court was stronger patent protection. Before 1980, a ruling in favor of a patent holder had only a 62% chance of being confirmed by a court of appeal, whereas 88% of verdicts that rejected infringement or patent validity were upheld by courts of appeal. Between 1982 and 1990, the statistics reflect a much more favorable attitude to plaintiffs. Ninety percent of rulings establishing infringement were upheld, while the proportion of rulings unfavorable to the plaintiff that were confirmed on appeal decreased to seventy-two percent [Jaffe, 2000].

In 1973, the Munich Convention, signed outside of the framework of the European Community, gave rise to the European patent system. This is essentially a centralized procedure for examining inventions at the European Patent Office (EPO), established for this purpose. The centralized procedure ensures that exactly the same patentability criteria are used from one European country to another. It also achieves economies of scale, since filers only have to complete the procedure once for all countries. However, this European patent did not supersede national patents. Once an invention has been declared patentable by the EPO, the inventor must then apply to the countries of his choice to obtain national patents.

This system has serious shortcomings. It encourages innovators to "shop around" for national patents, neglecting small countries where the expected profit is not high enough to cover the costs incurred. This leads to asymmetry between European countries, which reduces incentives to innovate. In addition, litigation for patent infringement takes place in national courts, which multiplies the legal costs for innovators and exacerbates these discrepancies.

To remedy these problems, in March 2003 the European Council finally decided to implement a genuine European patent. From 2010, disputes over patents will be centralized in a community jurisdiction attached to the Court of Justice in Luxembourg. There is still one problem, however: patent claims must be translated into all the languages of the European Union. Under the new system, a patent will cost € 23,000, compared with € 28,000 on average today, but compared with € 10,000 and € 16,500

respectively for a U.S. and a Japanese patent! Since, in practice, English is the universal language of patents, these costs are particularly high. In France, for example, translations are only consulted in 2% of cases.

- International agreements

On another scale, the globalization of intellectual property law has been through several stages, from the Paris Convention for the Protection of Industrial Property of 1883, which applies to patents only, to the TRIPS Agreement of 1994, which relates more generally to "trade-related aspects of intellectual property rights". Three main levels of international integration can be distinguished. First, a country can grant intellectual property rights unilaterally to nationals of other countries. Usually, however, these agreements imply reciprocity, which represents another level. Every contracting state to an agreement thus agrees to treat nationals of the other contracting states in the same way as their own nationals, in return for access to similar advantages for their own nationals in those other states. These two types of agreement do not alter the content of national intellectual property laws. They simply extend their coverage to new categories of persons. The third level of integration is the harmonization of different national laws by defining common rules on the content of intellectual property law. Harmonization may apply to the categories of patentable innovations, the duration of patents or patent examination procedures.

The Paris Convention, signed in 1883, requires the contracting states to grant to nationals of the other contracting states the same rights as to their own innovators. The TRIPS Agreement, negotiated within the framework of the World Trade Organization, represents a major advance toward the harmonization of intellectual property laws. For example, the United States has agreed to extend its legal period of patent validity from 17 to 20 years to comply with the international standard. The agreement also permits patent owners to ban the import of counterfeit products. Most importantly, it includes a general definition of patents. This definition, which adopts U.S. criteria, broadens the scope of patentable inventions. Unlike various national laws, it considers that all technical innovations are eligible for minimum protection, overruling exceptions previously granted to some countries. In

particular, by compelling contracting parties to grant patents on medicines, the TRIPS Agreement opened the way for the Doha Conference on trade-related public health issues.

Pharmaceutical patents: the Doha Conference

Given the considerable investments they require, medicines are one category of innovation where the incentive-giving role of patents works the best. But it is also in this category of innovations that deadweight loss is the cruelest. Indeed, the consumers excluded by monopoly pricing are sick people deprived of the treatment they need, which exists on the market. This exclusion is most harshly felt in poor countries. For example, AIDS affects 42 million people around the world, the vast majority of them in poor countries. Malaria kills 1 million people in Africa every year.

In many cases, a monopoly on supply of a drug in a poor country is highly unlikely to be a significant source of profit for an innovator. It would therefore seem appropriate to make a distinction between useful and harmful patents. Pharmaceutical firms stress the risk that their innovations will be produced by others in other countries, then reimported and sold at knockdown prices in rich countries, which are their traditional market. How can access to treatment be provided for people in poor countries, while ensuring protection of pharmaceutical firms' past and future investments in OECD countries?

This question was the focus of the Doha Conference, organized by the World Trade Organization in November 2001. The concluding declaration of the conference gives priority to access to treatment, by recognizing "the gravity of public health problems afflicting many developing... countries, especially those resulting from HIV/AIDS, tuberculosis, malaria and other epidemics" and indicating that "the TRIPS Agreement does not and should not prevent Members from taking measures to protect public health." Countries can grant compulsory licenses to enable their national industries to produce generic versions of drugs. However, this only applies to

countries that have a pharmaceutical industry, such as Brazil, India, South Africa and Thailand.

The development of mechanisms of parallel imports of generics by other poor countries was therefore decisive for the success of the Doha Agreement, as was the list of diseases covered. The discussion of these issues finally reached a solution at the Cancun Conference in September 2003. Under this agreement, poor countries are allowed to import generic drugs only in cases of public health emergency, and on condition that they take measures to prevent generics being shipped to industrialized countries. These restrictive conditions were imposed by developed countries, led by the United States, which claimed they were required to preserve pharmaceutical firms' incentives to invest. Sales of drugs threatened by the arrival of generics in 2007 have been evaluated at $50 billion, of which $17.8 billion for U.S. firms Merck and Pfizer.

● Extending patents to new categories of inventions

National laws generally indicate certain categories of innovations that cannot be patented. In Europe, for example, Article 52 of the Munich Convention on the Grant of European Patents does not regard scientific theories, aesthetic creations, methods of doing business, and computer programs as patentable "as such". Article 53 excludes plant and animal varieties. However, with the boom in new technologies, patentability has been extended in practice to new categories of inventions, despite the exemption rules.

The case of computer programs is a perfect illustration of this development. In the early 1980s, the U.S. authorities and courts were hostile to software patents. Likewise, the Munich Convention stipulates that computer programs are not patentable. However, in 2002, some 100,000 software patents were granted by the United States Patent and Trademark Office (USPTO) and 30,000 by the EPO. Some of these patents were for embedded software, such as the programs that pilot the cycle on a washing machine. But, in general, they reflect greater tolerance by patent offices,

which now grant patents for software as such. The USPTO is particularly permissive [Merges, 1999]. The European Office is stricter, but official recognition of computer programs as patentable innovations is being examined at European Union level.

On the fringe of software patents, the patentability of "business methods" was made official in 1998 by the Court of Appeals for the Federal Circuit. The ruling in question opened the way for a growing number of applications to patent business methods in the United States: 1,300 in 1998, then 2,600 in 1999. In Europe, these applications have been increasing since the late 1990s, although they are still far below the U.S. level (400 applications all together in 1998 and 1999). The service sector, particularly financial services and electronic commerce, are the driving forces behind this trend. We can cite Cybergold's patent on a method for measuring and rewarding the attention customers pay to advertising, or Amazon's "one click" patent on the easier online shopping method it developed.

The granting of patents on genetic inventions is undoubtedly the most significant aspect of the extension of patentability to new categories of inventions. Since the 1980s, patents have been granted in the USA on bacteria created in laboratories, genetically modified mice and gene sequences. In Europe, national laws have long been an impediment to patenting living things. The European Directive of July 6, 1998 on the legal protection of biotechnological inventions nevertheless aligned European law more closely with U.S. law. It excludes the human body from patentability, but stipulates that genes and gene sequences are patentable, even when they are derived from the human body, if a process has been developed to isolate them.

Intellectual property has also been extended to new categories of invention through the creation of "specially tailored" or "sui generis" rights. The logic behind these reforms is that existing rights – patents or copyrights – are not appropriate protection mechanisms for the inventions in question. In 1984, a sui generis right was created in the United States to protect innovations in the field of semiconductors. In Europe, a directive of 1996 defines a specific intellectual property right for databases to complement copyright protection, which was not considered sufficient by itself.

Strengthening, harmonization, and broadening of patent law have made intellectual property central to innovation policies. We have yet to verify whether this is the right choice, i.e., whether the patent law reforms undertaken in many countries in the 1980s have contributed to promoting innovation.

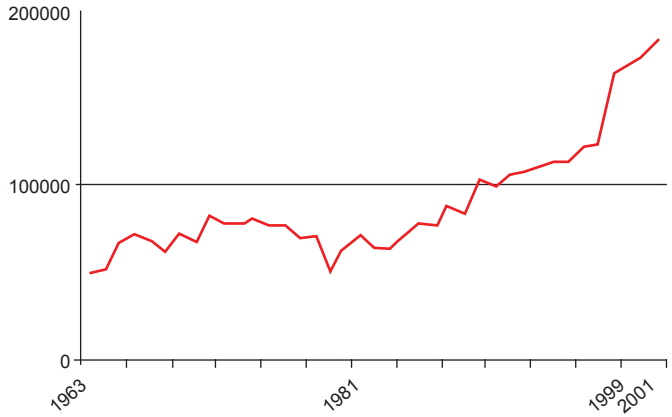
Patents in practice

Does intellectual property fulfill its mission? Is the allocation of a temporary monopoly an efficient way of providing incentives to innovators? If it is, the reforms in favor of patent law that began in the early 1980s should have shown up in an increase in innovation. This link is difficult to establish. To do so we first have to be able to measure innovation. Then we need to explain how the changes in patent law have affected the behavior of firms in a way that is favorable to innovation. Observation of the role played by patents in firms' strategies in fact leads us to minimize or even refute the claim that stronger intellectual property rules encourage innovation.

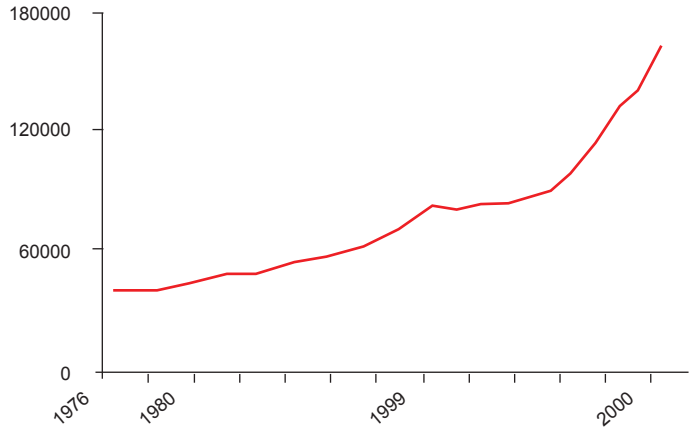
- Exponential increase in patent applications in the past 20 years

The strengthening of intellectual property law since the early 1980s has been reflected in an increase in the number of patents, particularly in the United States. The graph below shows the number of patents granted by the USPTO between 1963 and 2001. Although the general trend of the indicator is upward over the period, a sharp rise appears at the beginning of the 1980s. From that date onwards, patent grants began to increase at a much faster rate. They more than tripled between 1980 and 2001, whereas they had been practically stable over the previous 20 years. For example, 48,971 patents were granted in 1963, 66,170 in 1980, and 183,975 in 2001.

Patents granted by the USPTO, 1963-2001



Patent applications filed with INPI in France, 1976-2000



The example of patent applications filed with the French Institute for Industrial Property (INPI) between 1975 and 2000 shows a comparable trend for European countries, although it began later. There are indeed close links between different national patent systems, since there are numerous "twin" patents protecting the same innovation in Europe and America, and more broadly in the rest of the world. The table below shows the respective proportion of American, Japanese and European holders of patents granted in those three regions in 2001. Except for Japan, which is highly protected, the globalization of patent applications is striking.

Patent grants by geographical origin in 2001

	European Office	Japanese Office	U.S. Office
European member states	*18,303* *53%*	*5,076* *4%*	*28,459* *17%*
Japan	*6,580* *19%*	*109,375* *90%*	*33,223* *20%*
United States	*8,583* *25%*	*6,020* *5%*	*87,607* *53%*
Other	*1,238* *4%*	*1,280* *1%*	*16,750* *10%*
TOTAL	*34,704*	*121,742*	*166,039*

Source: Trilateral Statistical Report 2001 [EPO, JPO and USPTO, 2001].

Why have patent grants soared? One explanation is the beneficial effect of reforms strengthening patent law. The additional protection granted to innovators has encouraged more investment, leading to the discovery and commercial exploitation of new technological leads. Let us look at the figures available for the United States. Investment in R&D by U.S. firms employing fewer than 5,000 people more than doubled between 1987 and 1997 [National Science Foundation, 1997]. The volume of patent grants has risen in all sectors, but the increase is especially large in new technologies. Patents granted in information technology and biotechnology more than doubled between 1990 and 2000. The 100 top research-performing American universities tripled their annual income from patents between 1984 and 1994 [Cohen et al., 2000]. Technological progress is therefore one possible cause of the significant increase in the number of patents granted over the past 20 years. This also highlights the pioneering role of the United States in the development of new technologies such as information technology, electronics and biotechnology. However, technological progress is not a sufficient explanation. R&D investment certainly rose at the same time as the number of patents, but does not alone account for the entire increase. At most, we can

conclude at this stage that the higher number of patents is a consequence of increased innovation.

The econometrics of patents.

[from Jaffe and Trajtenberg, 2002].

Patent offices usually establish and maintain patent databases. Innovators and examiners use these databases to view prior art, on the basis of which the novelty and inventiveness of innovations are evaluated. The information contained in patent databases also represents useful statistical indicators for economists and highly practical material for econometrists.

The number of patents granted over a given period provides an interesting measure of innovation, which is otherwise difficult to quantify. In addition, as the referenced patents contain information about the identity of the owner, measures of innovation can be broken down by country, industry or firm.

Every patent also contains references to previous patents in the same technical field. Intended for examiners, these citations must refer to the prior art at the time the patent is drafted. They are also an important source of economic information.

The number of patents is an imperfect measure of innovation, because not all patents cover technologies of equal importance. One way of refining this measure of innovation is to weight each patent for the number of citations it generates in subsequent patents. This technique thus consists in using citations to measure the knowledge externalities created by the publication of patents. Indeed, the more the patented knowledge encourages or facilitates further research, the more the patent will be cited in patents stemming from that research. However, as for innovations, not all citations have the same value. For example, only half correspond to a genuine flow of knowledge and only a quarter to a decisive flow of knowledge.

● An instrument of secondary importance in practice

In fact patents only seem to play an incentive role in a small number of industries. Empirical studies show that the additional profits generated by a patent only have a positive effect on R&D expenditure in pharmaceuticals and biotechnologies [Arora et al., 2001]. These industries are characterized by extremely high R&D costs and by the difficulty of preventing infringers from imitating innovations. In the pharmaceutical industry, a new drug is only marketed at the end of a long process, which begins with general research and ends with clinical trials on patients before marketing. A total investment of around $1 billion is required to develop some 1,000 drugs, of which only one will be marketed in the end. Given these enormous costs, it would be disastrous for a firm if its innovation were to be copied by a competitor. Intellectual property protection is vital to return on investment when it is undertaken by the private sector.

This observation cannot be generalized, however. Several surveys of R&D managers from U.S. firms [Cohen et al., 2000] have highlighted their lack of faith in patents as a way of protecting their innovations. Firms cite trade secrecy as the most effective form of protection, ahead of patents. In the most recent survey, patents are only considered effective protection for 35% of product innovations and 23% of process innovations. By contrast, being the first to market an innovation is regarded as sufficient for 53% of product innovations and 38% of process innovations, and secrecy is considered effective in 51% of cases, both for product and process innovations. Other studies, conducted in Europe, [Lanjouw, 1998; Schankerman, 1998; Combe and Pfister, 2002] confirm these results. They estimate the value of patent protection at between 15% and 25% of R&D expenditure. In other words, patents seem to be inefficient at guaranteeing innovators return on their investment.

The protection conferred by patents must therefore be considered secondary or complementary to other types of protection, namely secrecy and the advantage of being the first innovator in a market. For

technologies of strategic importance, which are central to a firm's competitive advantage, a patent portfolio can provide extra security, by protecting the coded elements of the technology, while the related know-how is protected by trade secrecy [Somaya, 2001]. Philips' recognized world leadership in optical technologies, for example, consists essentially of the experience of the company's laboratory engineers. Patents only represent the visible tip of this technological capital, and mainly offer a way for the company to organize its relations with the rest of the industry-competitors, but also partners under license. The main function of patents is thus to facilitate trade, rather than to provide incentives to innovate.

● The role of patents in trade

Patents facilitate trade in technologies. Empirical studies show that license agreements are more common in industries where intellectual property rights confer effective protection, such as biotechnologies and chemicals [Arora et al., 2001]. The chemicals sector is a good illustration. Far from being used exclusively by patent holders, most innovations are licensed to other firms in the industry. The diffusion of technology is achieved through a vast licensing market, which gives the whole sector access to the most advanced technologies. In the case of a process innovation, innovators see an advantage in granting licenses to their competitors. Each firm reduces its costs, and the benefit of all these cost reductions finally returns to the innovator via royalties. Furthermore, by granting licenses to its competitors, a technological leader can avoid a costly patent race. Indeed, if competitors have access to the best technology, they have less incentive to invest in research to overtake it. The leader thus also avoids having to overinvest to maintain its lead, and at the same time enhances social welfare [Gallini, 1984].

The market in chemical technologies

Companies	Revenues 1988 ($ million)	Total number of licenses (including internal to the corporation) (1980-90)	Average estimated revenue per license ($ million)	R&D expenditure in 1988 ($ million)
Air Liquide (F)	*3,539*	*174 (45)*	*233*	*120*
Monsanto (US)	*7,453*	*144 (31)*	*204*	*590*
Union Carbide (US)	*8,324*	*143 (37)*	*192*	*59*
Shell (UK)	*11,848*	*172 (71)*	*183*	*773*
ICI (UK)	*21,125*	*148 (55)*	*168*	*1,020*
Air Products (US)	*2,237*	*88 (29)*	*107*	*72*
Amoco (US)	*4,300*	*78 (23)*	*99.5*	*?*
Phillips (US)	*2,500*	*77 (22)*	*99.5*	*?*
Rhône-Poulenc (F)	*10,802*	*72 (28)*	*79.6*	*632*
Texaco (US)	*1,500*	*53 (9)*	*79.6*	*?*
BASF (Ger)	*21,543*	*82 (45)*	*66.9*	*1,010*
Exxon (US)	*9,892*	*84 (49)*	*63.3*	*551*
Mitsui Toatsu (J)	*2,991*	*50 (15)*	*63.3*	*?*
Hoechst (Ger)	*21,948*	*78 (44)*	*61.5*	*1,363*
Du Pont (US)	*19,608*	*99 (66)*	*59.7*	*1,319*

Based on Arora and Fosturi [2000]

By allocating ownership rights over innovations, patents also enable vertical specialization. In the chemicals industry, some firms have specialized in R&D activities. They derive their revenues mainly from their patent portfolios by licensing their innovations to major corporations more geared toward production. Similarly, in the 1980s small-sized new entrants played a growing role in the semiconductor industry [Hall & Ziedonis, 2001]. These

firms specialized in new printed circuit designs and licensed their innovations to larger firms. The small firms took advantage of the allocative role of patents in order to specialize. The reinforcement of patent law has also enabled them to attract capital by protecting their first innovations.

Intellectual property plays a similar role in biotechnology. By making it easier to achieve a return on investment and to obtain financing from venture capitalists and the capital markets, intellectual property has encouraged the entry of private agents [Henry et al. 2003]. On the basis of their intellectual property rights, these innovating firms set up cooperation arrangements with traditional agents, namely universities and public laboratories. They also license their discoveries to downstream sectors such as pharmaceuticals, chemicals and seeds. However, the USPTO's generosity has triggered patent races and the multiplication of rights over genes and gene fragments. As a result, potential innovators are forced to acquire a large number of licenses in order to work, at the price in particular of high transaction costs [Henry et al. 2003]. Indeed, several gene fragments are required to produce a therapeutic protein or a diagnostic kit [Heller and Eisenberg, 1998]. Similarly, research requires access to protected databases, for which fees are increasingly charged [Maurer and Scotchmer, 1998b]. Contrary to its intended purpose, intellectual property is paradoxically becoming an impediment to innovation.

A legal weapon

Patents can actually be a powerful means for some firms to block technological development. Unlike cooperative information sharing, patent portfolios create a barrage of intellectual property rights, designed to exclude competitors from particular avenues of research or from the market altogether [Barton, 1997]. By constantly filing new patents to prevent the entry of new competitors, Xerox, the inventor of the photocopier, succeeded in maintaining its monopoly for years.

These strategies based on patent portfolios are particularly common in sectors such as electronics and information technology. Innovations in those sectors are constantly being improved on and combined to produce marketable final products. The hard drive of a personal computer, for

example, includes innovations protected by hundreds of patents. The different patents required to manufacture the hard drive belong to different owners. The patent holders must therefore cooperate by granting cross licenses to each other. A firm's bargaining power relative to the others depends on the size of its patent portfolio. The dispute between Intel and Intergraph in 1998 is enlightening here. Intergraph, a company that manufactures workstations, sued Intel on the grounds that Intel's microprocessors infringed some of its patents. In retaliation, Intel invoked its intellectual property rights to bar Intergraph from continuing to use its technology. In other words, Intergraph sued Intel for infringing its patents, so Intel prohibited Intergraph from using its trade secrets – which Intergraph needed to build systems compatible with Intel's.

The determinants of patent litigation

In an ideal world, all players would know exactly what their rights were and there would never be any litigation because the outcome of any legal action would be known in advance. The future losers would have every interest in saving on the cost of pointless litigation, by complying from the outset with the expected verdicts. By contrast, the day-to-day workings of real courts stem from the ambiguity of law, which creates litigious situations. The likelihood of litigation is higher when the parties have different expectations about the outcome. This is the case when patents concern a new technological area, for which there are few legal precedents.

Litigation is also more likely when the stakes are high. Based on U.S. data, Lanjouw and Schankerman [2001] showed that litigation for infringement is more common when the innovations concerned are at the base of a chain of cumulative innovations, i.e., when they represent a technological lead. By taking legal action, patent owners may also be attempting to establish a reputation. Indeed, patents are cited more often when they have been involved in litigation. Such a reputation also helps a firm enforce its other patents. Consequently, infringement litigation benefits large firms more, because they have large patent portfolios. Their portfolios also put them in a better position for negotiating settlements, in the form of cross license agreements. It is harder for startups to enforce their rights, despite the strategic importance of patents for them. Without patent portfolios, they lose out on both the effects of reputation and bargaining chip [Lanjouw and Schankerman, 2001]. A survey conducted in the biotechnology sector revealed that 55% of small firms regard litigation as an impediment to innovation, compared with only 33% of large firms [Lerner, 1995].

In general, legal action is rarely initiated and even less often taken to term, because firms often have an interest in settling to avoid high court costs [Crampes and Langinier, 2002]. In the United States, the median cost to each side of a trial and appeal is estimated at $1.5 million, compared with $800,000 for an out-of-court settlement. Of some 1,600 patent lawsuits filed each year, only 100 go as far as a court verdict [Lemley, 2001]. A dispute is thus an opportunity to clarify the relationship between two firms before negotiating the amount of royalties, for example.

The classic line of defense for an infringement defendant is to contest the validity of the patent at issue. By entering an agreement, the parties avoid the risk of the court overruling the patent. The parties will thus choose to settle in the shade of the monopoly guaranteed by the patent, rather than risk the appearance of new competitors if the patent is cancelled and losing their profits for good.

Empirical studies highlight the general effect of patent portfolio strategies in the semiconductor sector [Hall & Ziedonis, 2001]. Semiconductor firms say they put more faith in secrecy and the first innovator's advantage than in patents to protect their innovations. Their propensity to patent nevertheless doubled between 1982 and 1992, from 0.3 to 0.6 patents per million dollars spent on R&D. In microprocessors, 25,000 patents were granted in the United States between 1988 and 1998. In 1998, a total of 4,714 patents were registered, compared with fewer than 1,500 ten years earlier. This apparent paradox between discourse and practice stems

from the increase in patent portfolio strategies from the early 1980s onwards. As the authorities changed their attitude to patents, large companies started systematically filing for patents to reduce the risk of being blocked by someone else's patent and to be able to negotiate access to existing technologies on the best terms. Roger Smith, an intellectual property law counsel with IBM explained in 1990: "The IBM patent portfolio gains us the freedom to do what we need to do through cross-licensing – it gives us access to the inventions of others that are the key to rapid innovation. Access is far more valuable to IBM than the income it receives from its 9,000 active patents. There's no direct calculation of this value, but it's many times larger than the royalty income, perhaps an order of magnitude larger."

Information technology is another complex technology, where the strategic role of patent portfolios could stifle the incentive effect usually expected from intellectual property. As we have seen, patent offices started granting software patents in the 1980s. Since 2000, they have risen to 30,000 in Europe and 100,000 in the United States. Since this sector has seen major technological progress in the absence of strong intellectual property rights, many fear that holdup, in the form of infringement litigation, could dissuade many innovators that do not have patent portfolios to defend themselves. Indeed, most software patents are held by firms in the semiconductor sector. IBM alone holds 8% of these patents.

- The role of patent offices

Patent offices act as a filter. Their role is to examine patent applications on the basis of patentability criteria – novelty, inventiveness, and technical feasibility – in order to exclude minor or irrelevant innovations, thus avoiding unjustified monopolies. Failure to enforce the criteria can encourage firms to seek rents by patenting techniques that are already commonly used or ideas that are far too general. It is therefore crucial for patent office examiners to apply the criteria correctly. This is not always the case, however, particularly in the United States, owing to certain organizational factors at the patent office.

USPTO examiners have to justify their decisions only when they reject a patent application [Lemley, 2001]. Furthermore, their performance system

rewards the quantity of applications processed, rather than the quality of examination [Merges, 1999], which is an additional incentive to be lenient on applications. By contrast, the EPO can be considered relatively efficient.

After examination by the patent office, patent grants can be opposed by third parties, either with the office or in court. This system is imperfect in that no competitor has an interest in incurring the cost of opposition in the place of the others. As a consequence, the validity of patents is usually only opposed by firms accused of infringement in court, and not at the level of the patent offices. Here again, the European system is probably more efficient, since the rate of opposition in Europe is more than three times higher than the rate of reexamination in the United States [Graham et al., 2001].

A comparison of their procedures suggests that the EPO is better equipped than the USPTO to sort patent applications. This helps explain the exponential increase in the volume of patents granted in the United States, and the new role played by patents in firms' strategies. More generally, reforms to strengthen intellectual property have sometimes perverted it. Beyond their incentive role, patents have become a strategic weapon that is pushing market competition into the courts. Excessive generosity by patent offices and courts toward patent filers and owners can encourage firms to seek intellectual property rights for the economic power they confer, independently of their R&D efforts. These strategies, which consist in building patent portfolios to exclude competitors from technological leads, also risk stifling innovation, by imposing a cost on it. They create stable sectors dominated by a few incumbents and closed to new entrants other than firms specialized in R&D.

IV/Economic Analysis of Copyright

Copyright protects a wide variety of literary and artistic works, ranging from essays to photographs, from plays to music, from airport bestsellers to priceless works of art. To enjoy copyright protection, a work must be original – in other words, it must originate from the author. The list of protected works is therefore not closed. It grows as new techniques produce new forms of literary and artistic creation. In the past, for example, the scope of copyright was extended to include photographic and cinematographic works. More recently it has come to protect software.

What does this protection cover? Under the Berne Convention for the Protection of Literary and Artistic Works, copyright applies to the expression of works, in whatever mode or form. It thus gives authors an exclusive right over the reproduction, performance, adaptation and translation of their work. In addition to these economic rights, which are of most interest to economists, are moral rights, which vary from country to country. At international level, the Berne Convention grants authors the right to claim authorship of their work and to object to any modification of it that would be prejudicial to their honor or reputation. By contrast, that provision is absent from the TRIPS Agreement. Other moral rights, such as the French "right to rescind" (*droit de retrait* [Y1]), allowing authors to set a time limit on the commercial diffusion of their work, are not recognized in all countries. In the United States, copyright obeys a primarily economic logic, and moral rights are reduced to a minimum. Lastly, duration is also an aspect of copyright protection. Set by the Berne Convention at 50 years after the death of the

author, in practice it lasts for 70 years after the author's death in both Europe and the United States.

How does economic theory address the main legal characteristics of copyright? What is the purpose of copyright? Is it economically justified? Can it be improved? To answer these questions, economic analysis takes two main complementary lines of enquiry. The first is the tradeoff between creation and diffusion, which characterizes intellectual property law in general. The aim of this approach is to ascertain in what ways and to what extent this tradeoff applies to copyright. The second is to analyze transactions. In this approach, copyright is viewed as a basic element of economic organization, equivalent to an ordinary property right. After explaining these two theoretical approaches, we apply them to the reality of literary and artistic creation. Digital technology is a particularly enlightening test in this respect.

Incentive and access

The first function of copyright is protection against piracy, i.e., the identical reproduction of a work by a third party. It made it possible to control the publication of the first printed books. This function is also the most frequently studied by economists, who consider it as central to the tradeoff between incentive and access that justifies copyright.

Piracy is sometimes organized on a large scale, with a small number of agents producing and distributing copies. This was true of the counterfeiting printers denounced by Diderot in 1767 and still applies to some counterfeiting industries operating in some developing countries. Today, however, copies are usually made by consumers, with a large number of agents each making a small number of copies. In this case, the means of reproduction and diffusion are more complex.

Information is said to have been reproduced vertically [Shy, 2000] when each consumer makes a copy for the next consumer. If the quality of a copy is inferior to that of the original, the value of the copies diminishes at every stage, until it falls below the unit cost of producing them. There comes a point where it is no longer worthwhile making any further copies. Audio and video recordings can only be copied a limited number of times by analogue

Diderot on counterfeiting

"Indeed [...] skilful printers [...] had no sooner published an edition of a book, which they had prepared at great expense and whose craftsmanship and judicious choice brought them success, than the same book was reprinted by incompetents who possessed none of their talents. The latter, having engaged no expense, could sell their copies at a lower price, and profited from the monies advanced and late nights spent by the former, without incurring any of his risks. What happened? What was bound to happen and what will always happen:

Competition made the more noble enterprise ruinous. It took twenty years to sell an edition, whereas half that time would have been sufficient to sell two. While the counterfeit was inferior to the original edition, as was ordinarily the case, the counterfeiter sold his book at a low price and the impecunious man of letters preferred the cheaper edition to the better one. The counterfeiter scarcely became any richer, and the entrepreneurial, clever man, defeated by the inept, grasping man who deprived him unexpectedly of a gain commensurate with his care, expense, labor and the risks of his trade, lost his enthusiasm and remained discouraged.

[...]

The public certainly appeared to benefit from competition, since the man of letters could purchase a poorly bound book for a trifle, and the skilful printer, after having struggled for some time with the delay in income and the ensuing discomfort, lowered the price of his own edition. [...] But do not be mistaken, sir, [for this benefit] was only momentary and [...] proved detrimental to the discouraged profession and prejudicial to men of letters and to literature itself."

Diderot, Letter on the book trade [1767].

reproduction. Similarly, a document that is the result of several successive photocopies is hard to read. By contrast, digital reproduction of information makes identical copies possible. It therefore lends itself to unlimited vertical reproduction.

Information can also be reproduced horizontally when copies are made from the original only. This is typical of reproductions of a painting by a famous artist. Another example of horizontal reproduction is when, in a library, each user makes his own photocopy of a journal article. Lastly, reproduction is described as "mixed" when copies are made both horizontally and vertically.

When studying the economics of piracy before the digital revolution (see infra), the usual theoretical definition of information as a public good was not considered relevant. Because of the decrease in quality when paper or tape copies are made vertically, information in fact becomes a finite resource, and therefore a rival good. Furthermore, the diffusion of creations by piracy is not free – it has a cost, depending on the media on which the copies are made (paper, video tape, CD or DVD). These factors may limit diffusion by piracy, but do not prevent it all together. Independently of problems of imitation, an appropriate intellectual property right is therefore needed to control the publication of a work.

● Copyright and piracy

Because it protects the expression of works, copyright is an appropriate tool for combating piracy. Indeed, "expression" covers any identical reproduction, such as a radio broadcast of a piece of music or a new edition of a novel. The copyright owner thus controls any commercial exploitation of reproductions of the work, which provides the highest incentive to create.

More surprisingly, copyright can also achieve a gain in allocative efficiency. This is the case when the rights owner has a superior technology for reproducing works, particularly because of economies of scale. It is better, for example, to use a printing press than a photocopier to produce a magazine in a large number of copies. If the legal reproductions of the work are less expensive to produce than pirate copies, it may be preferable to use them, even if this accentuates the deadweight loss [Landes and Posner, 1989].

The rights owner's technological superiority in relation to pirates can also be artificial. The author has an interest in selling the originals in formats that are more difficult to copy. This might be done, for example, by

printing a book in colors that do not photocopy well, or by producing music CDs with added background noise that only becomes audible when the disk is copied onto a cassette [Novos and Waldman, 1987]. The resulting increase in the cost and/or decrease in the quality of the copy will dissuade some consumers from making copies and encourage them to buy originals. There is no gain in allocative efficiency here. Physical protection is simply a complement to copyright to remedy the non excludability of information. It can be seen in terms of the traditional tradeoff between incentive and access.

● Indirect appropriability

Rather than preventing it, copyright can also be used to control the production of copies by third parties. This applies in particular if the producer of the original can appropriate the value-the consumer utility-created by the copies. This is the case, for example, when a library pays a journal for the photocopies its users make. This process is called "indirect appropriability" [Liebowitz, 1985]. The copies generate profit for the creators, and therefore an incentive to create. Incentive and access are thus reconciled. Indirect appropriability is only possible, however, if the producer of the originals can practice price discrimination between direct consumers and consumers that make copies.

The mechanism of indirect appropriability can be illustrated by a simple example. Let us suppose that reading a journal article generates utility of $U(0)=20$ if the reader has access to the original an that each photocopy reduces the value of the document by half. The reader therefore enjoys utility of $U(1)=10$ with a photocopy of the original, and $U(2)=5$ with a photocopy of a photocopy. Each photocopy costs $C=4$. It is therefore not worthwhile making more than two successive photocopies, since $U(3)<C$.

Let us also suppose that the producer of the original only has access to two consumers, A and B. Consumer B is in contact with consumer C, who knows consumer D. In this case, A buys an original at a price of $p=U(0)=20$. But what price is B willing to pay for an original? B can sell a copy to C, who can in turn sell a copy of his copy to D at a price of $p=U(2)=5$. B can then sell the first photocopy of the article to C for a price of $U(2)+U(1)=15$, or the sum of C's personal utility and profit. B can

therefore buy his original at a price equal to the sum of the profit (15) and the utility (20) that he will derive from it, i.e. $p=35$. The final profit for the producer of the originals is $20+35=55$, which is the sum of the utility of all the consumers of originals and of copies.

The producer will only obtain this profit, however, if he can charge the prices he wants to A and B. In fact, B has an interest in buying his original at the same price as A, which would enable him to keep the profits of the photocopies for himself. But if the producer charges a uniform price of $p=35$ for every original, he will lose A as a customer, and his profit will fall to 35.

Thus, by improving the diffusion of a creation, copies benefit the creators of originals if they can practice price discrimination.

● Copyright and derivative creations

Copyright protection is not restricted to copies of original works. The Berne Convention stipulates that, in addition to the reproduction of works, copyright confers a monopoly on their translation, adaptation and performance. These three forms of expression are different from mere reproduction in that they involve an additional element of creativity. A translation of a novel is generally better if the translator has taken the trouble to render the style of the text, rather than translating word for word. A reader who knows languages will prefer to read a novel in the original, since he knows that a translation is already in some respects a different book. Similarly, the screen adaptation of a novel or a play requires creative input by the filmmaker. Lastly, the performance of a play, however famous, will be a flop if the director and actors are mediocre.

Whatever form it takes, a derivative creation of an original work thus creates a new type of use and poses the incentive/access tradeoff for literary and artistic works covered by copyright in new terms. Let us take the example of a playwright. Should he only be given exclusivity over the reproduction of his work on paper? Or, as stipulated in the Berne Convention, should he also be given rights over the performance of his work, with the consequence of putting it out of reach for amateur theatre troupes for example? Rights that are too narrow can discourage creation. But if they are too broad, they can hinder the diffusion of works.

This second point takes on considerable importance when several rights are involved [Moureau and Sagot-Duvauroux, 2002]. If different people hold rights to the same creation, each has a "right of veto" over the common work. Moreover, even if they agree to the diffusion of the work, if each rights holder demands high royalties, diffusion will cease to be profitable. The tragedy of the anticommons, highlighted by Eisenberg and Heller [1998] in the field of patents, therefore also concerns copyright. In the United States, the screening of the movie Twelve Monkeys was suspended after 28 days when an artist claimed that an armchair that appeared in the movie resembled the sketch of a chair that he had designed [Lessig, 2002].

More generally, excessive protection of derivative works by copyright can be counterproductive. If copyright were extended to the ideas contained in works, as is the case for patents, it would impede creation by increasing its cost [Landes and Posner, 1989]. Works protected by copyright reuse many existing ideas and can thus be compared to cumulative innovations. Consequently, stronger protection, extended to ideas, could represent a considerable impediment to creation, since each author would have to remunerate the owners of the ideas that he draws on. Pop music would probably never have enjoyed the success it has if exclusivity had been granted to the Beatles. Similarly, the protection of philosophical ideas would have a devastating effect on their development.

- What is the optimal scope of copyright?

Copyright protection was initially concerned with piracy. The extension of copyright to derivative works and ultimately to the underlying ideas enables authors to reap more of the benefits of their works, but it also increases the cost of subsequent creations. As a consequence, to encourage creation, it is preferable to limit the scope of protection to below the level that maximizes each author's profit [Landes and Posner, 1989]. This, combined with the traditional impediment to diffusion that monopoly power represents, justifies a relatively narrow copyright in practice. The criterion of "expression" does encompass derivative works, in addition to piracy. However it does not protect ideas, as a patent would.

Does the relative narrowness of copyright explain its length? The

TRIPS Agreement sets the term for copyright at 70 years after the author's death, whereas a patent lasts for only 20 years. This choice is based on a simple argument – the creator's lower profit in each period is compensated by a higher number of periods, to enable him to recover his costs and provide him with sufficient incentive [Landes and Posner, 2002]. However, this argument is weakened if copyright covers derivative works. In this case, the duration of the right also affects the cost of subsequent works. One has to wait longer for a work to enter the public domain, and therefore to be able to use it freely for new creations. For this reason, setting breadth then duration is unsatisfactory. There is another possible justification. The success of a work is uncertain and may come many years after the first edition. A long copyright is therefore an additional guarantee for the author or his beneficiaries of obtaining the profit from his work, even if this is delayed [Diderot, 1767; Landes and Posner, 2002].

In practice, the scope and the duration of copyright can also be explained by the influence wielded by interest groups. Originally set at 14 years, copyright in the United States has been gradually extended to the current 70 years after the author's death.

Disney, Mickey Mouse and the Sonny Bono Act

The Sonny Bono Copyright Term Extension Act, passed on October 27, 1999, extends the term of US copyright from 50 to 70 years after the author's death. This reform, which appears to offer more incentive to creators, at the expense of the diffusion of works, has sparked a major controversy. The Act is in fact only the latest episode in a series of eleven extensions of copyright duration in 40 years [Lessig, 2002]! Opponents of these reforms ascribe this legislative inflation to lobbying, most notably by Disney. They point out that, if it weren't for the Sonny Bono Act, the first drawing of Mickey Mouse would have entered the public domain in 2003, closely followed by Donald Duck and Goofy. Indeed, the Act sets forth that the extension of the term of copyright also applies to existing creations, which clearly cannot be justified by the incentive function of copyright. Its oppo-

nents cite the powerful economic interests at stake, notably Hollywood, which represents one of the United States' leading export items.

Opponents of the Sonny Bono Act decry the risk of privatization and stifling of culture. The Act was contested in court by Eric Elder, creator of a website that distributes old, rare and out-of-print books. Elder's strategy is to publish classics as soon as they enter the public domain. He intended to add works from the 1920s to his catalogue, such as Winnie the Pooh by A. A. Milne and Three Stories and Ten Poems by Ernest Hemingway, the rights of which are due to expire shortly. However, since the Supreme Court upheld the Sonny Bono Act in January 2003, Mr. Elder will now have to wait until 2019.

Copyright and industrial organization

Apart from offering incentives to create, copyrights underpin a form of industrial organization based on the exchange and exploitation of property rights. This allocative function of rights reconciles incentive and access: by facilitating the diffusion of works through exchange, copyrights increase the profits of creators and therefore the incentives to create. This can be deduced from Coase's Theorem, according to which granting property rights guarantees efficient allocation in the absence of transaction costs. However, since in real life situations these costs must be taken into account, the legal system must be designed to minimize the production and transaction costs stemming from the exploitation of creations. This aim is reflected in the organizational choices of economic agents with regard to copyrights. It also justifies certain legal adjustments to copyright, such as the fair use doctrine in the United States.

● Publishing contracts and profit-sharing

When copyrights are granted on original creations they can be allocated subsequently to the agents that value them the most. The author

who can sell his right to the highest bidder enjoys maximum incentive to create. A publishing contract, which shares rights between creators and publishers, is a good illustration of this type of transaction. The author entrusts the reproduction and distribution of his work to a publisher in return for payment. This division of labor – creation on one side, production and distribution on the other – produces a gain in efficiency when the work can be exploited at lesser cost by a specialized agent. Few writers are willing to invest in printing equipment and most do not know how to use it or to supply bookstores. However, beyond the principle of this division of labor, the terms of the contract must be set. Is there an optimal publishing contract? It should guarantee maximum profit for the author, to optimize the incentive function of copyright. The key parameter of a publishing contract is therefore the way the profits from production and distribution of the work are to be shared. The contract determines the share of each contracting party and how it will be calculated. The author's royalties can either be a fixed amount agreed in advance or be proportional to sales. With royalties that are a percentage of sales, the auctor economicus has every interest in writing a bestseller. If his payment is fixed, his only motivation to produce quality work is a concern for reputation. In turn, the distributor will have more incentive to maximize sales if its remuneration is proportional to sales.

The profit-sharing mode has other effects, which must also be taken into consideration in a publishing contract. Variable royalties paid to the author can have indirect consequences that are unfavorable to the contracting parties [Watt, 2000]. Unlike a fixed payment at the outset, royalties proportional to sales increase the unit cost of the originals for the publisher. This prompts the publisher to raise its monopoly price. However, raising the price will reduce the total profit to be shared between author and publisher. Ultimately, the classic problem of a double margin is thus to the author's disadvantage. Furthermore, the unit cost of copies remains stable, while the price of the originals increases, which encourages piracy.

Although variable royalties affect the sales price of the originals in a way that is unfavorable to the author, they nevertheless enable him to control that price. Theoretically, the author can thus appropriate all the profit generated by the work, by combining fixed and variable payments [Watt, 2000]. To do this, he must set variable royalties so as to obtain the highest

price from the publisher, and then recover the total profit in a fixed payment. This is, of course, unrealistic. It implies that the author is in a position to impose the terms of the contract. Above all, it implies that he has advance knowledge of demand for the originals. Raising that assumption helps us understand the features of standard publishing contracts.

● Publishing contracts and risk-sharing

The introduction of risk, in the form of uncertainty over future demand for originals, sheds new light on the economic function of a publishing contract [Liebowitz, 1987]. This type of uncertainty is extremely high with intellectual property rights. It is very difficult to predict the success of a new novel or a new song. Unlike other goods, comparisons of similar articles are impossible, since the protected creations are by definition unique! At best, the work can be compared to a close substitute. This technique may be relatively accurate for romance novels, but it is much more tenuous for novels in the running for literary prizes, for example. The uncertainty of demand highlights an essential function of copyright. By granting control over a good, a property right attaches the associated risk and profit. Transferring a property right in exchange for a fixed amount transfers not only control of the good, but also the risk relating to the uncertain income that the good will generate. The owner of a copyright will reap the reward of the commercial success of a creation. He must also accept the risk of failure. This risk may be too high for an author. A publishing contract is thus a way to share risk, by transferring all or some of the copyrights to the publisher.

There are several ways to share risk between the creator and the distributor. One possibility is for the author not to transfer rights, but to pay a fixed amount to the publisher, who is thus assimilated to an employee or subcontractor. The author will thus be the sole beneficiary of a commercial success, but he will also have to meet all expenses in the event of failure. A second option is for the author to sell all the rights to the distributor for a fixed price. The distributor is then free to keep the work for himself, rent it out or sell it again. He will also have to cover all the associated risks. A standard publishing contract represents an intermediate solution between these two options. The copyright is shared over time: it belongs to the

distributor until a certain date, after which it returns to the author.

This practice, which can be ascribed to an unequal relationship that is favorable to the publisher, is paradoxical in the light of economic logic [Liebowitz, 1987]. Indeed, it would make economic sense for risk to be covered entirely by distributors, be they book publishers, record producers or television networks. They are big enough to cope with the uncertainty of demand. Portfolio strategies are their main way of diversifying risk. A book publisher signs a large number of contracts with different authors and can thus offset a commercial failure with a success. This is a publisher's backlist, i.e., all the rights it owns on existing works, particularly on strong-selling titles, which gives it sufficient guarantees to take the risk of working with a new, unknown author. By contrast, an artist is entirely dependent on the success of the work he produces himself. Lastly, distributors have access to the most complete information on demand. They are therefore in the best position to evaluate and treat the risk associated with a new work.

● Collective copyright management organizations

Transaction costs are a key factor in the exploitation of copyrights. The first of these are enforcement costs. Indeed, legal protection against copying is ineffectual if works can be pirated with impunity. The rights owner, whether the author or the distributor, must therefore spend money to monitor and enforce their copyright. Since a distributor usually has more financial clout than an isolated author, sharing rights through a publishing contract is also a way to minimize enforcement costs. However, the partial transfer of rights also has a cost in itself, that of drafting and enforcing the contract. For example, an art photographer who does not want his distributor to authorize the reproduction of his photographs on packaging or wallpaper must stipulate this in the contract between them and subsequently check that the terms of the contract are respected. More generally, the transaction costs relating to exploitation of a copyright increase in line with the number of agents to which the work is diffused.

These various transaction costs reduce the allocative efficiency of copyright. They can even cancel it out all together if they are higher than the gains in the deal. It is therefore beneficial to minimize them. According to

economic theory, costs of transaction through the market should be compared to the operating costs of a hierarchical, centralized organization, which is often more efficient. Collective copyright management organizations, which group creators from the same artistic field, are an excellent illustration of this. In the United States, the American Society for Composers, Authors and Publishers (ASCAP) manages rights for these three groups. Bodies like these handle most of the exploitation of copyright and associated transaction costs on behalf of authors. They fulfill several functions: they grant user licenses; they negotiate, collect and redistribute royalties to authors; and they enforce copyright by suing infringers [Hollander, 1984].

These functions are less expensive when they are grouped. Thus, collective organizations can grant blanket user licenses to their clients, whereas a single author is limited to his own works. A radio station only has to make one transaction with ASCAP to be able to broadcast a large number of music titles. Compared with a completely decentralized form of organization, where radio stations would have to negotiate the broadcast of every title with its respective author, centralized management of rights achieves a considerable saving on transaction costs. Similarly, collective copyright management organizations benefit from economies of scale by contracting with specialized lawyers.

- Fair use and exceptions to copyright

Although they operate in a centralized manner, collective copyright management organizations result from the private initiative of creators, who choose to use their copyrights in this way. By facilitating the diffusion of works, they enable authors to draw a bigger profit, which also encourages creation. Collective organizations of authors are not a universal solution, however. They reduce some types of transaction costs, but do not eliminate them. Transactions whose cost is higher than the profit cannot be realized, which limits the diffusion of works to a sub-optimal level. This occurs when consumers give a very low, but positive value to a work. In this case, they will not be willing to meet the cost of a transaction with the copyright holder. The diffusion of a work is also less likely if it depends on a large number of

copyrights held by different owners. In this situation, each owner tends to demand too high a price for resources to be allocated efficiently [Depoorter and Parisi, 2002]. For example, this book would not have been published if we had had to negotiate the prior authorization of all the authors cited. These situations reflect a failure of the copyright system itself. Indeed, the exclusive allocation of the profit of a work to one agent prohibits access by others, without it being profitable for that agent. To resolve this problem, limits must be set on copyright.

The doctrine of fair use, specific to United States law, defines situations where a copyrighted work can be used without the permission of its author. Drawn from United States judicial decisions, this doctrine has no real equivalent in Europe. Certain rules specific to other national laws nevertheless obey a similar logic. In France, there are exceptions to economic rights. The "right to cite" (droit de citation), for example, allows free quotation from a copyrighted work, as long as explicit reference is made to the creator. In the United Kingdom, the right to parody allows people to pastiche a work, without fear of infringing copyright. The fair use doctrine covers very different uses of works: criticism, commentary, teaching and research. The decisive element is that the doctrine allows a work to be used in situations where high transaction costs would otherwise have made it impossible. In this sense, it is an efficient complement to the legal system of copyright. In practice, the United States courts use the transaction cost

Applying the fair use doctrine (based on Depoorter and Parisi [2002])

Two judicial rulings in the United States illustrate the way in which the courts cite the work of Ronald Coase to determine the applicability of the fair use doctrine. The 1991 Nobel laureate in economics stated that when transaction costs are too high, they block transactions. This is why the courts consider the effect of copies on the potential market and on the value of the protected work. If transaction costs are low, pirate users could just as easily buy the originals. Pirate copies thus have a negative impact on the potential market of the originals and reduce the value of the protected work. Therefore,

the fair use doctrine does not apply here. Conversely, if the transaction costs are so high that the work cannot be diffused by the market, the production of copies is not prejudicial to the author, and fair use rights are applicable.

In the following two cases, the copies could have been obtained legally. Since they were not, they harmed the authors of the originals. In American Geophysical Union v. Texaco Inc (1995), a group of scientific publishers sued Texaco's Research Department for photocopying articles from scientific journals without permission. The court found in favor of the plaintiffs because there was a legal procedure for obtaining permission for copies and paying royalties through an institution established for that purpose. The existence of a legal system of access to copied creations was therefore decisive. In Princeton University Press v. Michigan Document Service (1997), Princeton University Press, Macmillan, and St. Martin's Press sued a student-run "copy shop" that compiled "coursepacks" for students consisting of photocopies of materials provided by university professors. The defendants claimed fair use, but court found against them because the university publishers operated departments that process requests for permission to copy copyrighted works, i.e. a form of market, which Michigan Document Service had chosen to ignore.

explanation to determine the applicability of the doctrine.

Whether applied to a publishing contract, collective copyright management organizations or copyright exemptions, the analysis of transactions reveals an important allocative function of copyright and, more generally, of the legal system based on it. This function is at once distinct from and complementary to the incentive function of intellectual property. Considering both together reveals the sophistication of a tried and tested legal system that covers a wide variety of works. The copyright system has constantly adjusted to new types of creations as they have emerged. However, the major change to information brought by digital technology marks an unprecedented challenge to copyright.

Digital works

The emergence and expansion of information and communication technologies have radically changed the conditions under which literary and artistic works are created and diffused. New and old creations can now be digitized and diffused very easily. An opera by Mozart can be distributed and reproduced on a CD or exchanged over the Internet as a MP3 file. There is a need to strike a new balance between incentive and access in the copyright system.

● A digital "revolution"

Digital technology has revolutionized literary and artistic creation, not only by giving rise to new forms of creation, but also by providing a new medium for existing works. Almost all the forms of expression protected by copyright can be digitized. And there are a large number of available formats for working on the digital versions of a text. An image can be scanned, then stored and diffused in Gif or JPEG format. Similar standards exist for video (MPEG) and audio documents (MP3, WMA). In addition to new modes of diffusion, these media are generating new forms of creation within the copyright system. For example, some filmmakers are now choosing to work with digital cameras. Digital media are extending the limits of copyrightable material by creating new forms of expression, such as computer graphics, electronic music, website design and computer programming.

What are the economic consequences of this revolution? At next to no cost, digital versions of works can be copied identically, with no loss in quality. Moreover, the range of technologies used to store and transmit information-diskettes, CDs, DVDs and computer networks-allows for potentially infinite horizontal and vertical reproduction of digital works. In theory, a single original is sufficient to produce and diffuse as many copies as required. The only physical obstacle to piracy becomes the cost of identifying and contacting users interested in a copy [Shy, 2000]. Indeed, piracy is seen as a major problem by authors and publishers of copyrighted digital goods. According to the 2002 Business Software Alliance survey conducted in 85

countries, the rate of software piracy – measured as the percentage of unlicensed software installed over that year – was 40 percent in 2001, causing losses of around $11 billion. Similarly, the MP3 format, which is used to digitize, compress and exchange music files over the Internet, is considered a serious threat by the music industry. By facilitating the diffusion of works at the expense of the authors' capacity to derive a profit from them, information technologies are upsetting the incentive/access balance struck by copyright.

Napster and its successors

Created in 1987 by the Fraunhofer Institut, the MP3 format makes it possible to compress audio files at a high ratio, while preserving near CD quality. This technology, combined with the increase in Internet speed, opened the way for the online exchange of music files. In 1999, an American student called Shawn Fanning launched Napster, a software program he designed initially to swap MP3 files with his friends. It was an overnight success. By April 2000, up to 700,000 users were logged on to Napster. Record companies, represented by the Recording Industry Association of America (RIAA), were swift to file a complaint against Napster for copyright violation. Rap artist Dr. Dre and rock group Metallica also sued for piracy in April 2000. Ordered to pay damages, Napster, with its 23 million registered users, was taken over by Bertelsmann Music Group in November 2000, to develop a secure, fee-based version of its music distribution system.

The neutralization of Napster did not stop the exchange of MP3 files from taking off again, however. Napster's legal weakness was its centralized file-swapping system, which kept lists of files exchanged on the company's server. Napster's successors, including Kazaa, MusicCity and Gnutella, avoided that problem by using peer-to-peer technologies that link users directly to each other, without going through a fixed server. These firms simply distribute a software program, with advertisements from which they derive their revenues. They have no means of controlling the nature of the files exchanged. The record and movie industries nevertheless filed complaints against these new file-swapping systems in 2001.

A negotiated solution might involve digital rights management (DRM) technology. The company that owns the Morpheus audio and video file-swapping service agreed in March 2002 to use DRM technology to charge for its services and counter piracy. New types of services are developing, such as monthly subscription services that offer customers unlimited access to a catalog of music, and pay-per-download services like iTunes' 99-cents-per-song deal.

Digital technology also considerably extends the legal reach of copyright. By definition, copyright is primarily concerned with protecting the expression of works, and therefore with controlling copies. However, every time a digital document is accessed, a copy is stored on the computer's memory. The frequency of technical copies, in particular over the Internet, gives the author a right over every single use of the digital versions of his work. Unlike a book, the digital version of a work will therefore never have any independence from copyright. Once a book has been bought, it can be lent or given to another user legally. This is not so for a software program bought under a single-user license. Thus, from a strictly legal point of view, information technologies strengthen the legal monopoly conferred by copyright. This second upset in the tradeoff between creation and use, in favor of creation this time, is far from being purely theoretical. Authors can use technology to protect the digital versions of their works [Lessig, 2002], namely encryption, on which digital rights management (DRM) is based. Encryption technology can be used to drastically limit the number of copies and to track the use of files downloaded from the Internet. In this case, the second imbalance prevails: diffusion is strictly controlled by the copyright owner, with the result that deadweight loss increases in line with its monopoly power.

Depending on the technical resources available to copyright owners and pirates, information technologies tip the creation-diffusion balance that justifies copyright in one or other direction. The problem is then to adapt it to digital works. For example, the European Copyright Directive of May 22, 2001 excludes technical copies stored in computer memories from the scope

of copyright. In the United States, the Digital Millennium Copyright Act (DMCA) of October 12, 1998 explicitly prohibits the circumvention of technology-based protection against piracy. More generally, both laws endeavor to determine which types of diffusion are exempt from copyright. Exemption for educational purposes, already provided for by the fair use rule, is for example reaffirmed. The DMCA also establishes that Internet service providers are not responsible for copyright violations relating to documents that transit via their services. These provisions, far from comprehensive, will need to be clarified and expanded by case law. Efforts must also be made to achieve international consistency, considering that these are borderless technologies.

- Software

Among the digital works protected by copyright, software is in a category of its own. Copyright protection for software has less to do with the literary or artistic nature of software than with the malleability of copyright. Given the need to develop an intellectual property right for software, legislators preferred to apply copyright to the "text" of computer programs rather than to create a new right or to use patent law. To adapt copyright to software, some rules were changed or dropped. Is it an appropriate type of intellectual property? It seems rather to offer default protection, which software developers can claim by complementing it with technology-based protection or trade secrecy, or abandon if this is to their advantage.

Software protection in France: between copyright and patent

In France, software is protected by a hybrid form of copyright, which in many respects is similar to patent law. For example, the criterion of originality is interpreted so strictly that it resembles the novelty requirement for patents. Furthermore, the law stipulates that software developed within the framework of an employment contract belongs to the employer, unless the contract specifies otherwise. This rule, according to which the author is no longer the owner of his creation, is unusual for literary and artistic intellectual property, but is integral to patent law. Moreover, software copyrights, unlike other copyrights, are stripped of some moral rights. For example, a software author cannot object to the modification of his work if it is used for its intended purpose unless this is prejudicial to his reputation or honor. He also has no "right to rescind" to block the commercialization of his work. Lastly, the intellectual property of software makes allowances for copying. The number of authorized private reproductions is limited to a single backup copy, unless copying enhances the software's compatibility with other applications.

To what extent does the tradeoff between incentive and access apply to software? The high rate of piracy that software publishers complain of seems a key factor in that tradeoff. But the diffusion of copied software can also be beneficial for copyright owners. The commercialization of software often depends on indirect appropriability. This mode of diffusion allows the author to derive profit from the production of copies by third parties. It hinges on the ability to practice price discrimination between ordinary customers and pirate-customers. For example, this mechanism justifies charging higher prices to companies than to individuals for software licenses. A company will thus agree to pay more for a piece of software if its employees can copy and use the program at home outside office hours [Shy, 2000]. In this case, copyright serves to manage, rather than prevent, the production of copies.

The rights owner can also profit from piracy if the software enjoys network effects. These exist when the software users benefit from other people using the same software. The higher total number of users, the higher the individual value of the software. A word processor, for example, is far less useful if the documents produced on it cannot be transferred to other computers on which the same software has been installed. Likewise, there is not much point in creating a digital image or animation if no one else has the software to view it. This need for compatibility, expressed by the consumers of some software, is an incentive for developers not to protect their creations. The ability to diffuse copies of software freely will undoubtedly turn some customers into pirates, but it will also increase the price at which the

remaining customers will be willing to buy the software. If the proportion of customers engaging in piracy is not too high – schools or companies, for example, are less inclined to piracy – the positive effect will prevail. This is why, in the 1990s, technology-based protection of software was gradually reduced, and even removed in the case of word processors and spreadsheets [Shy, 2000]. Protected by a hybrid copyright, software is also distinguished from other digital creations insofar as it is not always to the publisher's advantage to enforce protection.

Whether applied to classics or the latest digital creations, economic analysis reveals the originality of copyright in comparison to other intellectual property rights. Designed initially to encourage creators by protecting them against literal copying, copyright plays a key role in the organization of the media and entertainment industries. The trend towards stronger copyright protection, through the extension of its duration, its expansion to derivative works and its application to digital technology, enhances both this linchpin role and the market power it confers. It remains to be seen whether stronger copyright encourages creation for greater social welfare. The tragedy of the anticommons resulting from a multiplication of rights on derivative works and from technological barriers to private copying suggests prudence on this issue.

V/Intellectual Property and Competition Law

Economists are increasingly critical of intellectual property. Until now they were only skeptical of patents' supposedly favorable effect on innovation, given scant empirical evidence that patents spur an increase in R&D. Now they fear that stronger patent rights will actually impede innovation. The same criticism is made of copyright. Control of derivative rights and extension over time of copyright eventually stifles creation [Lessig, 2002]. Initially intended as an incentive instrument, intellectual property now seems to be a factor of distortion: encouraging monopoly rent-seeking to the detriment of consumers, blocking competitors, etc. To counter these effects, some call competition policy to the rescue. Is it a remedy for the abuses and excesses of intellectual property law?

The relationship between intellectual property and competition law

At first sight, the two bodies of law appear to be at cross-purposes. Intellectual property law grants monopolies, whereas competition law seeks to break them up. This perception prevailed in the United States and Europe until the late 1960s [Tom and Newberg, 1997]. Today the two bodies of law are seen as complementary instruments, which must be balanced against each other. A legal system that overprotects intellectual property and

underenforces antitrust law poses dangers to competition and ultimately to innovation, just as one that underprotects intellectual property and overenforces antitrust principles can also harm incentives to innovate [Pitofsky, 2001].

- A closer look at competition law

The view that intellectual property law and competition law are in conflict is based on two erroneous simplifications. One is that competition law prohibits monopolies, and the other that intellectual property rights automatically bestow a monopoly.

Antitrust law protects competition by preventing behavior that hampers market forces. For example, it prohibits price fixing and partitioning of the market by a group of producers. As a general rule, antitrust law does not punish monopoly power per se, but the abuse of that power, which is something quite different. Competition law recognizes a company's right to enjoy a monopoly that it has acquired by merit. Its role is not to penalize a company that has gained an advantage over its rivals by producing at a lower cost or by offering higher-quality products to consumers. However, a company will be penalized if, in order to preserve and extend its monopoly position, it practices predatory pricing or enters into exclusive contracts to close the market. Let's take the example of Microsoft. The Antitrust Division of the U.S. Justice Department did not take exception to the monopoly of Windows or Office. Rather, Bill Gates' corporation was found to be at fault for seeking to maintain its dominant position through illegal practices, particularly license contracts.

European jurisprudence [ECJ, 1971] and U.S. legislation [DoJ and FTC, 1995] clearly state that they do not presume that ownership of a patent or copyright creates market power. Market power is recognized as the ability to raise the price profitably above the competitive price. This is only possible when no substitutes exist. However, in the eyes of consumers, just because a product is protected does not mean there is no alternative. To take just one example, most detective novels are covered by copyright. But no one can seriously claim that any one book has a monopoly over the market. As for patents, most are left idle and never used commercially; they therefore do not

confer a monopoly. However, a patent does give monopoly power if the new product or process has characteristics that give it an advantage over others. Because of these characteristics, it will only be in competition with imperfect substitutes.

Since intellectual property does not confer a monopoly in a market ipso facto, the competition authorities need to establish two facts to find against a company: first that the patent or copyright bestows or is associated with the company's dominant position; and further that the company abuses that position. This approach is illustrated by the Magill case.

Magill or abuse of a copyright to preserve a monopoly in weekly television guides

In the 1980s, three television broadcasters, including the BBC, operated in Ireland. Each company published a weekly guide of its own programs, the listings of which were covered by copyright. Each channel also licensed free of charge advance information about their programming schedule to newspapers. Magill, a publishing company, attempted to publish a magazine that contained the programs and schedules of all three channels. The television companies claimed that this was an infringement of their copyright and obtained an injunction preventing the publication. Magill took the case to the European Commission, which in 1988 ruled that the refusal to license in this case amounted to abuse of a dominant position. The Commission ordered the three broadcasters to "[supply] third parties on request and on a nondiscriminatory basis with their individual advance weekly program listings and [permit] reproduction of those listings by such parties." The Commission's decision was upheld by the Luxembourg Court of Justice in 1995. The court held that mere ownership of an intellectual property right did not confer a dominant position. However, the court found that the three television networks "had a de facto monopoly over the information used to compile listings for television programs, which put them in a position to prevent effective competition on the market in weekly television guides." It

added that there was no substitute for the information and that, by denying access to it, the broadcasters prevented the appearance of a new product, which they themselves did not offer and for which there was potential consumer demand.

- Complementary laws

From the point of view of efficiency, we observe a division of roles between the two bodies of law. By according an exclusive right to inventions and creations, intellectual property encourages innovation and therefore dynamic efficiency. By eliminating the loss of consumer surplus associated with monopolies, competition law favors static efficiency. It seeks above all to reestablish a lower price and a higher quantity offered on the market.

However, both laws strike a balance between short-run losses and long-run gains in welfare. Intellectual property law provides for static efficiency by limiting the duration of protection. If the sole purpose of patents and copyrights were to encourage innovation, they would have an infinite life, because that is the condition that maximizes the private revenues of inventors and creators. Competition law also achieves a balance between static and dynamic efficiency, but it is less visible because the cut-off point between short-term and long-term effects is not set by law. Let's take the example of merger control. Mergers must be approved by the competition authorities. A transaction will be prohibited if it has an anticompetitive effect that disadvantages consumers. The competition authorities nevertheless take the positive effects of concentration into account and weigh them up against its negative anticompetitive effect. The authorities consider cost reductions, such as those generated by economies of scale, and dynamic gains achieved by better organization or better R&D financing. U.S. competition law takes into account both the immediate and over-time gains of a merger. However, the latter are given a fairly low weighting because they are approximate and difficult to forecast.

Both laws thus ensure a balance between dynamic and static efficiency, but with a different emphasis. Intellectual property law is slanted toward dynamic efficiency, while competition law stresses static efficiency.

- The pre-eminence of competition law over intellectual property law

Competition authorities act ex post (except for merger control) and patent offices ex ante. Competition authorities can therefore be tempted to reverse decisions made by patent offices and to use competition law to correct flaws in intellectual property protection. This approach was taken in 1972 against Xerox. The FTC took exception to the company's acquisition of a "killer patent portfolio". This strategy involves piling up patents year after year in order to push back a product's entry into the public domain and block competitors for longer.

The role of competition authorities thus seems to be to pare down the scope and duration of intellectual property rights when these are excessive. Patent holders can be compelled to grant licenses or to make the terms of licenses more favorable to licensees. Competition law thus appears to take pre-eminence over intellectual property, fine-tuning the scope of rights.

FTC v. Xerox

In 1972, the United States Federal Trade Commission (FTC), initiated action against Xerox for restrictive commercial practices and monopolizing the market in photocopying machines. Central to the dispute was the extension over time of Xerox's monopoly through an accumulation of patents.

Michael Scherer was chief economist at the FTC at the time. He describes the case as follows [Anderson and Gallini, 1998]:

"I was never so scared about anything in my life as accepting a decree providing for compulsory licensing of all of Xerox's patents. Xerox was one of the great technological triumphs of the 20th century. It was a major innovation. It was a very difficult innovation and they carried it off brilliantly. Why should one intervene in such a situation? Why should one tamper with their patent rights? They had somewhere between 1,000 and 2,000 patents in the mid-1970s. They were adding to their portfolio at a rate of several hundred patents a year. They had the technology completely encircled, and a consideration that prompted our decision to intervene with compulsory licensing was that the 914

Copier was introduced in 1959. The case came for a decision in 1975. They had enjoyed 16 years of a spectacular patent monopoly. How long should a monopoly last? We intervened because we thought essentially that 17 years was what the law had in mind, 17 years was enough. [...] But the essence of the case was, frankly, social engineering. It was time to break open this monopoly and create competition. It was a task that was going to be very difficult to achieve just through the market, without intervention, and that was the essential rationale."

Most economists do not recommend this kind of fine-tuning, because of the confusing message it sends to inventors and creators. If they do not know in advance whether their rights will be whittled down or upheld by competition authorities, they cannot correctly estimate the return on their investment. This heightened legal insecurity reduces incentives and, consequently, R&D efforts. Moreover, competition law is not equipped to set the right level of innovation. Competition authorities do not have the scientific and technical expertise to evaluate whether a particular intellectual property right is too broad or too long. In fact, neither competition authorities nor patent offices have the knowledge required to determine optimal patent scope, but of the two, the patent offices seem to be in a better position to make trade-offs between incentives for first as opposed to subsequent innovators [OECD, 2001].

Therefore, it is preferable to reform intellectual property law rather than to employ competition law to reduce the flaws and excesses of intellectual property protection. Antitrust authorities have a role to play in this, of course. As the advocates of competition, they can inform intellectual property policy choices by pointing out the effects of various reforms. For example, the Federal Trade Commission highlighted the dangers of broad patents in the field of information technology in the mid-1990s.

Comments on computer-related patents from the FTC [FTC's comments, 1995]

In response to a paper from the Patent and Trademark Office (PTO) on the patentability of software, the Federal Trade Commission urged the PTO to exercise caution in drafting new guidelines for examining patent applications for computer-related inventions.

The FTC pointed out that "inappropriate or overbroad grants of intellectual property rights may interfere with the competition that often drives innovation." It added that their negative effects on innovation "can be heightened by strong network effects [and] if a patent is inappropriately granted to software that is already part of the prior art and has become embodied in existing products, interfaces and approaches, both the producers of current products and would-be innovators may find it very difficult to devise alternate technical solutions acceptable to the marketplace."

The FTC recommended that the PTO reconsider any changes to the guidelines that would have the effect of easing the subject matter test, since this would require greater reliance on the novelty and nonobviousness tests, which the PTO itself has recognized do not currently function as well in software as they do in other areas.

The application of competition policy to license agreements

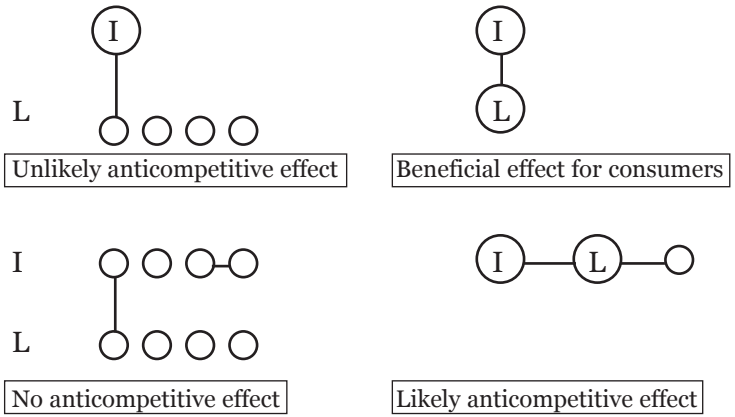
Between 1996 and 2000, the European competition authority examined 140 cases of anticompetitive practices relating to intellectual property rights [EC, 2001]. These decisions accounted for 7% of the Commission's work on competition. A little over half of the cases processed concerned patents and around a quarter concerned copyright. Eight cases out of ten were related to licensing.

- Economic aspects

Economic analysis offers a valuable guide for appraising the anticompetitive effects of license agreements. The economic method is based on two key questions. Do the licensor and licensee enjoy a monopoly power in their markets? Are their products complements or substitutes?

Firstly, it is useful to recall a few definitions. Monopoly power refers to the ability to raise the price profitably. It is generally greater when the number of companies in the market is small and the product is hard to substitute. A substitute is a product that enjoys increased demand when the price of the other product goes up. This is the case of Pepsi and Coca Cola. Conversely, a complement is a product that enjoys increased demand when the price of the other product goes down. This is the case of ski bindings and sticks, demand for which rises when the price of skis falls. Based on those concepts, economic analysis makes a distinction between the four cases shown in the diagram. These cases illustrate a simple situation: an exclusive unilateral license between an inventor or creator (I) and a licensee (L). The benchmark situation, against which the competition authorities evaluate the effects of license agreements, is no license.

The effects of licensing, depending on the market power and the horizontal or vertical nature of the relationship between licensor and licensee



- The effects of exclusive vertical licenses

In the first of the four cases (top left of the diagram) a technology company develops an innovation and licenses it to a manufacturer. The technology firm has a broad patent that gives it market power. The manufacturer combines the license with other inputs to produce a marketable product. This is a very common situation because intellectual property is rarely a good that can be consumed without having been combined with other factors. It is typically combined with other complementary goods, which may be tangible – in particular manufacturing equipment-or intangible – for example other intellectual property rights. The manufacturer does not have a monopoly power in its market. Therefore the license agreement will not generate additional anticompetitive effects, and will even be beneficial for consumers.

What would happen if there were no license at all? To exploit its market power, the holder of the intellectual property right would have to develop the complementary business itself. In terms of anticompetitive effects, there would be no difference between no license and an exclusive license. In both cases, downstream companies would be denied access to the new technology. The rights holder would extract its monopoly rent directly from the final consumers, instead of receiving it indirectly from the manufacturer through license fees. However, the solution of integration can be less efficient than a license contract, because it does not allow the parties to take advantage of a division of labor to reduce costs. It is inefficient for the owner of the intellectual property to produce the item itself because it lacks the necessary competencies and know-how to enter the downstream industry. And, unless it has sufficient output, it will also fail to take advantage of economies of scale. Given the predominance and efficiency of vertical license agreements, the public authority generally hold the view that licensing intellectual property increases welfare [DoJ and FTC, 1995, OECD, 2001].

Competition authorities nevertheless examine these agreements individually for any abusive clauses they might contain. With licenses, the devil's in the detail. Anticompetitive effects stem from the clauses that set out the precise undertakings and obligations of licensor and licensee, which can be used to restrict competition. In the United States, the courts found against

Microsoft because of the multiple restrictions on computer manufacturers that it included in the Windows license. Manufacturers were not permitted to preinstall browsers other than Internet Explorer and were required to display its icon on the screen. Two examples of restrictions included a requirement for licensees to pay royalties on a second technology that was no longer protected and a prohibition on licensees challenging the validity of the licensor's patents. In these case-by-case examinations, the competition authorities ask three questions. Does the license contain a clause that creates a situation that is more anticompetitive than if there were no license at all? Is this clause essential to the benefit that the license brings? If the answer is yes to both these questions, does the benefit of the license outweigh the loss induced by the reduction in competition? The authorities thus weigh up the negative and positive effects.

- Other cases

In the second case – top right of the diagram – there is a vertical license between two firms that both enjoy market power. The license benefits both consumers and the firms, in addition to achieving a gain in efficiency through a division of labor. The French economist Antoine Augustin Cournot [1838] once quipped that the only thing worse than a monopoly is a chain of monopolies. Cournot demonstrated that a merger between two companies producing complementary goods generates both a higher joint profit and a lower price for final consumers. This observation makes sense if we consider that a lack of coordination between the two monopolies would prompt each to apply a margin without taking account of the negative effect on the other company. Since the goods are complementary, an increase in the price of one causes a decrease in demand for the other and therefore a lower profit for the company that makes it. When the two companies merge, this double margin problem disappears. The effect of an increase (or a decrease) in price is integrated into the calculation of the joint profit. From an analytical point of view, granting a license can play the same role as a merger. If the fee set by the license contract contains a fixed amount equal to the licensee's monopoly surplus and a variable amount for each product sold equal to its marginal cost, the price on the downstream market will be equivalent to that of the

merged company. If the licensor and licensee have market power and are in a vertical relationship, the license is therefore beneficial for consumers.

In the third case – bottom left of the diagram – the granting of a license never has an anticompetitive effect. Here, the intellectual property right is narrow. The licensor and licensee both have many competitors and do not enjoy market power. Owing to competitive pressure, the royalty is therefore equal to marginal cost. The license only allows the technology company to cover its annual fees to the patent office. In this case, a vertical license between companies manufacturing complementary products – or even a horizontal license between competitors – cannot be unfavorable to consumers. For this reason, the U.S. Antitrust Guidelines for the Licensing of Intellectual Property [DoJ and FTC, 1995] explicitly authorize licenses between competitors whose market share does not exceed 20%.

By contrast, a license agreement between competitors becomes problematic when the firms involved do enjoy market power. This is the last case, shown on the bottom right of the diagram. In this case, licensing strengthens dominant positions. The market will be slightly less competitive. License contracts can thus be an opportunity for firms to agree on clauses that limit competition – for example that restrict the licensee's commercial activity, or that set a minimum price. The exchange of technology thus forms the basis of a broader agreement designed to support collusion [Lin, 1997]. A cross licensing contract, i.e., an agreement under which each party grants a license to the other, also provides competitors with a golden opportunity to operate like a cartel, by sharing the market or fixing prices. They might agree, for example, on the price to charge consumers, as in FTC v. Summit Technology and VISX. Or they might set excessively high royalties, which compensate each other out for the firms involved, but which are passed on to consumers [Fershtman and Kamien, 1992]. A horizontal licensing agreement, whether a cross license or not, on blocking patents, can also be a major barrier to the entry of new competitors. For example, new entrants in the semiconductor industry need to spend $100-$200 million of revenues to license what are now considered basic manufacturing principles but which do not transfer any currently useful technologies [Hall and Ziedonis, 2001]. In other cases, it is the absence of a license agreement that can put newcomers at a technological disadvantage in relation to established firms [Rockett,

FTC v. Summit Technology and VISX

In 1998, the FTC took action against two firms that produce the laser equipment used in photorefractive keratectomy, a form of eye surgery performed to correct vision. Summit and VISX each have a patent protecting a different technology, which they pooled. The firms charged doctors a fee of $250 for every operation performed with either a Summit or VISX laser. The FTC considered that if there had not been a license, the two firms would be competing with each other. The firms argued that the patent pool was a way of settling their intellectual property dispute. The FTC retorted that litigation could have been avoided by far less restrictive means, such as ordinary or cross licenses that did not dictate the price of their equipment to users. An arrangement was finally found in 1999 between the FTC and the two firms, which agreed to dissolve their partnership.

1990].

- Compulsory licensing and refusal to license

Having seen the conditions under which licenses are granted, let's take a look at the circumstances in which competition authorities can impose compulsory licensing on patent holders. The Xerox and Magill cases mentioned previously are useful examples here.

The FTC's 1972 decision compelling the photocopier manufacturer to license its patents would not be made today. Recent U.S. jurisprudence has granted a kind of antitrust immunity to intellectual property [Pitofsky, 2001]. The precedent was set in 2000 by a case involving Xerox again, this time against a group of independent companies that service and maintain photocopiers and printers. The plaintiffs challenged Xerox's refusal to sell or license parts and software to them, on the grounds that it prevented them from competing with Xerox's own after-sales services. The Federal Circuit dismissed their claim, indicating in its ruling that only a small number of restrictive conditions can be invoked to overturn a refusal to license (see inset on the essential facilities doctrine).

In the Magill case, the decision to impose compulsory licensing was justified by a combination of exceptional circumstances. Firstly, there were no substitutes. It was not possible to publish a television guide without the broadcasters' program listings; and the broadcasters were the only source of that information. Secondly, by refusing to license, the channels had reserved to themselves the secondary market in weekly television guides. The refusal to grant access to the listings precluded all competition. Lastly, there was no merit in having the information. The information on program times and content was simply a sub-product of the networks' broadcasting activity. Compulsory licensing therefore did not affect the incentives to produce that information. These circumstances explain why Magill did not open the gates to a series of decisions imposing compulsory licenses. At the time, however, the judgment of the Luxembourg Court of Justice raised fears among observers that patent holders in Europe would be compelled to grant licenses to secondary innovators.

Since Magill, the European Commission has only ordered compulsory licensing in one other case-and only as an interim measure. At issue was the segmentation of the German pharmaceutical market into a 1,860-zone structure based on postal codes, protected by copyright law. U.S. firm IMS, world leader in pharmaceutical market information, refused to grant a license to enable its competitor, NDC, to use the segmentation structure. In its decision, the Commission followed precedents by seeking to establish exceptional circumstances, which allowed it to assimilate the refusal to license to abuse of a dominant position. It ruled that the refusal effectively prevented the entry of any rival on the German market. The Commission found that there was no substitute for this standard for the provision of reports detailing regional sales data on drug purchases and prescriptions. It also stressed that the standard was developed by the German pharmaceutical industry.

The common feature of the Magill and IMS decisions is that they are based on the essential facilities doctrine, which confirms that competition law puts intellectual property on a par with other forms of property and only deems a refusal to license illegal in exceptional circumstances.

Application of the essential facilities doctrine to intellectual property rights

The essential facilities doctrine originated in U.S. antitrust law. It developed in Europe from the mid-1980s onwards. The term "essential facility" was first used by the European Commission in the 1992 decision taken in the B&I Line/Stena-Sealink case. On both sides of the Atlantic, the doctrine is based on the same premise: when access to a resource is essential to operate in a market, the owner of the facility can, in certain circumstances, be compelled to guarantee it to operators. Monopoly infrastructures such as the electricity grid or the local telephone loop are prime examples.

In Europe, three principle conditions must be met to demonstrate that a denial of access to resources infringes competition law. Firstly, there must be no objective reasons justifying the refusal, for example safety in the case of connection to the electricity grid. Secondly, the denial of access must be likely to eliminate all potential competitors. Thirdly, the facility must be essential to operate in the market, inasmuch as there is no actual or potential substitute.

The essential facilities doctrine is rarely invoked to open access to a resource, whether tangible or not. The difficulty of its application lies in the fact that enforcing access amounts to expropriating a monopoly that was acquired legitimately (if this were not the case, it would be sufficient to challenge a monopoly position created by undue means). But competition law, also concerned with dynamic efficiency, is not designed to eliminate monopolies acquired by merit.

In the United States, the essential facilities doctrine is not applied to intellectual property. Only three far more restrictive conditions can lift the antitrust immunity bestowed by exclusive use of a patent: (i) the patent was obtained fraudulently (ii), the litigation is a sham to cover the implementation of an anticompetitive arrangement (iii) the patent is employed in a tying strategy to extend market power beyond the scope of the patent.

- Cross licenses and patent pools

Some exchanges of licenses combine the intellectual property of several rights holders. These can be divided into two categories: cross licenses and patent pools. In a cross licensing arrangement, two creators-rarely more-reciprocally authorize use of each other's innovations. These licenses usually involve competing companies, as in the agreement between Summit Technology and VISX. In patent pools, many innovators pool their intellectual property rights and offer a package license to users.

We saw earlier how a licensing agreement between two companies in a horizontal relationship can cause an anticompetitive effect, in the form of collusion or a barrier to the entry of new competitors. Cross licensing therefore entails a risk of static inefficiency. It can, however, offer a benefit that offsets or exceeds that effect. Let us take the example of two blocking patents. The first patent is broad and dominates a narrow patent that improves on the first invention. The holder of the narrow patent cannot use its invention without a license from the holder of the broad patent; likewise, the holder of the broad patent cannot benefit from the improvement. A cross licensing agreement offers a way out of this double bind. From the point of view of the general interest, it improves productive efficiency. It also avoids the litigation costs that would inevitably ensue if each owner decided to market its product regardless. In practice, cross-licensing agreements are often a way of settling property disputes.

However, cross licensing is not always an ex post arrangement to exchange technologies or settle a dispute. It is also used to forestall hold-up, particularly in sectors characterized by rapid technological progress. In these industries, such as semiconductors, the primary inventor cannot be sure of maintaining his lead in R&D, because others are in a position to improve on his innovation. Furthermore, he cannot foresee future infringements of his intellectual property rights. These are innovations that have not yet been developed or patent applications that have not yet been examined. As Frederic Scherer pointed out [1995], companies "are essentially finding themselves in a minefield: there are lots of unexploded patents out there, and you might step on one and have your corporate leg blown off." By agreeing to a reciprocal exchange of licenses to come on technologies and improvements

that have not yet been patented, innovators guard against the risk of not being able to use their inventions or being sued. By reducing the risk of being held to ransom, these types of agreement restore incentives to invest in R&D and are therefore favorable to the general interest.

Patent pooling expands the system of cross licensing to a larger number of parties. The first documented example of this type of agreement dates from 1856. It was an initiative by American sewing-machine manufacturers. Since then, almost 100 pools have been created and administered by the industry, 63 of them in the United States [Lerner et al., 2002]. Competition authorities have long been wary of these groupings because of their close resemblance to cartels. Gilbert [2002] has identified 22 cases examined by U.S. courts that mark a change in jurisprudence. The most recent concern digital technologies, such as the Moving Pictures Expert Group (MPEG) standard, created by eight companies that have pooled some 100 patents.

The MPEG-2 pool only contains essential patents. These "by definition have no substitutes; one needs licenses to each of them in order to comply with the standard" [Klein, 1999]. The criterion of "essentiality" is fundamental to a cost-benefit analysis of patent pools. Firstly, it implies that the licenses cover complementary patents, both in the technical and economic sense. If the price of one of the licenses in the pool falls, demand for the other licenses increases. Secondly, there must be no substitutes whatsoever, i.e., the patents in the pool cannot be substituted either by each other or by outside patents. The patents thus form a pool of monopolies. Patent pooling is therefore an efficient response to the problem of multiple margins. Cournot's theorem is relevant here: if the holders of essential patents do not act in concert, the license for the patent package will be more expensive and their profit will be lower. Other advantages add to this gain in efficiency. The patent pool enables users to save on commercial expenses. Instead of having to approach and negotiate with several parties to obtain the patents necessary for the MPEG-2 standard, licensees only have to deal with a single intermediary. In addition, patent pooling, like cross licensing, is a way of limiting intellectual property disputes for the companies in the pool. It prevents hold-up and reduces litigation costs. In sum, patent pooling eliminates the problem of multiple margins and reduces transaction costs.

The MPEG-2 patent pool

The MPEG technical standard (or more accurately, MPEG-2 because it is a second version) is used to compress video data. It has become the industry standard for all devices that store or transmit image data (televisions, DVD players, etc.) and has been incorporated into more than 300 million machines. This figure can be expected to increase six-fold by 2006 and the estimated value of products using the MPEG-2 standard will be more than $500 million by the same date [Futa, 2002]. Apart from the University of Columbia, the owners of the patents in the pool are eight major electronics and telecommunications companies, including Sony, Lucent and Mitsubishi. They themselves use the standard they developed. In addition, there are almost 500 licensees.

The MPEG-2 pool is a model in terms of prevention of anticompetitive effects. It only contains patents that are essential to the compression technology, and every effort is made to reduce the number of patents in the pool. Management of the pool and licensing are handled by a specialized agent, MPEG-LA. The agent selects new essential patents as the technology evolves. It is also responsible for removing patents that have become nonessential. The "essentiality" of a patent, which determines whether it should included in or excluded from the pool, is evaluated by independent experts. The rights holders receive income proportional to their share of patents in the pool. At end-2002, the pool contained 525 essential patents, which is five times more than at the outset. They belong to 22 companies, i.e., almost triple the initial number. MPEG-LA is also required to sell the license on a nondiscriminatory basis to anyone who requests it. Every patent can also be licensed separately from the others. If, for example, a patent has another application outside of the standard, the user does not have to buy all the patents in the pool, including those for which he has no use. The members of the pool also agree to cross-sell their own licenses to each other separately. This independent licensing requirement, imposed by the competition authorities, is a good way of ensuring that the patents in the pool enhance welfare [Lerner and Tirole, 2002].

On the advantages and disadvantages of licenses, particularly in terms of their anticompetitive effects, we have seen in this section that economic analysis takes a favorable view of licensing. It suggests that the granting of an intellectual property right is usually in the general interest. It also provides methodical considerations for examining situations on a case-by-case basis. It should be stressed, however, that these considerations are based necessarily on simplifications. One of these is the dichotomy between vertical and horizontal relationships. This is key to evaluating the benefits of licenses, but can be difficult to determine. Innovations are rarely pure substitutes or pure complements. A patent may contain both complementary and substitutable elements. Moreover, from a dynamic point of view, a complement may become a substitute. This is the case with operating systems and Internet browsers. Netscape is a complement, not a substitute, for Windows. However, many, including Microsoft, believe that this type of program could one day become middleware that could replace some operating system functions.

Conclusion

"No economist, on the basis of present knowledge, could possibly state with certainty that the patent system, as it now operates, confers a net benefit or net loss upon society [...] If we did not have a patent system, it would be irresponsible [...] to recommend instituting one. But since we have had a patent system for a long time, it would be irresponsible, on the basis of our present knowledge, to recommend abolishing it."

These statements were made in a study on patents commissioned by the U.S. Congress in the late 1950s [Machlup, 1958]. Since then, new empirical and theoretical knowledge has emerged. This book has described and summarized these developments. Do they lead us to revise Machlup's view?

- Should intellectual property be abolished?

The current dispute over intellectual property began with the extension of patents to biotechnology products, which raised fears of the privatization of genetic inventions and the appropriation of the Southern Hemisphere's genetic resources by corporations from rich countries. It spread with the IT and Internet boom, which pitted supporters of freeware and open architecture against proponents of proprietary products.

A similar anti-patent and anti-copyright movement arose in the third quarter of the 19th century. It succeeded in abolishing patent laws in the Netherlands for 40 years and almost eliminated protection for inventions in Britain and Prussia.

Anti-intellectual property movements in the 19th century (from Machlup and Penrose [1950] and Sagot-Duvauroux [2002])

Intellectual property protection laws were criticized by American libertarians in the second half of the 19th century. Benjamin Tucker, who translated Pierre-Joseph Proudhon into English, regarded patents and copyrights as undeserved privileges, regardless of whether they were conferred by the state or by a monarch [Merges, 1997].

In Europe at the same time, intellectual property protection was decried as an impediment to trade. Patent legislation was called into question in many countries. In 1868, Bismarck recommended its repeal in Prussia. A year later, the Netherlands abolished patents. In 1872, the House of Lords reformed British patent law. Countries, such as Switzerland, that had not yet adopted laws to protect inventions decided not to introduce them. However, the anti-patent movement was soon cut short by economic recession in the early 1870s. A return to protectionism quashed the stirrings of reform: the British government returned to the status quo ante in 1874; the German empire adopted a law on patents in 1877; and Switzerland joined the fold by signing the Paris Convention in 1883.

Copyright endured similar criticism. Many countries were opposed to the extension of copyright internationally. In the United States, where for a long time copyright on foreign books was not recognized [Plant, 1934], liberals such as Charles Henry Carey criticized Britain's monopoly on book distribution. In 1868, Britain decided not to abolish copyright and instead set about strengthening it in its colonies and other countries.

Economists of the day participated actively in the public debate on intellectual property protection. In France, for example, the *Journal des Economistes* served as a forum for different views. Abolitionists like Pierre-Joseph Proudhon railed against the appropriation of ideas by copyright, while liberals led by Frédéric Bastiat advocated a perpetual

property right. Léon Walras and Jules Dupuit expressed more balanced viewpoints. Walras, the father of general equilibrium theory, considered that an author or inventor who makes his idea known should be allowed by society to exploit it as a monopoly for a certain time; otherwise "it is certain that the pursuit of scientific theories, the development of industrial inventions, and the composition of works of art, while not completely abandoned, would at least be seriously neglected". Dupuit, an engineer and economist and pioneer of infrastructure pricing, regarded the allocation of a temporary monopoly to be a second-best solution. He considered it as the least socially harmful way to stimulate innovation that had been found, but that it was nevertheless prejudicial, since "books and inventions are not destroyed by use. Their use is unlimited, i.e., their use by some people does not prevent their use by others, nor does today's use prevent tomorrow's".

The abolition or preservation of intellectual property protection is thus not just a purely theoretical question. To decide on it from an economic viewpoint, we must be able to assess all the consequences of protection and determine whether the total favorable effects for society outweigh the total negative effects. Unfortunately, this exercise is no more within our reach today than it was in Machlup's day.

On the contrary, economic analysis has increased the complexity of such an evaluation by bringing to light previously unsuspected costs and benefits. Three major adverse effects have been identified by economists since the mid-20th century: patent races, the cumulative nature of technical and artistic progress, and the tragedy of the anticommons. Let us recapitulate the basic principles of these three ideas. Firstly, the prospect of obtaining a temporary monopoly encourages too many innovators to pursue the same research projects. They enter a race to patent, which needlessly absorbs a share of the available economic resources. Secondly, cumulativity refers to the fact that creation and invention are based on the knowledge that precedes

them. To make a new contribution, artists and researchers "stand on the shoulders" of their predecessors. Rewarding pioneers amounts to discouraging secondary inventors and creators; conversely, favoring the latter reduces the incentives of the former. Thirdly, in the tragedy of the anticommons, the fragmentation of intellectual property makes access to the collective body of knowledge more difficult and more costly, by multiplying the number of rights holders who must be contacted to obtain a license and who must be paid royalties. We are a long way from the days when the English economist Jeremy Bentham [1785] could defend intellectual property protection by arguing that it did not cost society anything.

Among the recently discovered benefits, the most important is the role of intellectual property in facilitating trade. It was not until 1960 that economic analysis understood the origin of the friction that hampers transactions and how property rights can reduce this friction. Intellectual property rights are no exception. They facilitate the exploitation of ideas and creations by those who value them most.

● Overprotection ultimately stifles research and creation

Although economic analysis does not make it possible to make a definitive judgment of intellectual property, it can point up the dangers of excessive protection. Since the 1980s, intellectual property law has been gradually strengthened and extended. This has led to a situation of overprotection, which now seems to be stifling more than stimulating innovation.

To recall a few illustrations of this trend: it has become increasingly difficult, especially in the United States, to challenge patent validity successfully; patents have been extended to cover genes, software and business methods; and copyright duration has been extended by 20 years. A theoretical study of these developments shows that each generates numerous negative effects for little or no benefit in terms of welfare. The extension of copyright is a good example. On the cost side, the decision by the U.S. Congress in 1999 deprives consumers of free access to works from the 1920s to the 1940s. They will have to wait another 20 years before being able to buy *Rhapsody in Blue* in a less expensive compilation, or a cheap edition of *The Great Gatsby*. The extension of protection is also costly for creators. Many books and films reuse old stories, documentaries include extracts from archived footage, and music remixes and transforms old tunes and songs. If these elements continue to be protected, new creators must negotiate permission and royalties with the rights holders. They must also pay the costs of the search, which is all the more difficult and therefore expensive when a work is old. Extension thus hampers creation. Does it stimulate it in other ways? The answer is no. The benefits in terms of incentives to create – and therefore the production of additional literary and artistic works for society – are negligible. In the case of a work produced 30 years before the death of the author, with a constant annual flow of royalties and a discount rate of 7%, the additional 20 years of protection will only generate a further 0.33% for the rights holders. Who could seriously assert that the 20-year extension will spur new creative efforts?

Empirical studies on the consequences of strengthening and extending intellectual property protection, particularly patents, suggest there are no effects on investment. In the United States, for example, the increase in R&D spending cannot be ascribed to changes in intellectual property law [Jaffe, 2000]. Stronger intellectual property protection has caused a rapid increase in the number of patents, but not in investment. According to surveys, entrepreneurs from outside the pharmaceuticals and biotechnology sectors perceive patents as only a secondary means to guarantee a return on their investment in R&D. This does not prevent firms from systematically filing, since patent ownership reduces the risk of being blocked by a competitor and improves their bargaining power in negotiations over access to technology or finance.

Thus, on the one side, theoretical analysis shows how the allocation of broad patents, the extension of patentability to previously excluded fields, the extension of the duration of copyright, and the broadening of derivative rights can impede innovation; on the other, empirical studies highlight a lack of incentive effects generated by stronger intellectual property protection. In other words, the reforms undertaken since the 1980s have pushed the intellectual property system towards overprotection, which is unfavorable to innovation.

● A need for reform

Unlike some of their 19th-century peers, today's economists do not suggest throwing the baby out with the bathwater. Rather than arguing in favor of abolishing intellectual property protection, they focus on correcting its shortcomings. Let us cite several ways to achieve this.

A first measure, in the field of copyright, would be to institute compulsory registration subject to payment of an annual fee, however modest [Lessig, 2002; Landes and Posner, 2002]. The aim is to reduce research costs for the rights holders and to allow old works that are still protected to be rediscovered and exploited. Such a measure would be a way of centralizing information about rights holders, similar to a cadastral survey of real-estate owners. As with patent renewal today, if the annual fee were not paid, protection would lapse before the legal expiration date. The advantage of this system is that it would eliminate creations of no value.

A second measure would be to remove the factors that encourage patent offices to lower their guard and approve applications carelessly. As the United States precedent shows, examiners are influenced by numerous counter incentives: patent offices earn money when examiners accept patents and lose money when they reject applications; rejection of an application entails additional work because, unlike an approval, it must be justified; and, since opposition is by nature contrary to the interests of filers and their lawyers, this can reduce an examiner's chances of finding employment with one of the major law firms specialized in patents. There is therefore a need to rebuild a system of incentives that realigns the interests of patent offices with those of society in general, and not just with those of filers.

A third measure would be to set up a public fund, to be managed by the competition authorities, which could be used to facilitate challenges to some intellectual property rights [Gilbert, 2002]. The courts do not provide a sufficiently efficient check on poor patent-grant decisions. Because of free riding, parties are reluctant to take matters to court, or else the high costs of litigation encourage parties to settle before the judgment. A public fund could reverse this situation, by clearing the way for competition to blocking patents of dubious validity.

As this book has demonstrated, although economic analysis still has

not been able to offer policymakers with a basis for choosing between "all or nothing" where intellectual property protection is concerned, "it does provide a sufficiently firm basis for decisions about 'a little more or a little less' of various ingredients of the patent system." [Machlup, 1958].

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