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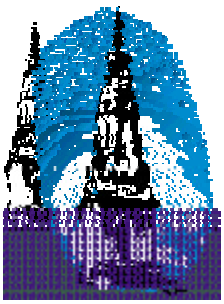

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IS APPROPRIABILITY A "PROBLEM" FOR INNOVATIONS IN DIGITAL INFORMATION GOODS?

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IS APPROPRIABILITY A "PROBLEM" FOR INNOVATIONS IN DIGITAL INFORMATION GOODS?[1]

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"With intellectual property, the upfront costs are what it's all about," (Microsoft Chairman Bill Gates) explained to the business titans assembled at the Redmond, Wash., campus (last May). "Say a piece of software costs $10 million to create and the marginal costs, because it's going to be distributed electronically, are basically zero." Once the costs of development have been recouped, "every single additional unit is pure profit." But if someone comes along with a significantly superior product, "your demand can literally almost drop to zero."
- *Wall Street Journal*, August 23, 2001

1. Introduction

The accelerating innovation and commercialization of digital information goods challenge commonly accepted precepts of how firms profit from investments in R&D. Even though digital information goods – computer programs and games, digital documents, websites, photographs, films, works of music, and the like – are notably easy and cheap to copy, firms still develop them, often investing enormous sums. Just to take the example of software applications, according to studies by the International Planning and Research Corporation, the estimated global software piracy rate was 46% in 1995. Over the next four years, it fell to 36%, and then rose again slightly to 37% in 2000[2]. Annual revenue losses to the global software industry due to piracy in recent years were estimated at around $12 billion (Business Software Alliance, 2000, 2001).[3] Yet the U.S. Department of Commerce (2000) determined that real business investment in IT equipment and software more than doubled in the period 1995-1999, from $243 billion to $510 billion. The software component of these figures rose from $82 billion to $149 billion.

The problem of appropriability concerns the degree to which the returns from investments in R&D accrue to the innovator or to other market participants. In the traditional economic analysis of appropriability (Arrow, 1962, Nelson, 1959), it is argued that due to the "public good" nature of information, firms will lack adequate incentives to invest in R&D. Ways of addressing appropriability concerns include patents and related intellectual property rights, along with other forms of market intervention such as government and university sponsorship of basic research. Digital information goods come close to the classic characterization of a pure public good: one person's consumption does not diminish their availability to others, and they can be perfectly reproduced at essentially zero marginal costs. This chapter asks: To what degree, and in what ways, is appropriability – as might be expected from the theoretical work on this subject, and the precipitous recent demise of many dot.coms - a "problem" for innovations in digital information goods? How do firms capture the returns from their investments in R&D?

Basically, we argue that while the problem of appropriability is highly challenging for the producers of digital information goods, solutions do exist. Not all firms have successfully dealt with the challenges of appropriability, and problem areas remain. Yet capturing the profits from innovations in digital information goods would seem mainly a "problem" for those firms unwilling or unable to think in untraditional manners, and to implement the requisite strategies effectively.

Innovating firms, we will show, have both extensively utilized existing intellectual property rights (patents, copyrights and trademarks), and evolved a new rights system (Internet domain names). They have brought other methods of appropriation into play as well: lead time, exploiting network externalities, branding, facilitating controlled access, technical barriers to imitation, cross-subsidization, bundling, and price differentiation. The different approaches to appropriation vary according to their comparative feasibility and cost. Sometimes, firms seek to exclude others from their innovations, sometimes to diffuse the innovations as widely and rapidly as possible.

Three factors, we argue, affect the choice and effectiveness of appropriability strategies for digital information goods. The first concerns the nature of the incentives to innovate. Unlike many other industries, government and university academics have made key contributions in basic research, which firms have learned from and built on. Many private individuals even seem willing, if not eager, to create and disseminate digital information goods for free. The second factor concerns the nature of the

digital information good: To what degree, for example, can the product be protected by the underlying process? Goods consisting primarily of content, such as music CDs, are easier to imitate than computer programs where access to the underlying algorithms can effectively be barred. The final factor concerns the degree to which would-be imitators possess the assets and competencies to understand and implement the digital information good. While imitation may be easy, this is not the same as realizing the value of the good.

The arguments in this chapter are organized as follows. First, the characteristics of digital information goods are discussed in Section 2. In Sections 3 and 4, we explore how innovative firms have sought to appropriate returns from their investments in R&D. Section 5 considers the question of feasibility and cost, and Section 6 investigates the factors affecting the choice and effectiveness of the different strategies of appropriability. The conclusions form the subject of Section 7.

2. Appropriability considerations for digital information goods

2.1. Theoretical background

The basic economics of appropriability (Nelson, 1959, Arrow, 1962, Machlup, 1968) have been extensively explored in the literature, as well as the social costs and benefits of intellectual property rights more specifically (Granstrand, 1999, Besen & Raskind, 1991). But issues relating to the appropriability of digital information goods in particular are not well understood. At the firm level, analyses of who "wins" and who "loses" from innovation (Teece, 1986, Lieberman & Montgomery, 1988) include examples from the computer industry. A number of empirical studies of firm strategies of appropriability exist as well (Levin *et al*., 1987, Bertin & Wyatt, 1988, Harabi, 1994, Cohen *et al*., 2000). None of these studies, however, seeks to apply the analysis of appropriability to digital information goods in particular. Notably, Arrow (1999, p. 156), states that "it is surprising to find how poorly current theories apply to the situation of high fixed costs which arises when information acquisition becomes a major part of a firm's activity," as reflected in both the continued difficulties in defining intellectual property for innovations in information goods and the unresolved problems in the economic theory of pricing and competition.

Some scholars have analyzed the new dynamics of innovation and pricing in Internet technologies e.g. Eliasson, ed., 1999), including the cooperative invention of Internet-based innovations like Linux (Jonason, 1999a, Kollock, 1997). Others have investigated how information goods differ from physical goods, and the implications for firm innovation and pricing policies (Arrow, 1999, Evans & Wurster, 1999, Varian, 1996b). The most comprehensive treatment of this subject may be found in Shapiro & Varian (1999), who explore among other things the conundrum that it can, under certain circumstances, make eminent economic sense to give digital information goods away for free. Innovating firms can earn rents from associated strategies like "locking in" customers once they have become dependent on the good, and/or benefiting over the longer term because the product has become an industry standard (Grindley, 1995). Their focus, nevertheless, are the general economic effects of recent developments in information technology, not their implications for intellectual property rights. Others have considered, more specifically, the problem of imitation of intellectual property rights in software (Takeyama, 1994, Pearson, 1992, Conner & Rumelt, 1991). There is also an important emerging economic and legal literature on intellectual property rights and the Internet (Jonason, 1999b, Choi *et al.*, 1997, Goldman, 1997, Davies, 1999). This chapter will build on and extend the findings of these and related studies.

2.2. Digital information goods

Digital information goods are unique for two reasons (1) unlike physical goods, they can be encoded as streams of bits, and (2) they consist of information, which differs in substantial ways from other commodities.

Digital technologies are characterized by several unusual features (Shapiro and Varian, 1999, Choi *et al.*, 1997). For one thing, the costs of reproduction are often insignificant, as compared with the costs of copying physical products. Digital copies – unlike analogue copies made by photocopying machines, video and music tape recorders, and fax machines – are also perfect in quality: the first copy, and the thousandth copy, are indistinguishable. Thus there is no incentive for imitators to return to the original source to obtain a new original. By contrast, while a tape recording represents a cheap

way to copy music, the sound fidelity is not as high as the original. If the tape itself is copied, the quality of the sound declines further.

Digital copies can readily be altered. This means both that producers lose control over the integrity of their products, and that imitators can cheaply and easily make marginal changes to the original. Typed documents, by contrast, are not easily altered. An individual sentence may be "whited out" and the new sentence meticulously typed over the old, but without the same look as the original, making it difficult to disguise changes in typed documents. Alternatively, the entire document may be retyped with the desired revisions. But this is a time consuming process. With digital technology, alterations may be performed by much simpler means, with the changed text (due to the ease of reproduction) appearing as if it were the original.

In addition, digital technology allows information goods to be distributed much more quickly, easily and cheaply. A video cassette is an inexpensive way to copy a movie, but it is still just as costly to distribute the copy of the cassette as to distribute the original cassette. While a hundred cassette tapes are considerably more costly to distribute than a single cassette, a hundred computer files can be quickly loaded onto and stored in a single CD, which can then be easily accessed by another user. When information goods are distributed over the Internet, there is very little (if any) difference in distributing one – or thousands or millions – of the good, given the development of common address lists and websites enabling the unlimited downloading of featured files.

Second, digital information goods consist of information. Information, like other production inputs – whether for physical or virtual products – is both costly to create and potentially valuable. But it is also different from other economic commodities. For one thing, information represents a particular form of "experience good." This is, again, true of many types of commodities, where companies – to enable consumers to judge for themselves the value of the good – often give away samples of new products or price them at a discount. Yet information goods represent an extreme form of experience goods: they must be experienced *every* time they are consumed. For example, even if a consumer is a regular subscriber to a newspaper, she can't be sure about the value of each new edition of that newspaper until she has read it (Shapiro & Varian, 1999).

Second, information has many characteristics of a public good. It is "non-rival" in the sense that it does not diminish with use. When a person gives a physical object like a glass or a chair to another person, he loses it, but when he gives the same person an idea, he does not lose it – both parties possess the idea. A second distinctive feature of information is that it is difficult to turn into property, due to its public good characteristic of "non-excludability." Once the information has been provided, it the producer has trouble preventing others from consuming it to their own gain. With the advent of the Internet, there are no longer any significant technical, economic, or temporal limits to the amount of information distribution – or copying – that can occur. In August 2001, the number of Internet users worldwide was estimated at 513 million (Nua Internet, 2001) – growing exponentially. Users (often with minimal technical expertise) can at any time or any place with Internet access, reproduce complex computerized products and programs, created anywhere in the world, for themselves.

The following two sections explore how firms seek to appropriate the rents from their investments in R&D in digital information goods, through obtaining legal protection in the form of intellectual property rights, or other approaches to appropriability – or both.

3. Intellectual property rights

Patents. A patent gives the inventor the exclusive right to make, sell or use a new product or process for a limited time period (twenty years). In return, the inventor publishes the details of the invention in the patent document, so that others may learn from it and build further on the new technology. Only inventions that are novel, industrially applicable, and substantially different from existing technologies may be patented. Patent rights can also be licensed to other firms

Initially, computer programs were not eligible for patent protection, falling under the law of copyright (see below). Nevertheless, software firms, particularly in the United States, have continuously pressed for more direct patent protection of software, often finding a sympathetic ear in the courts.[4] The reason is that a patent protects the underlying idea of the invention, thereby conferring broader protection than a copyright, which protects only the expression of the idea. Moreover, the early software developers also produced computer hardware which, as machines, *could* be patented. In the United States, and

eventually in Europe and other countries, patent protection was gradually extended to cover computer programs that were integral to a process used in manufacturing a technical product, and programs that were part of the patent application for the computer hardware. Currently, in the United States, electronic methods of doing business can also be patented, as long as the claim is structured so as to fulfill the criteria of patentability.[5] These issues are explored in Chapter ___ ("Patents and the Internet") elsewhere in this book.

To achieve effective protection, a patent must be taken out in every country in which the firm does business, or plans to do business. The costs of patenting comprise not only the the application process, both at national the international levels (fees, establishing patentability, translation into foreign languages, etc.), but also the uncertainties of patenting (not knowing whether, or when, the application will be granted), along with enforcing the patent rights once the patent has been granted (discovering infringers, pursuing lawsuits). Often, many patents must be taken out on the same basic innovation to prevent rival firms from taking out their own patents on marginal variations of the original (see Davis, 1988). Moreover, software patents are difficult to enforce with regard to unauthorized use of the technologies by consumers.

Copyrights. Any software program can be protected by copyright, as long as it is original. A competitor that develops a slightly different version of the program obtain its own copyright. Like patents, copyrights can be problematic to enforce, not least in relation to consumers who download programs directly from the Internet. Complicating matters is that users are regulated under their national jurisdictions. How, then, can firms effectively address infringements of their copyrights when their web sites are accessed by individuals outside their national jurisdictions?

License agreements covering the use of copyrighted technology have become a prominent feature of the software industry. When a consumer opens a software program for the first time, for example, she is asked to indicate consent to the Terms and Conditions by clicking on the box "I agree." The enforceability of such "click-wrap" agreements raises two fundamental issues of contract law (Raysman & Brown, 1998). The first has to do with contract formation. Normally, buyers and sellers negotiate and sign a contract before taking possession of the good. But here, consumers are asked to click their agreement *after* purchase. Some consumers have argued that such agreements are not acceptable because the parties have not been able to bargain over or modify the terms of the agreement

before purchase. The second issue concerns what is meant by consent. Traditionally, a contract is enforceable when the parties have signed it. With a click-wrap agreement, the "signature" is a click of the mouse. Is this sufficient to bind the buyer to its terms? In the 1990s, several court cases in the U.S. upheld the enforceability of on-line contracts. In July, 2001, however, federal district court found that software users were not bound by such agreements (Anonymous, *Intellectual Property & Technology Law Journal*, 2001).

Similar questions arise as to the validity of "shrink-wrap" clauses, specifying the terms of use, which are sealed under the packaging of software products, and can only be read after the customer breaks open the package. Unlike click-wrap agreements, the buyer doesn't necessarily know them before purchase. Such clauses are normally not seen as binding unless buyers fully understood their terms before purchase, and had the right to return the good and get their money back.

Trademarks. A third important intellectual property right for digital information goods is the trademark. The trademark protects a special, unique name or symbol, and serves to identify and differentiate the firm and/or its products or services from its competitors. As said earlier, information represents a particular form of "experience good." One implication is that trademarks, as a signal of distinctiveness and quality, are highly prized. Trademarks can also be critical in relation to advertising for mass market products such as music CDs. In other senses, however, the effectiveness of trademarks as a strategy of appropriability is limited. The trademark protects only the name or symbol, not the invention itself (as does the patent). And even though trademarks, as a guarantee of quality, have often been important to firms like Cartier and Lego in combating cheap imitations of their goods, this advantage is less important for software producers, since software copies have the same quality as the original.

Trademarks are frequently featured on Internet in home pages or advertising flags. Sometimes, companies give away their intellectual property for free to attract visitors to their home pages, then sell advertising space on the site to others to bring in revenue. These advertisers include e-mail accounts, interactive news agents, editorial periodicals, and search engines and indexes. Yet again, there are limitations to these practices, not least because Internet users find advertising flags irritating.

One novel and intriguing Internet-facilitated approach to appropriability for trademarks concerns the use of metatags. A metatag is a hidden list of words or sentences within a web site that summarizes the information contained on that site, and forms the basis of an Internet search. Firms have included the trademarks (both registered and unregistered) that belong to other firms in the metatags in order to attract consumers to their own site. But while they may represent a form of unfair competition, it is difficult to use trademark law to restrict their use, since they arguably do not confuse the consumer (metatags are invisible to the Internet surfer). A firm can find out if competitors are inserting its trademark in their metatags by entering its trademark on a search engine, noting the sites where the mark does not appear visibly, and viewing the HTML version of the page (Waelde, 2000).

Internet domain names. Finally, a variation of the use of trademarks that has arisen specifically with the Internet is the Domain Name System, which enables users at different addresses to connect with each other (Tiller, 2001). Internet domain names are today registered by a number of organizations certified by ICANN (Internet Corporation for Assigned Names and Numbers). Only one name can be registered under each top-level domain (.com, .org, .net, and so forth). Registration takes place on a first come, first served basis, for a period of up to ten years, for a very nominal fee. The Domain Name System was developed as a common standard to facilitate communication between the tens of millions of Internet users. There is no requirement that the domain name holder actually use the name commercially, as is the case for trademarks.

Since it is so easy and inexpensive to register domain names, with no requirement for use, many firms and individuals initially bought up the domain names of larger firms (or simply potentially attractive names) and offered to sell them to the highest bidder, a practice known as "domain name grabbing." This practice was encouraged by the appearance of auction sites on the Internet to facilitate the process. Other opportunities exist as well. The tiny country of Tuvalu in the South Pacific reportedly leases out its ".tv" suffix to interested parties; domain names like "free.tv" and "comedy.tv" are said to be offered at yearly rentals of $100,000 (Khokhar, 2001). In some cases, problems have arisen due to the "confusability" of domain names. Under trademark law, firms register their names or sign for a *particular* class of goods. Other firms may use the same mark for a different class of goods, without infringing the original mark. Under the Domain Name System, only one rights holder can possess the name to a particular domain (irregardless of how many firms may be entitled to use the same trademark in their respective classes).

4. Capturing the returns of innovations in digital technologies

Legal protection in the form of intellectual property rights, as emphasized, is by no means the only approach to appropriability. This section presents several further ways in which firms can attempt to appropriate the rents from their innovations in digital information goods. These methods are not mutually independent and in practice often overlap with each other, and/or can be used in combination with intellectual property rights. Nor, given the variety of actors on the market and the speed of technological progress, should the list be seen as exhaustive.

*Lead time***.** Firms can achieve important competitive advantages by coming first on the market with the new good, a strategy often described as lead time. According to empirical studies (Levin *et al*., 1987, Bertin & Wyatt, 1988, Harabi, 1994), lead time has traditionally been important to electronics firms generally, which rate it as a far more effective strategy of appropriability than patents. By being first on the market, a firm enjoys a monopoly position for a brief period of time (even if it doesn't have a patent), enabling it to charge high prices. Because digital information goods become quickly outdated, by the time a competitor enters the market with a similar good, it may have lost much of its value to customers. The innovator, meanwhile, may well have moved on to another leading-edge technology and can exploit the associated first-mover advantages.

Exploiting network externalities. A frequent approach with regard to digital information goods is to come first on the market but charge a *low* price, in the hopes of eventually "locking in" customers. The electronics and telecommunications industries, for example, are characterized by positive network externalities, where the value of a good rises with the number of users of that good. Thus in the early telephone industry, the value of having a telephone greatly increased as more and more people acquired telephones. The same dynamics hold for computer programs, in the sense that the more people who use a given program, the easier it is to communicate with other people who use the same program (and convert their documents), and the greater the likelihood that instruction booklets and technical assistance will be available. Clearly, the more a computer program is copied, the greater the number of users. But once users have become dependent on the program, the costs of switching to another

program increase. The producer can often then raise the price of the good to a level just under the customer's switching costs (Shapiro & Varian, 1999).

Branding. The ease by which previously proprietary digital information can be disseminated over the Internet has begun to break down the relationship between creative people and the institutions that traditionally looked out for their interests and conferred status on them (Rothenberg, 2000). Musicians, writers, programmers, consultants – to name only the vanguard – can now reach their public directly over the Internet. For newly established artists, the Internet represents the opportunity to "speak" directly to consumers, bypassing the entry barriers erected by the established organizations. For well-known artists, it represents a way of avoiding the traditional restrictions and fees. Web entrepreneurs believe that free distribution widens their appeal and builds their image, and that even if copying occurs, "personal branding" will increase sales. While such ventures are not always successful (Steven King's recent book, for example, might well have done better had it been released in the "traditional" format), the allure of personal branding is often irresistable.

Facilitating controlled access. License agreements with users, as described in Section 3, are one means by which firms provide wide access to their technologies, but under controlled conditions. Microsoft's end-user license agreement for pre-release software, for example, allows customers to install and use the product, but users are restricted in their rights to modify the software or reverse engineer it, and may not sell, lease or export it to others. Similarly, development tools are provided with a mixture of rights and restrictions. The Access database comes with two or three sample databases with which users can work. Microsoft supplies the sample codes, and customers can modify and further develop the programs for their own ends. At the same time, Microsoft restricts the number of application programming interfaces available to users. As a result, programs like Excel or Word run more efficiently on the Microsoft operating system than on competing systems (this was been a major point of contention in the antitrust suit brought by the U.S. Justice Department against Microsoft). And by developing systems applications to the needs of individual users, offering comprehensive service functions as part of the "package," companies can prevent would-be competitors from replacing them.

Technical barriers to imitation. Various technical solutions have also been developed to help firms control access to their intellectual property. To take one example, the American National Football League, to ensure that only authorized media organizations, licensees and sponsors can access the more

than three thousand photos scanned into its Internet site each season, allows only pre-approved users with their own passwords to enter the site and download the photographs (Nemes, 2001). Other technical barriers to imitation include the distribution of intellectual property of limited functionality (for example, software that cannot print or save), date bombs (where access is cut off at a particular date), copy protection (where the vendor limits the number of times a file can be copied), encryption envelopes (where access is limited to users with the proper key), electronic watermarks (see section 6.2), and contracts enabling people to use intellectual property rights in excess of the rights granted under normal copyright laws. To this list can be added metering systems such as access codes, debit cards (purchased beforehand by the user, and containing a certain amount of value), and digital signatures (which certify that a user is authorized to access an electronic file) (Pack, 2001, Goldman, 1997, Shapiro & Varian, 1999, Jonason, 1999b).

Cross-subsidization. Cross-subsidization refers to the practice of selling in two different markets, where the firm is willing to sustain losses in the first market because it can earn higher profits in the second. For example, a firm might sell warranties which guarantee free technical service during the specified period if anything went wrong, increasing the consumer's incentive to buy. It could price these warranties high enough to maximize their overall return. Software and data suppliers might give away their products to users in the hopes that they would later buy a more complete version of the program or an upgraded version. Or they might provide consumers with a free copy of a work limited in duration or functionality, in the hopes that they would later buy a full copy (Shapiro and Varian, 1999). To take a somewhat different example, while the Linux operating system is freely available to all, its creator can earn money by giving lectures about the system – and thereby also spread word of the system to people who otherwise might not have known about it.

Bundling. By offering packages of related goods for sale as a set, and firms can achieve cost savings, exploit complementarities among the goods involved, and obtain a higher price for the bundle of goods (though they must take care not to violate antitrust laws, cf. Rogers, 2001). Examples include Lotus's "Smart Suite" or "Microsoft Office". In 1993, Microsoft offered its "Office" package – a word processor, a spreadsheet, a presentation tool and a database – at a suggested retail price of $750. The individual applications, if bought separately, would cost a total of $1,565. The firm reduces its costs since it does not have to sell the goods individually. Consumers gain in that software programs sold as a set often work together better than off-the-shelf programs. They also gain to the degree that network

externalities occur. The firm can increase revenues to the degree that consumers purchase goods as part of a package that they otherwise would not purchase individually (Varian, 1996a). Companies like IBM have also found it profitable to bundle proprietary hardware and software.

*Price differentiation***.** As Varian (1996a,b), among others, has pointed out, the usual prescription for economically efficient pricing, where price equals marginal costs, breaks down for telecommunications and information technologies characterized by increasing returns to scale, large fixed costs and economies of scope. Price differentiation, where different types of consumers are charged different prices, can represent an efficient solution. Common methods of price differentiation include discounts to particular groups such as students, retired people, etc. (third-degree price discrimination), discounts based on the amount of the good purchased, exemplified by volume discounts (second-degree price discrimination), and systems whereby the producer *both* sells different units of output for different prices and these prices may differ from person to person (first-degree price discrimination), extracting all the consumers' surplus in the market. In long-distance telecommunications, for example, firms offer both large and small customers quantity discounts, charge business and individual customers different rates, and offer calling plans featuring discounted rates based on individual characteristics and usage patterns. For software producers, and particularly for the distributors of software over the Internet, price differentiation may prove a highly effective means by which to capture value from their innovations.

5. Feasibility and cost

The innovating firm's choice of appropriation strategy, or combination of strategies, will depend on their relative feasibility and cost. For example, certain aspects of digital information goods can be patented. Yet as noted in Section 3, patents are also a highly costly method of appropriation. Copyright protection for a computer program, by contrast, is both cheaper and easier than patent protection. Yet a copyright is also relatively more difficult to enforce, since infringement is as a general rule easier, and more anonymous. Similarly, trademarks are cheaper and easier to obtain than patents. But they involve their own set of costs, particularly the costs involved in upholding the value of the firm's reputation. Thus if the trademark should become associated in consumers' minds with lack of safety the damage is extremely costly to repair.

The implications of the recent developments in Internet technology for the enforcement of copyright law are only beginning to be explored. Recently, for example, Cadence Design Systems Inc. filed a $1.2 billion suit against some of its former employees, accusing them of stealing its intellectual property for Avant! Corp., a competitor. Its evidence included "electronic footprints" showing how an employee e-mailed six megabytes of source code to his private account before leaving to join Avant! Later, that source code, including typographical errors, appeared in one of Avant!'s own products. Often, firms do not even know that intruders are tinkering with their systems, and even if they do discover them, they are loath to report them. Again, the lack of geographical boundaries means that Internet intruders around the world may gain access to proprietary software, rendering both detection and enforcement even more complicated (Radcliff, 1998).

A related issue has to do with the use of company Web sites. Firms often purchase Web site designs from specialists. Yet if these designers incorporate intellectual property rights belonging to others, such as graphics, the Web site owner can be sued for copyright or trademark infringement. One important issue here is that people often do not know that when they copy or download an image from one Web site and use it in another, they are breaking the law (Trembley, 1999).

By considering the costs and benefits of these different methods together, firms can determine which are both feasible and cost effective to satisfy a particular goal. Often, digital information goods may protected by all three forms of intellectual property. Microsoft, for example, patents certain features underlying its computer programs, copyrights the programs themselves, and uses its trademark to market them. Intellectual property rights may be supplemented, where suitable, by other methods of appropriation.

As regards the other methods of appropriation, exploiting network externalities will clearly be more suitable for digital innovations such as Microsoft’s Word program (where the value of the program clearly increases with the number of users), than for innovations such as a new computerized administrative system for a bank (whose value critically depends on its being kept internal to the bank). The value of encryption systems depends on the degree to which they can be secured against circumvention by intruders. Ranged against them is a whole subculture of hackers, motivated both by the desire to subvert such systems and the ideology that everyone should have free and unlimited

access to the Internet. Encryption systems are costly to develop and implement, but once they are broken, they have no value to the developer of the intellectual property unless or until they can be revised and reinstated. This involves further costs. To take one final example, a key problem related to the use of price discrimination is the costs of determining which prices should be charged to which groups, and of implementing and enforcing the system.

Often, firms must make a fundamental choice, between seeking to protect the new product by restricting access, and disseminating it as widely as possible to increase market share. Connor & Rumelt (1991), for example, in a study of software piracy, have argued that in some circumstances, even where software piracy is significant, not protecting can be the best policy, both with regard to raising firm profits and lowering the prices charged to consumers. Piracy raises the total number of program users, since while some people - if forced to do so by stringent enforcement measures - would buy the product, more would choose to do without. A smaller user base leads to a lower overall program value, and might well actually reduce profits.

When a person purchases a computer program, the retail price is only a small portion of the total costs over time of using the program, which include learning how to use the software effectively, and customization to individual needs. Complementary products such as independently prepared computer guidebooks, tutorial programs written for popular programs, and compatible programs that expand or tailor the program to individual needs without requiring the user to learn a new command structure, and the like, can contribute to reducing these costs. The costs of tracking down infringements and uncovering digital pirates must also be weighed against the costs to the firm of not using those resources in other, more productive ways.

Sometimes a particular strategy of appropriability can be used for a different purpose than is typically assumed. According to sources, IT firms often apply for patents on their new technologies, but not – necessarily – to prevent imitation. As one director of a small IT firm expressed it: “We apply for a lot of patents, without even trying to find out whether the invention is new. There are so many patent applications these days in our field that there is no way the Patent Office can keep up. And by the time they decide to grant or reject the patent, we will probably have moved on to a whole new area.” For this firm, the patent served mainly as a “signal” to other market participants as regards where it was headed, as an indication of value to potential investors, and as a means initially to exclude others from

developing the technology. It clearly also carried the possible future benefit that the patent might be granted, and might have value, if the technology proved more long-lived than the norm. But the patent application, here, served more as an ancillary to the firm's first-mover strategy than as a strategy of appropriability in its own right.

6. Factors affecting the choice of appropriation strategy

Three factors in particular, we argue, affect the cost-effectiveness of the different strategies. These aspects will be briefly explored below.

6.1. Incentive structures

From the beginning, computer and telecommunications firms have adopted a different approach to appropriability than firms in many other sectors. The growth of the computer industry is firmly rooted in university research. Work on the first calculator was begun at Harvard in 1939. The first computer, ENIAC, was developed at the University of Pennsylvania. Early access to key basic research from the universities, along with procurement contracts with U.S. military and space agencies, considerably mitigated the need to earn rents through an exclusionary approach to intellectual property rights. The development of the Internet was spurred by the establishment of the ARPANET by the U.S. Advanced Research Projects Agency, the World Wide Web was developed at the Swiss institute for particle physics, CERN. And e-commerce owes its origins to work in cybernetics in the 1970s by Ivan Sutherland of the Rand Corporation. Key early inventions like the Web browser and one-click links were not patented. Today, university scientists and engineers may well draw on their research backgrounds to start up their own businesses. The resulting cross-fertilization of ideas may make it more difficult to protect proprietary technology through intellectual property rights, but also provides a huge information base upon which commercial innovative activities can draw.

One particularly intriguing aspect of the emergence of the Internet is that it has facilitated the cooperative development of software based on inputs from programmers from around the world, donating their work for free, without proprietary controls. The creation of Linux, a clone of the

powerful and sophisticated Unix operating system, should logically never have gotten off the ground. Since the operating system would be made freely available to all comers, regardless of whether or not they had contributed to the project (due to the non-excludability characteristic of information), the temptation would be strong to let others do the work. There was additionally a risk that not enough people could be persuaded to contribute to the project, in which case any individual contributions would be wasted. Yet there was no lack of interest in participating in this joint effort – quite the contrary.

Why did technicians willingly dedicate their time to the development of this technology? First, the Internet proved to be a highly efficient medium for coordinating the different skills of many experts. Second, people found the project interesting, even "glamorous." And third, because the system was available to all, technicians knew that not only would others gain access to their own contributions, but also that they would be able to access to work done by others, both at present and in terms of future modifications. Further, because the source code was available to all, an informal monitoring system arose, creating an incentive to all to contribute well written code (Kollock, 1997).

Thus there are key differences between the nature of the incentives to innovate for digital information goods, and for other types of goods. Software innovations such as Linux and Freenet were specifically designed as non-proprietary, and at least in part motivated by the desire to erode the proprietary positions of companies like Microsoft. Many private individuals develop new digital information goods "simply" for the fun or pride of doing so, posting their products on their homepages for free downloading. The stunning success of Internet-based services like Napster is due not only to users' desire to save money, but also to enable less well-known artists to post their songs directly on the web.

6.2. The nature of the technology

The second important factor has to do with the nature of the digital information good. To what degree does it consist mainly of content, and to what degree can it be protected by the process behind the product? Music CDs, for example, consist only of content, and can easily be downloaded and copied; a computer program, on the other hand, can – at least to some extent – be protected by the underlying

algorithm, either through encryption techniques, or by patenting its technical effect. Also important is the degree to which the digital information good can be combined with other types of technologies and services to enhance appropriability. For example, patents on computer hardware may also be effective at protecting the associated software.

On the one hand, there is very little that record companies or performing artists can do to prevent the copying of their CDs. An important recent challenge to the effectiveness of copyrights has been the emergence of Napster and related services, which permit two or more computers (equipped with a simple program) to exchange files over the Internet. Due to the easy reproducibility and transmission of digital information goods, such exchanges can take place between users all over the world. Napster's decentral structure rendered it impossible to register what copying occurred, and who was responsible. The lawsuit by recording companies against Napster compelled Napster to restrict access to its files – but other services quickly emerged to replace it.

By contrast, a computer engineer described how he had developed a complex computer simulation of potential interest to several buyers. He used a combination of methods to protect the simulation, including a patent application and encryption. When demonstrating the simulation, he revealed only the first one or two levels of the program, keeping the lower levels secret. The most important information he carried around in his head. Without access to this information, it was impossible to imitate the program.

An important factor concerns the degree to which the software underlying the digital information good is easily accessible. According to sources, the software underlying programs that are distributed by CD-rom or downloading can easily be copied. The software underlying a website, by contrast, cannot be copied directly – though it can be accessed by hacking into the firm's server or by performing a kind of "backwards engineering" based on an examination of the characteristics of the site. Certain computer modules or functions are easier to keep hidden than others. Firms can also use a combination of programming techniques, thereby protecting the specific parts of the program that are the most secret.

To take a final example, when a file is copied from the Internet, a copy is stored both at the user's computer and at the server level. The data is stored at multiple hardware locations as the packets are routed to their final destination. By the use of technical tracking and identification devices, the creators of digital information goods can search the web to locate the hardware platforms containing their imitated work. Since digital copies are perfect replicas of the original, all content stored on the original will be transferred to the copy (Jonason, 1999b, Burk, 1998, Shapiro & Varian, 1999). To facilitate tracing, content producers can store digital watermarks within their products, which can be recognized by search engines. A case in point is the Marc Spider, from Digimarc Corporation. Digimarc embeds copyright and ownership information, including details of its creator, throughout the digital good. It then searches the Web, reporting back about the use and location of the digital information. For music content, a related solution involves the use of sonic watermarks. A recording of a high or low note in a short or unique sequence, inaudible to the human ear, can be placed alongside the digital work of music, enabling the creator to trace illicit copies. Infringements could here be prosecuted according to existing copyright laws.

There are, of course, ways to block such tracking devices. For one thing, they apply only to content stored on the public domain of the World Wide Web; if the illicit copy is stored behind a firewall, it cannot be traced. And discovering an infringement is not the same as preventing it. Thus the use of digital watermarks can make it possible to use existing copyright laws, but this in itself is not enough to enable the effective appropriation of rents.

6.3. The ability of the would-be imitator to realize the value of the innovation

The third factor concerns the degree to which a firm possesses the assets and competencies to understand and effectively exploit the digital information good. Even if a company has the ability to copy a digital information good, this does not necessarily mean that it can realize the full value of this good. The more complex and sophisticated the good, and the greater the degree to which the underlying software can be excluded from imitation (as described in the previous section), the greater these problems will be.

In most cases, information cannot simply be acquired from another firm "off the shelf" and put to effective commercial use. For one thing, access to information is not synonymous with the ability to understand and use it effectively. Firms must possess, or acquire, the necessary internal competencies not only to understand what might be valuable to imitate, but also to use this knowledge productively for their own purposes (Rosenberg, 1990, Cohen & Levinthal, 1989). To translate another firm's knowledge into competitive advantage, what matters is not so much the knowledge itself, but the degree to which the firm possesses the necessary skills and competencies to utilize it effectively (Rumelt, 1984, Barney, 1986).

Teece (1986) emphasizes the importance of complementary assets in determining who wins and who loses from innovation. Sometimes an innovator, through a strong patent position, is able to realize the value of its investments in R&D. More often, however, the lion's share of the profits are accrued to the firm that possesses the most well-developed complementary assets, including more efficient manufacturing facilities, a strong international distribution network, and the like. Thus even if a firm imitates a digital information good, this does not necessarily mean that it can exploit it successfully. One solution is to license the rights to use the digital information good. A contract can be drawn up to specify the legal conditions of the cooperation, perhaps including provisions governing the sharing of the necessary know-how.

The effectiveness of lead time, as discussed earlier, may well depend on factors such as the firm's size and reputation. It is typically easier for a large firm to carry the initial costs of saturating the market with a new good, powered by sophisticated marketing techniques and a global distribution network. For goods characterized by network externalities, such a firm is *ceteris paribus* also more likely to charge a price below cost for what may be a long time. Brand-name advertising, where the firm's trademark provides a signal of quality and reputation, clearly also cannot be replicated by a start-up company. Adapting standard software packages to the needs of individual users also makes it more difficult for would-be rivals to copy.

The very low costs of distributing digital information goods over the Internet may, at least to some degree, have changed this equation, enabling companies like Yahoo!Inc. to start from virtually nothing and rapidly grow. But how many such companies can emerge – and survive – over the longer term?

7. Conclusion

This chapter has generally addressed a central paradox of the continuing global march of digital information technology: Even though digital information goods are often easily imitated, at virtually no cost, this has not diminished the rate of innovation for these goods – quite the contrary. The reproduction and transmission of digital information goods combined with the fact that documents are so easy to alter not only makes infringement easier to accomplish – it also makes it more difficult even to know that an alteration has occurred, who has done it, and when. Even so, solutions have been found. Rents may be earned by a combination of applicable intellectual property rights and other strategies such as lead time. The optimal approach may differ from innovation to innovation and firm to firm, and may change over time.

Furthermore, it is important to see appropriability issues for digital information goods in their wider context. Problems of appropriability have existed for all industries, both at present and in the past, to a greater or lesser degree. The nature of digital information goods presents a series of new challenges, but they are not unsurmountable. Earlier revolutionary technologies, such as the printing press, the steam engine, chemicals, electricity, and the telephone, for example, were generally – in comparison with digital information goods – more difficult to copy. The key innovations were technically highly sophisticated for their era and thus out of the reach of non-specialists, and developing the innovations required large investments in capital equipment and infrastructure. Yet at the same time, the innovators concerned did not possess the relative advantages that globalization and rapid technological development can provide, namely that new products can be brought more quickly to market, and be more easily distributed to buyers all over the world. Again *ceteris paribus*, the opportunities for realizing steep profits very quickly are higher. Thus while the "public good" nature of digital information goods, in some respects, exacerbates the problem of appropriability, this is not necessarily a detriment.

A salient difference between digital information goods and other types of goods is that they can be imitated not only by other companies (along the entire supply chain), but also by consumers. Again, however, this provides opportunities. As noted in Section 4, software firms may gain from extensive

copying, due to the sales of complementary products and the ability to "lock in" customers. The incentive to produce a new computer guidebook is not based on *who* buys the book (i.e. whether or not they have purchased the relevant software, or pirated it), but on the *number* of books purchased.

In addition, due to the "non-rival" feature of information, innovators never actually lose the information they create, even though it becomes available to others. Even if a competitor gains access to secret proprietary know-how, or infringes the patent, the innovator can continue to exploit the same information commercially, in its own way. Its investment in R&D is not lost, it is simply reduced, and depending on developments in the market, it may in the long run generate even greater returns than if copying had not occurred.

Certain areas of concern clearly remain. For example, it is critical to ensure that intellectual property laws "keep up" with developments in this industry. In particular, the problems of copyright and file-sharing services faced by the music industry require greater precision in the law. That performing artists are concerned as well is reflected, for example, by the lyrics of groups such as Bare Naked Ladies, who sing "Stop stealing my music and buy my album!" While established institutions, such as publishing houses, have traditionally extracted rents from their authors under contract, and erected market entry barriers, they also have also performed the valuable role of selecting promising authors and discouraging the less talented.

The immense speed of technological progress in digital information goods has also created problems for the international system of intellectual property rights. What should be patentable? How strong should copyright protection be? How can an effective Domain Name System be implemented. During the past two decades, for example, the United States has granted patent protection to software and software-implemented technologies more readily than other countries. This has considerably strained the resources of the U.S. Patent and Trademark Office, and put huge pressures on patent authorities around the world. It increases costs on firms, too, to determine what is patentable, compare the standards for patentability in different countries, and the like. Ideally, patent authorities should seek to cooperate on such matters at an earlier stage. The recent Trade Related Agreement on Intellectual Property Rights, under the WTO, has been an important step in this direction (e.g. Primo Braga, 1995).

But broadly speaking, for firms specializing in digital information goods, while the problem of appropriability has been challenging, it has in practice not led to a lack of innovation – quite the contrary. Firms have developed a range viable, cost-effective solutions to appropriate rents from their investments in R&D, such as the extension of patent protection to cover certain technical aspects of computer programs, exploiting network externalities, branding, cross-subsidization, bundling, and price differentiation. Sometimes they have evolved novel and highly original solutions, such as on-line "click-wrap" copyright license agreements, metatags, encryption systems, and digital watermarks. In this sense, the developers of digital information goods have distinctively renewed and refreshed our understanding of the incentives to innovate, just as they have revolutionized other aspects of economic life.

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NOTES

[1] This chapter is an extensively revised version of an earlier paper: Davis, Lee N. (2001). “Profiting from innovations in digital information goods: the role of intellectual property rights,” in Dundar F. Kocaoglu and Timothy R. Anderson, eds., Technology Management in the Knowledge Era (Portland International Conference on Management and Technology (PICMET), Portland State University), pp. 471-480. I would like to thank the participants of the PICMET conference, along with Jerome Davis, Volker Mancke, Besher Wattar, and the editors of this book, for valuable comments on earlier versions of the text.

[2] The piracy rate was defined as the volume of pirated software applications as a percentage of the total software installed in each country in the survey. To estimate the volume of pirated software applications, the authors of the report substracted the volume of software applications legally shipped from the volume of software applications installed.

[3] As regards digital information goods more generally, while precise figures are difficult to come by, the value of digital online content more generally, according to another recent estimate, may be as high as $200-300 billion. How much of this has been copied is unknown. One indication, according to the International Federation of the Phonographic Industry, is that worldwide music sales fell 1.3% in 2000, “evidence of the impact of free online music.” (both figures are from Boeri, 2001).

[4] Researchers at Microsoft, for example, have taken out patents on a "Method and System for Scheduling the Transfer of Data Sequences" and "Concurrency and Recovery for Index Trees with Nodal Updates using Multiple Atomic Actions," to give just two examples (www.research.microsoft.com).

[5] Examples include British Telecom’s patent on an ”information handling system in which information is derived from a computer at a remote point and transmitted via the public telephone network to terminal apparatus” (seen as a patent on a hyperlink), Amazon.com’s patent on a ”one-click system of e-commerce,” and DE Technologies’ patent on ”a system designed to help import and export products via the Internet.” Dell Computers has obtained 42 granted and pending patents on its innovative business model, including its customer-configurable on-line ordering system as well as the methods by which that system is integrated with Dells manufacturing, logistics and customer service operations (Rivette & Kline, 2000a). Such patents have thus far only been issued in the United States, but the practice may well spread to the rest of the world (as was the case with regard to patents on software).