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PIRACY AND INNOVATION: DOES PIRACY RESTORE COMPETITION?

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Key words: Piracy, Innovation, Digital goods, Public goods, Competition, Monopoly, IPR

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Abstract

One of the main issues usually associated with piracy is that it hinders innovation. As this leads to smaller profits, firms have no incentive to innovate. In this article, we show that even if piracy is usually seen as innovation "killer" it may, on the contrary, increase innovation: piracy places firms in a highly competitive environment and pushes them to innovate continuously in order to maintain their market power. We then evaluate the benefits of this innovation, stating that even if innovation is indeed encouraged, the type and level of innovation may be suboptimal. This leads to the discussion of different policies aiming at solving the piracy problem. We show that, even though reinforcing IPRs is usually seen as the best way to solve this problem, increasing the level of IPR protection may not be the best solution. Indeed we show that high level of IPR protection creates additional market distortions, and consequently an additional loss of welfare. Finally, we introduce two type of policies aiming at producing efficient level of innovations: a system of tax/subsidy, and, surprisingly enough, perfect competition.

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Introduction

One of the main issues usually associated with piracy is that it hinders innovation. The idea behind that is that, as the firms know that their products will be pirated, they have no incentive to innovate. For firms piracy means indeed that they won't get any "reward" for their innovation, and that as they are experiencing a smaller amount of sales, their revenues won't cover the R&D expenses. It seems, however, that the sectors of the industry that are the most affected by piracy are also the most innovative: software, games, movie and music industry. The impact of piracy on innovation becomes then rather ambiguous: on one hand it seems to prevent innovation, and on the other hand this problem seems to concern mostly firms that are, and remain, innovative.

The aim of this article is to show that even if piracy can be seen as innovation "killer", on the contrary, it may increase innovation. In the first section, we discuss the relation between digital goods and IPR. Then we show, in the second section, that the extent of piracy phenomenon seriously decreases the benefits of IPR protection systems. In the third section, we point out that piracy places firms in a highly competitive environment and pushes them to innovate. In the fourth section, we try to evaluate the benefits of this innovation, stating that even if innovation is indeed encouraged, the type and level of innovation may be suboptimal. Finally, In the fifth section, we discuss the pro and cons of different policies aiming at solving the piracy problem.

1 Knowledge-based goods and IPR

The first thing one can notice when examining the issue of piracy is that massive piracy is related only to some types of goods: movies, music, software or documents. These goods have a common property: they can be coded in binary form (i.e. a succession of 0 and 1), therefore they are usually referred to as digital goods. The digital nature of these goods has a very important consequence: these goods have non-rivalness and non-excludability properties, and thus can be considered as public goods (Rayna, 2002). This is due to the fact that digital goods can be "cloned" (we mean here, an exact copy, as there is no loss when copying digital data) easily and nearly for free. As they can be cloned, there is non-rivalness since an unlimited number of consumers can use, at the same time, the same unit of good. As it's easy and cheap to copy digital goods, production (or sale) of one unit of digital good means it has been produced for everybody, as everybody can copy this unit of good. Likewise there is non-excludability since, despite the fact that the firms have a control on who is buying the good, and thus can exclude consumers, they can't

prevent consumers from copying the good from another consumer. Therefore once the first unit has been sold, firms can't exclude consumers anymore as the consumers can get the good from another source.

This has a very important consequence on innovation [1] and the creation of digital goods. The non-rivalness of digital goods, as well as the fact that they are aspacial, makes them very close to knowledge, information, and ideas that share these properties (Quah, 2002), and therefore are facing the same problems.

There is an abundant literature in Economics related to innovation, knowledge and ideas. The usual argument (Arrow, 1962; Nordhaus, 1969; Aghion and Howitt, 1992) is that, in absence of a proper protection system, the market fails to produce a sufficient quantity of these goods. This is due to the fact that since the replication cost for these goods is negligible, the marginal cost of such goods is equal to zero. Therefore in a competitive environment, the price of these goods is equal to zero. In this situation, there is no incentive to innovate, as the expected value of the good is equal to zero. As the market fails to produce innovation or knowledge, the usual remedy is to establish a protection system, via copyright and patents, giving to the producer of innovation or knowledge a temporary monopoly power. The monopoly rent associated with the discovery of new ideas is then seen as a strong incentive to produce a sufficient quantity of these goods. These arguments have been the basis for the establishment of a strong IPR protection system in most of the countries. The usage of patents and copyright to protect knowledge and ideas is often seen as a successful way to increase innovation [2].

2 Piracy and softlifting

As the digital goods have the same properties as knowledge or ideas, they are subject to the same phenomenon: due to their non-rivalness and spatialization, their expected value in a competitive environment is equal to zero. Therefore, without any protection system, the market should fail to deliver a sufficient (if any) quantity of those digital goods.

As knowledge and ideas, digital goods also enjoy an IPR protection system in the form of copyright, and in some cases in the form of patents. The problem

[1] In a simplification purpose, we mean by innovation the discovery of new technology, but also the development of new software, the discovery of new artists, the creation of a new movie, etc.

[2] Even though, as further discussed in part 5, the efficiency of such protections should be discussed

is that these protections are far from being as successful towards digital goods, as they are towards knowledge or ideas.

The success of IPR protection for knowledge and ideas is due to the fact that it's possible, even though sometimes it's difficult, to detect copyright and patent infringements. The purpose of these infringements is a subsequent sale of a good or a service by another company, therefore such infringements are relatively easy to detect, and the IPR can be enforced.

When this kind of infringements also takes place in the digital goods market, most of the infringements are done to consumers and not firms, and the purpose of these infringements is restricted to private consumption. Shore et al. (2001) show that what is usually referred to as piracy can in fact be redefined in two different categories:

- Softlifting, which involves the unauthorized copying of software for personal use and without monetary gain
- Piracy, or counterfeiting, which generally involves monetary gain

The usual concept of piracy is therefore replaced by the concept of "unethical copying", this concept includes two categories: softlifting and piracy.

Thus, we can notice that most of the IPR infringements related to ideas and knowledge are due to piracy, whereas digital goods IPR infringements are mostly related with softlifting. This is indeed the main issue associated with digital goods. Softlifting is particularly difficult to monitor. Even though the industry is trying hard to monitor the exchange of digital goods on the Internet, it's obviously impossible to monitor the direct exchange of digital goods between consumers. What's more, the extent of softlifting is so high that even when infringements are discovered, it's unrealistic to think that all these infringements could be prosecuted. For example, the peer-to-peer exchange service Kazaa claims to have more than 70 milions of regular users. Moreover this service is rather highly centralised, so it's possible to know the global number of users. However, due to recent prosecution leaded by the RIAA, consumers tend now to switch from Kazaa to less centralised, and more anonymous services, like eDonkey/eMule or BitTorrent, where the number of consumers using peer-to-peer services is more difficult to monitor. During its period of glory, 350 000 new users were joining Kazaa every day. Even though the recent legal actions might have discorage some consumers, the recent loss of popularity of Kazaa is more likely to be due to consumers switching to other, more secured, peer-to-peer services.

Likewise, other recent studies [3] show that about 30 % of Internet users (which is about 40 milions users, for the sole United States territory) have downloaded

[3] `http://www.pewinternet.org/reports/`

music files to their computer, and about 4 % do so on daily basis. What is more, this phenomenon is not restricted to teenage users as 20 % of this Internet users are older than 30, and 14 % of them older than 50. One should also keep in mind that this is only the tip of the iceberg, as direct exchange of digital goods is even more difficult to monitor.

This distinction between piracy and softlifting helps us to understand the particular problem of unethical copying of digital goods. As we have shown, piracy can be rather easily monitored, and is executed by a relatively small number of individuals/firms. On the other hand, softlifting can be considered as a consumption behavior [4], and thus is difficult to observe and to prevent as most of the consumers tend to adopt this behaviour.

If the usual IPR protections, copyright and patents, are rather efficient in inforcing IPR in the case of piracy, they are particularly useless in the case of softlifting. Therefore, firms producing digital goods seem to be in the same situation, regarding innovation, as the firm spending resources on R&D when patents and copyright don't exist. By comparing these two situations, it seems that the impact of piracy on innovation is then obvious: as stated by the Economic Theory about the copyright and patents system: in the absence of a system of "protection" piracy [5] prevents innovation and creation of new digital goods. As soon as a few units of the digital goods are sold, consumers start softlifiting. Thus the only reward for innovation will be the profit earned by selling a small number of units. And unfortunately it's not very likely that these profits will cover the expenses that the firm made to produce this new product. Novos and Waldman (1984) show that lower profits reduce the *ex ante* incentives to provide quality. The same kind of reasoning is used in Johnson (1985) to show that lower profits also reduce the incentive to provide variety.

Thus, due to the softlifting behaviour of the consumers, the innovation in the digital goods industry should decrease, since the reduced profits of the firms are not high enough to incite them to increase the quality and the variety of the digital goods.

[4] In Rayna (2002), we show that, since digital goods can be considered as public goods, softlifting is, in fact, the usual free-riding behaviour caused by the presence of a public good

[5] More precisely, as defined above, nonethical copying

3 Piracy and innovation: Forced innovation

Following what was stated above, such an extent of piracy should have stopped innovation , or at least strongly reduced innovation in the digital goods industry. However, despite the fact that the piracy/softlifting has increased over the past years, the firms producing digital goods remain highly innovative. What is more this type of firms certainly stand among the most innovative firms. For example, Microsoft, despite piracy, keeps releasing new software. Windows XP was presented as the most innovative operating system ever released by Microsoft, and Microsoft promises that the next version of Windows (called *Longhorn*) will be even more innovative. Also, as shown on Fig. 1, the number of movies produced by the industry, is far from decreasing: somewhat constant in the United States, the number of films produced in Europe and Japan increased despite the constantly growing exchange of pirated movies on the Internet. Moreover, new albums of both well-known and new singers or bands are released every year. Also, important innovations that increased the quality of the products came to the market these last years. The DVD, for example, delivers a quality of image and sound far superior than the "old" VCR. It seems, therefore, that despite the predictions of Economic Theory, there is still incentive for firms to innovate.

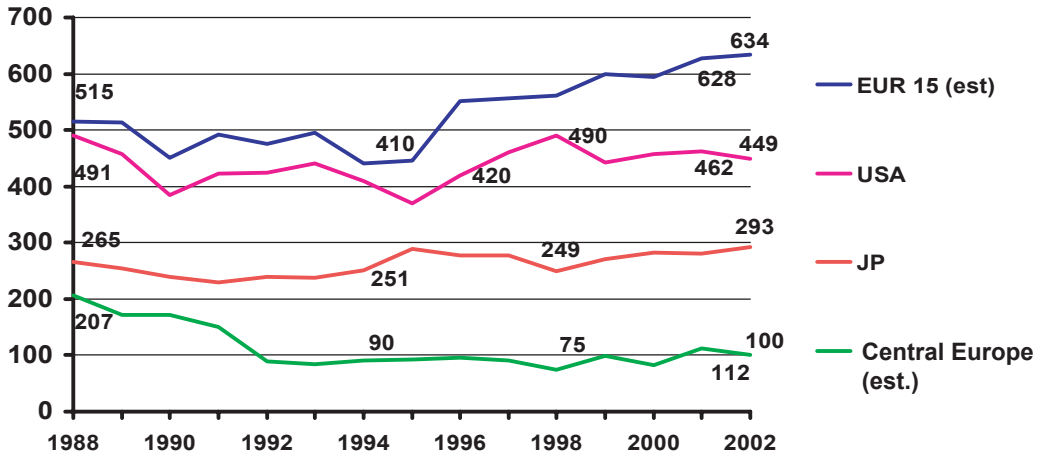

Fig. 1. Production of movies in the USA, Europe and Japan (1998-2002)

This phenomenon can be explained by the particular nature of digital goods. In Rayna (2002) we show that even though digital goods may be considered as public goods, this is not necessarily the case. The nature of digital goods is such that they *tend* to be public goods. Nevertheless, their level of *publicness* depends on a lot of factors. The technology, for example, influences the level of non-rivalness and of non-excludability of the goods. Indeed, non-rivalness implies that the cost of copying a digital good should be close to zero. If the cost of copying increases, then the goods become more rival. Likewise, there shouldn't be any technology able to control the usage of the digital

good. If such a technology exists, the digital good then becomes excludable as producers can prevent consumers from using this good.

The behaviour of the consumers also influences the level of publicness of the digital goods: if none of the consumer is willing to share a digital good, then the only way to acquire this good is to buy it from the producer.

Last but not least, the level of publicness of the digital goods depends on the behaviour of the firms. If the firms don't try to protect their products, then digital goods are *de facto* public goods. On the other hand, firms can fight piracy by introducing protections systems in their products. If these protections are successful, the level of publicness of the digital goods may be strongly decreased.

3.1 Anti-piracy driven innovation

Therefore, one of the incentives for the firms to keep on innovating is to prevent piracy. That is obviously some sort of paradox: piracy encourages innovation because firms need to innovate in order to prevent piracy. By doing so, the firms aim at lowering the level of publicness of the digital goods by increasing rivalness and excludability. As the usual IPR protection systems don't protect firms from piracy, they have to develop their own protection systems.

Thus, firms are devoting significant part of their income to R&D in order to develop effective anti-copy systems. In the past years, a multitude of different protection systems have been developed. Their common feature is that they all aim at increasing either the rivalness or the excludability of the digital goods. In order to increase rivalness, a great number of systems were developed in order to prevent consummers from being able to copy the digital goods. One of the most known anti-copy system is the CCS[6] used to prevent a copied DVD to be read in any DVD player. More recently, Sony introduced a system that prevents the consumer from reading an audio CD in a computer, thus preventing the copy of the audio CD. This kind of systems increases the level of rivalness. Indeed, as it becomes impossible (or too costly) to copy a digital good, the digital good is consequently not independent from the physical support (CD, DVD, etc.) anymore. As this support is a pure private good, the digital good becomes then a private good as well.

Likewise, Windows XP introduced a new protection system called "Windows Product Activation". Once Windows XP is installed on the computer, a serial number is created. This serial number is generated according to specific parts

[6] Content Scrambling System: the movie on the DVD is encrypted and therefore can't be copied on the hard drive

of the computer (brand and size of the hard drive, number of RAM modules, etc.). Then the consumer has to contact Microsoft in order to get a key pass. This key is unique and matches exactly the serial number previously created. Therefore this copy of Windows will only work on this particular computer. This system obviously introduces excludability. If a consumer copies the Windows from another consumer, this copy will be useless, as the key of the first consumer won't allow Windows to run on another computer. The only way to solve this problem is to contact Microsoft to ask them for a key. That's precisely the moment when Microsoft has the power to exclude the consumer, as in order to get a key, the consumer has to prove that he/she has actually bought an official version of Windows.

Unfortunately for the firms, all these various protection systems have in common the fact that they were all "cracked": there is always a way for the consumers to avoid or deactivate these systems. For example, the "crack" [7] allowing to bypass the Windows Product Activation was widely available on the Internet even before Microsoft started to sell Windows XP (Patrizio, 2001). Likewise, DeCSS, a program breaking the CSS protection system, and thus allowing to copy DVDs, appeared only a few months after the release of the first DVDs. As for the audio CD protection system, three months passed before somebody was able to find out that only a short line written with a marker allowed to remove the protection and to read the CDs on a computer.

Still, these protections are not completely useless. As there is a gap between the time when the protection appears and the time the crack is released, in the meantime the publicness of the digital good is reduced.This can create a strong incentive for consumers to buy the product as they can't softlift it. Therefore, firms are incited to innovate continuously in order to create as many "gaps" as possible.

3.2 Differentiation driven innovation

However, innovation in the last few years is far from being restricted to anti-piracy systems. As was mentioned above, an important number of new software, new movies, new albums were released in the last years, even though the piracy phenomenon has been constantly increasing at the same time. The conclusion could be made that there should still be a strong incentive for firms to innovate and to release new products.

The reason for that is that there is, once again, a limit in the publicness of the digital goods. More precisely, the copy of a digital good is not necessarily the

[7] A crack is usually a small program able to modify the code of another program, and thus allowing to disable some of the functions of this program

equivalent of the digital good itself. This means that a digital good and copy of this digital goods are usually close substitutes, but not necessarily *perfect substitutes*.

The first reason for that is a technological reason: the available technology is not necessarily advanced enough to produce an exact copy of the digital good. A good example of that is the case of the DVD. When the first DVDs were released, there were no DVD burners available. What is more, at that time, there wasn't any removable media able to contain the video file of a DVD [8]. The only way to copy a DVD was thus to create a "lighter" version of a DVD. Therefore, the video and audio had to be compressed, which implies a loss of quality in both audio and video signal. Moreover, some special feature included in the DVD couldn't be included with the copy (Table 1). Thus the MPEG-4 [9] copy of a DVD is not a perfect substitute of this DVD.

Table 1
Differences between a DVD-Video and the MPEG-4 copy of this DVD

	DVD	MPEG-4
Video	High definition	Heavily compressed: - presence of artifacts - smaller definition
Audio	- High quality - 5-Channels Surround - Several languages	- Compressed format (MP3) - Stereo - One language
Subtitles	Several languages	- None / separate file
Bonus	- Additional scenes - Making of - etc.	- None / separate files
Size	4.7 GB / 8.5 GB	700 MB

The same kind of problem occurs with audio files - the quality of a MP3 compressed file is lower than the quality of the original audio CD - and with software. For example, before the CD burners became available on personal computers, most of the software was supplied on CD-ROMs. At this time, as it was impossible for consumers to burn their own CDs, they had to copy the software on floppy disks. Hence, copying Microsoft Office required more than

[8] For example, a DVD contains more data than 10 CDs

[9] Algorithm allowing to reduce/compress a video file. It's in fact the equivalent of the MP3 for video. Several variants exists, the most well-known are DivX, XviD and the official MPEG-4 codec.

40 floppy disks. Even though the software, once installed on the computer is the same, carrying it around on a CD-ROM is definitely not equivalent to carrying 40 floppy disks.

It's evident that when the original digital good and the copy are not perfect substitutes, there is a strong incentive for consumer to buy the original version instead of copying the original. A difference in quality can thus reduce the extent of softlifting. The problem for the firms producing digital goods, remains, however, as the other firms producing the hardware have strong incentives to innovate in order to push consumers to renew their equipment. Therefore, the available technology always progresses and tend to reduce the difference of quality between the original and the copy. As soon as the DVD burners started to be supplied with personal computer, it became possible to make an exact copy of a DVD including all the features and advantages of the original DVD. Here, as the copy is a perfect substitute to the original, the incentive for the consumers to buy the original drops.

Also, another reason for the success of MPEG-4 encoders was that the available Internet technology, e.g. the bandwidth, wasn't sufficient to transfer a whole DVD over the internet. Consequently the only movie files available on the Internet where the MPEG-4 files. However, now, when a lot of consumer have a broadband access, the "master files" (blueprints) of DVDs are more and more available on the Internet. It is thus possible to download the content of a DVD, and to burn it on a DVD-R. The consumer then possesses an exact copy of the original DVD.

Hardware manufacturers are not the only ones causing problems to the producers of digital goods. As the consumers are obviously willing to get a copy as close as possible to the original, other digital goods producers are trying to take advantage of that. A lot of developers are improving the audio and video compression algorithms in order to get a quality as close as possible to the original. Despite the fact that the MP3 is still the most popular format for music files, some more recent algorithms, such as AAC, Ogg-Vobis, MP3 pro, deliver a far better quality and are able to reduce even more the size of the files. The video codecs have also improved a lot, and the new versions of this algorithm deliver a quality so close to the original that the difference is hardly noticable. What's more, the new MPEG-4 movie files now support 5-channels surround, subtitles, etc.

A difference of quality between the original digital good and its copy is a good way to incite consumers to buy digital goods instead of copying them. Unfortunately, due to constant innovation in both hardware and digital good industry, this quality gap is continuously closing down, and copy becomes a perfect substitute of the original. Piracy tends then to increase innovation, as firms need to maintain a difference of quality between the digital goods

they sell and the copies the consumer can make.[10]. Indeed, if the difference of quality is too small, it means that even "quality lovers" consumers, who usually are the most loyal customers, may be "contaminated" and also start pirating, as the difference in quality is not worth the cost of buying the original.

3.3 Continuous innovation

Despite the particular nature of digital goods, there is still a way for firms to prevent piracy: innovation. Innovation in protection systems will allow the firms to reduce the publicness of the goods and therefore to encourage consumers to buy digital goods. Innovation in quality will also create incentives for consumers to buy the original instead of getting a copy.

Unfortunately, the effects of innovation decrease over the time, and firms thus need to innovate continuously in order to sell. The main issue in regards to piracy is that it dramatically reduces the amount of time firms have to sell their products. All the countermeasures described above have only a short-term effect: once the pirated version is widely available on the Internet, the incentive for consumers to buy the official version is very low. It seems then, being caricatural, that the firms have only "one month" to sell their products. If it's actually the case, it means then that firms have to release new products on regular basis, e.g. innovate continuously in order to keep their market position.

Hence it seems that the main impact of piracy on innovation is that it deprives firms of the revenues associated with the market power the firms usually enjoy due to copyright and patents, and places them in a highly competitive environment. Having no guaranty that the revenues from the sales will cover the R&D costs, a good strategy could then be to stop innovating. The problem is that selling actually requires innovating - as there is otherwise not enough incentive for consumers to buy - and stopping innovating is equivalent to leaving the market, as the revenues of the firms will continuously decrease over the time.

One good reason for the firms to stay on the market is that they have means to change the level of competition. That's not surprising, as it's indeed the goal of any firm in a competitive environment: create barriers to entry and product differentiation in order to increase their market power and to enjoy a monopoly rent (Tirole, 1988; Porter, 1985). Thus the situation on the digital

[10] The same type of arguments can be used when innovation, instead of a being a technical progress, is the release of a software, movie, album. As it takes time for a digital good to spread over the Internet, releasing a new digital good creates a period of time when consumers have no choice but to buy the good ... or to wait

good market is not that different from the other markets: in absence of legal protection system [11], firms are in a competitive environment. Consequently firms will develop strategies in order to decrease competition and increase their market power [12]:

- Creation of barriers to entry: anti-piracy protection systems
- Product differentiation: quality differentiation

The main peculiarity of the digital goods market is that the increase in market power (and the rent associated) triggered by such strategies doesn't last long [13] [14]. Therefore firms have to innovate constantly in order to make a profit.

Instead of constantly innovating, firms could decide to leave the market if they think that the situation is not profitable enough. This would certainly harm innovation. On the other hand, as long as digital goods are not perfect public goods, i.e. as long as there is a (even very small) degree of rivalness and/or excludability, it is still possible to make profits in the short run, and thus firms will enter the market [15]. The empirical facts (Oberholzer and Strumpf, 2004; Ziemann, 2002) show that, despite the increasing competition caused by piracy, the digital goods industry seems to be rather profitable. The profits of the main companies are still way above the zero economic profits, even though piracy might have reduced them.

Economists often see a competitive environment as being disastrous for innovation, since firms are not able to cover their R&D expenses, and are thus not incited to innovate. As piracy places firms in a highly competitive environment, this phenomenon should, in theory, consequently harm innovation. It seems that, on the contrary, piracy, by restoring competition, creates a strong incentive for the firms producing digital goods to innovate as they need to innovate to reduce competition (by protect themselves and by differentiating their products). Interestingly enough, these innovations created by the firms in their turn, produce incentives for other actors, individuals or firms, to innovate: they innovate in order to break the protections created by the industry and also to increase the quality of the copy of a digital good. It seems thus

[11] As we've seen p. 3, they exist, but are rather useless.
[12] Other example of strategies are given in Rayna (2002). Nearly all of them requires innovation in order for comany to be successful.
[13] As shown p. 8 and 10.
[14] Interestingly enough, it seems that this particular phenomenon is not restricted to digital goods, but seem to be present in most of the high-tech industries.
[15] This reasoning is obviously a partial equilibrium reasoning. The sole fact that other industries, for example hardware, need to have innovative digital goods as these are complementary with the good they produce, is a sufficient reason for the market of digital goods not to be "empty".

that instead of harming innovation, piracy, by restoring competition, triggers in fact chains of innovation.

Table 2
Innovation triggered by piracy

	Digital Goods Industry	Others
Anti-piracy protection	Innovate to create protection systems	Innovate to crack protection systems
Quality	Innovate to increase the quality of the original	Innovate to increase the quality of the copy

4 Piracy, innovation and efficiency: useless innovation?

From a social point of view, stating that piracy encourages innovation doesn't exactly "solve the problem". First of all because the innovation produced may not be useful for the society, but also because the level of innovation produced may be too low in comparison to the situation where piracy doesn't exist.

Considering, the failure of the current IPR protection system towards digital goods, and the constantly increasing extent of softlifting (Dyson, Nov 2003), this problem is indeed of the greatest importance for economists.

The first question one can raise is the following: is the innovation induced by piracy useful? Even though it's rather difficult to have an accurate idea of what is a useful innovation, we can still try to answer a question by using a qualitative approach.

So, what is a useful innovation from a social point of view? We can reasonably assume that it should comply with the following:

- An innovation that increases the productivity of a firm.
- An innovation that increases the utility of the consumers.
- An innovation that increases the global welfare.

One can also notice that some innovations might not be useful at the time of their discovery or in the industry where this innovation happened, but can be used latter or in another industry.

It is now clear that according to the above stated definition, innovation related to anti-piracy protection systems doesn't seem to be very useful. It is certainly useful for the firms, but from a social point of view, it doesn't add

any value, since it doesn't increase neither the productivity nor the utility of consumers. The effect on global welfare is clearly unambiguous: since this kind of protection reinforces the firms market power, prices will go up. Thus the consumers' surplus will decrease and the surplus of the firms will increase. This will unfortunately create, in most of the cases, a deadweight loss and consequently will reduce welfare.

This last point is illustrated in Chen and Png (2003). They show that a social cost arise if firms spend resources on protection systems. In, their model, the expected utility from illegal copying depends on the detection probability. The firms can adopt two different strategies in order to eliminate copies: they can lower their price or spend additional resources on a technology that increases the detection probability. From a social point of view, these two strategies lead to different effects on welfare. A lower price unambiguously improves welfare because less effort in copying is needed [16], whereas increasing the detection system is wasteful from a social point of view and reduces the surplus of consumers.

What's more, we can be sure that if the digital goods were private goods this kind of innovations wouldn't exist - neither would they exist if digital goods were pure public goods.

Likewise, this kind of innovations mostly rely on previous innovations that occurred in other industries such as computer security, cryptography, network security, etc. and thus don't provide innovations that could be used in other industries.

What is more, protection systems can't even be used to "stabilise" the publicness of the digital goods, as they are broken on regular basis.

It seems then that part of the innovation induced by piracy is not useful innovation: if there was a way to make the digital goods either completely private, or completely public, innovations related to protection systems wouldn't exist, and financial resources, time and energy used to create them and to destroy them could be used in a more fruitful way.

The situation is obviously completely different for the innovations related to the quality both of the digital goods and their copies. One can assume that this kind of innovation greatly improves the utility of the consumers. Likewise, some of these innovations, such as those related to audio and video compression, also have increased productivity by making the broadcast and distribution of high quality multimedia content cheaper. For example most of MPEG-4 type algorithms, that were at first mainly used for softlifting, are

[16] This copying effort includes the resources spent on cracking the detection/protection system.

now used as basis to develop compression algorithms for 3G mobile phones, and are even used by the digital goods industry to broadcast content on the Internet.

The same kind of phenomenon occurred with the peer-to-peer exchange networks (Rayna, 2003). A few years ago, it was extremely costly to broadcast content on the Internet due to the amount of ressources that this process requires[17]. Encouraged by the desire of consumers to softlift, peer-to-peer networks were created and constantly improved. Thus, it is now possible for people with limited financial resources to distribute high quality content on the Internet using the peer-to-peer networks. It gives a chance to independent filmmakers to distribute their creations without having to pay the high fixed cost associated with the setting up of an Internet server.

One can notice that these last two examples of innovation would also certainly take place without piracy, as innovations related to the quality of digital goods and in the networks have been constantly taking place over the last decades. Therefore, our next task is to try to compare the level of innovation produced when piracy exists with the level of innovation that might have been reached if piracy didn't exist.

5 Efficient production of innovation: Monopoly vs. Competition

The phenomenon of piracy has recently created an important debate on how to solve this problem, and a lot of governments are about to take, or already took, actions to try to prevent consumers from softlifting. These kind of policies are demanded by the digital goods industry that claims that piracy reduces their profits and is therefore harmful for the society as it decreases the incentive for the firms to create digital goods. This kind of arguments are based on the usual Economic Theory results (c.f. sec. 1, p. 3), stating that since piracy decreases the incentive to innovate, it also decreases welfare, as the level of innovation produced is not high enough.

The particular nature of the digital goods breaks the allocative efficiency of the competitive market. Thus we need to find the possible policies allowing to reestablish this efficiency. If several solutions exist, then any reasonable policy should adopt the most efficient.

[17] For example, the bandwidth of a standard broadband connection is not sufficient to broadcast a video stream of medium quality to one person

The usual answer to this problem is the creation of IPRs protection system, such as patent or copyright. Even though these protection systems, create an incentive for firms to innovate, they also harm welfare, since they give a monopoly power to the firms and lead to a decrease of welfare due to the dead weight loss. Nevertheless, this solution is usually seen as the "second best" solution, and consequently governments tend to choose policies increasing the power of IPR protections. Increasing the IPR protection system is obviously in the best interest of the firms, as it increases their market power, nevertheless we still need to investigate whether choosing this kind of policies is in the society's best interest.

For Arrow (1962), choosing the optimal level of IPR protection is a trade-off between underprovision and underutilisation. If the IPR protections are too low, producers don't have enough incentive to provide quality or variety, thus there is a problem of underprovision. On the other hand, if the IPR protection level is high, fewer consumers can access the good and this leads to underutilisation. Novos and Waldman (1984) show in their model that increasing the IPR protection level leads to an increase in quality, and thus that a strict copyright enforcement is required to solve the underprovision problem. Since, in their model, the underutilisation is due to the additional cost of copying, increasing level of protection doesn't lead to the usual welfare loss caused by underutilisation: as the level of protection increases, consumers switch from the copy to the original, and thus, save the additional cost of copying. Consequently, it seems that increasing the level of protection is the best policy as it will reduce the loss of social welfare [18] .

Belleflamme (2002) also shows that, as piracy decreases the profits of the firms, the social welfare in the long run might be decreased, as not enough incentives to innovate are provided [19] .

Nevertheless, increasing the IPR protection level might not be as efficient as suggested. Yoon (2002) shows that at the social optimum, the copyright is not fully protected, and thus that increasing the IPR protection level can lead to a sub-optimal outcome. Bae and Choi (2002) consider two types of costs associated with piracy: the reproduction cost and the degradation cost. They show

[18] One should still notice that their model is based on the assumption that there are relatively more consumers with higher than with lower copying costs. Also the welfare loss due to underutilisation is caused by the "waste" of copying cost. Since the cost of copying continuously decreased over the last years, these two conditions don't seem to be realistic anymore.

[19] Unless copies are a poor alternative to the original and/or are expensive to acquire, and this is not usually the case.

that if a higher level of IPR protection leads to an increase in the degradation cost, "the conventional wisdom on IPR protections" applies: the social welfare in the short run is decreased due to the firms' market power, whereas the long run social welfare inceases due to the incentive for the producer to provide higher quality. However, if the IPR protection systems aim at increasing the reproduction cost, the effect on welfare in the short run becomes unclear: fewer consumers are using the digital goods, but more consumers obtain the software from the monopolist with more efficient technology. In the long run, due to the marginal consumer's lower valuation for the software, the monopolist has less incentive to provide higher quality. Therefore, increasing IPR protections is not a simple matter as it requires to target precisely the degradation cost in order to avoid a loss of welfare in the long run.

Takalo and Kanniainen (2000) show that increasing the IPR protection system, while encouraging innovation, may differ the diffusion of innovation. In their model, an innovating firm has uncertain property right to its innovation. The impact of a commitment to an R&D project is to create future options for patenting and market introduction. Each decision undertaken will change the conditions in which the innovator operates. They show that an increase in patent protection reduces the elasticity of the option value of the program with respect to the value of the project, raising the threshold value of market introduction and enhancing the ability of the innovator to wait. Thus, while the effect of patent is to raise the rents on and thereby the potential amount of innovations, it also tends to slow down market introduction.

What is more, increasing the level of IPR protection can even be a serious problem for some digital goods, due to the existence of network externalities. Warren-Boulton et al. (1994) and Zimmermann (1999) show that when the level of protection in the software industry is too high, it can harm both welfare and competition. This is due to the fact that the copyright holder may be able to appropriate the result of the efforts of others, and to raise the costs or reduce the opportunities available to suppliers of substitute products. Therefore copyright protection should not be extended to interface specifications or to de facto standards. Warren-Boulton et al. (1994) recommend to grand copyright protection to software programs only when the unwarranted grant of monopoly is de minimis. This would allow to achieves a balance between the need to reward innovative developers of software programs and the need to encourage suppliers of complementary and substituted products to build upon and advance prior work.

Ironically, since then, copyright have been granted on regular basis for interface elements and de facto standards, creating problems, as expected, of interoperability and increasing the market power of some of the major firms [20] . Thus

[20] The best example of that is certainly Microsoft. It's interesting to notice that the

achieving an optimal outcome when network effects are present would actually mean *decreasing* the level of IPR protections.

5.2 Monopoly and innovation

Firms are demanding a higher level of IPR protection in order to restore their market power, that has been constantly decreased because of piracy. As stated above, increasing the level of IPR protection can reduce efficiency and significantly decrease welfare. The idea behind that in regards to the global welfare is quite clear: the increased market power consequently reduces the consumers' surplus. One could still wonder if high IPR protection level *really* increases innovation. Indeed, as a simple principle of economics, a monopoly has no incentive to innovate, and no incentive to create new products that may lower prices to consumers. Indeed, a monopoly has incentive only to promote barriers to entry and to increase monopoly profits. Why would a monopoly voluntarily cede market share by deploying new products that might give rise to competitive entry? It would not do so, and would seek instead to bar competitors from offering consumers a choice of services that would erode the monopolist's market share.

Thus, once protected by IPR, the monopoly's only incentive to innovate, is to deter the entry of competitors. The fact that the IPR protection is temporary pushing firms to innovate in order to get another protection when the current one expires. It is also necessary to innovate in order to maintain a competitive advantage. Therefore, one can surely assume that a monoply without competitors wouldn't have any incentive to innovate at all. Thus if firms are able to find means to deter the entry of competitors, they will have no interest to innovate. This situation can be observed when natural barriers to entry, implying large sunk costs, exist.

Interestingly enough, this was the case for some of the digital goods industries, such as recording industry or movie industry. Due to the large amount of sunk costs associated with these industries [21] , the market is strongly concentrated. This is for example the case in the recording industry, where the five major companies represent 75 % of the market. The fact that these firms were, in addition, granted IPR protections undoubtedly reinforced their dominant position.

Despite the claims that oligopolistic market structure should be efficient with

law suit issued by the European Commission against Microsoft is closely related to this question of de facto standards and interoperability.

[21] Large costs were indeed associated with both the recording/production process and distribution process

regards to innovation, and is worth the loss of efficiency it creates, some facts make us call this into question.

Indeed, with such a concentration ratio, the digital goods industry is not only a strong oligopolistic structure, it's also an "oligopsony" [22] : a large numbers of sellers (musicians, actors, producers, etc.) are in interraction with a very small numbers of buyers (five in the case of the music industry). Therefore, the major players in the music industry can be seen as both a monopsony towards artists *and* a monopoly towards consumers. Thus, instead of having one market distortion, due to the presence of protections, these are in fact two market distortions that are created by this type a market structure.

Similarly to a monopoly, a monopsony leads to a loss of welfare and efficiency. The maximising profit behaviour of the monopsony results in a loss of surplus for the sellers. The equilibrium price will be lower than the price in a competitive situation, and the quantity of factor bought by the monopsony will be lower as well. Since this loss of sellers' surplus is not compensated by the increase in the buyer's surplus, the monopsony creates a deadweight loss. Having a look at the facts, one can notice that this describes accurately the relations between artists and the recording industry. First of all, less than 1 % of the artists get a chance to sign a contract with a recording company. The "price" they get is impressively low:

> Producer Steve Albini, trashing label practices in The Baffler magazine, outlines a hypothetical but typical record deal that bestows a $250,000 advance on a young band. The album sells 250,000 copies, earning $710,000 for the label. The band, after repaying expenses ranging from recording fees and video budgets to catering, wardrobe and tour bus costs, is left $14,000 in the hole on royalties.(Gundersen, 2002)

What is more, the "power" of the monopsony is not only shown in the price, but also in the terms of the contract:

> Sen. Orrin Hatch, R-Utah, once stated that the record business is the only industry in which the bank still owns the house after the mortgage is paid.(Gundersen, 2002)

A lot of other examples illustrating this point could be found(Gundersen, 2002). Thus, the monopsony market structure puts artists in a situation worse than it would have been in a perfect competitive environment. What's more, the loss of welfare for the sellers is not the only negative outcome of this

[22] Due to the small number of firms in the industry, and their repeated interactions, we can assume that there is tacit collusion between the major players (Tirole, 1988). This allows us to consider, without loss of generality, the major players as a single monopoly.

situation. Due to fact that the equilibrium price is lower than in perfect competition, some artists will decide to leave the market. Thus a loss in quality may appear, as we can assume that some brilliant and creative musicians will exit the market. The reasoning allowing to explain this phenomenon is close to the one used in "market for lemons"(Akerlof, 1970): "good quality" artists don't feel rewarded enough by the market price and consequently decide to leave the market. As we can reasonably assume that consumers have preference for quality, the monopsony price leads to a decrease in the consumers' welfare.

As stated above, a monopsony also leads to a smaller quantity of factor being bought. This means that, by considering the sole impact of the monopsony, we can see that there will be a loss for the consumers. As, the quantity of factors bought by the monopsony is smaller than in perfect competition, the variety supplied to the consumer will be consequently smaller; assuming that consumers have a preference for variety, this creates an additional loss of welfare [23] .

Unfortunately, one has to add to the loss of welfare due to the monopsony, a loss of welfare due to the monopoly situation. Tirole (1988) asks the following question: "What is worse than a monopoly?". The famous answer to this question is "a chain of monopolies". This phenomenon occurs due to the multiple price distortion caused by the multiple-marginalisation happening in the chain of monopolies. The solution to this problem is a vertical merging of the chain of monopolies, resulting in a single marginalisation, and thus a single price distortion. The question we could raise here is "what is worse than a chain of monopolies". The answer would be "A chain of monopsony and monopoly". Unfortunately, as the monopsony and the monopoly are already intergrated, there is no way to cancel this double price distortion.

This obviously has an important impact on innovation: both the monopsony and the monopoly "sides" tend to reduce the quality and the variety of the digital goods and as a matter of fact, innovation. Even though it's difficult to obtain quantitative data on this subject, the recent interviews we conducted with members of the musical industry gave us some insight on the innovation in this industry. We were told, first of all, that the proportion of compilations in the new album released increased dramatically these last years. This phenomenon started a long time ago: in the early 90's, the proportion of compilations was already close to 30 % and was continuously increasing. Since compilations can obviously not be seen as innovation, this shows that these

[23] An additional loss of quality can be caused by the fact that, due to the chance of signing a contract being so small, bands will tend to change their music in order to meet the industry's"taste". This leads to a keynesian beauty contest reducing the variety of music.

firms, being in a monopolistic situation, started to decrease their innovation level a long time before the problem of piracy arose.

Our interviews also showed that the industry tends to release "fake" innovations. When a new technical standard is realeased, instead of taking full advantage of the new standard's capabilities, the majors tend to only adapt their former products to the new standard. For example, most of the CDs released during the 80's were based on the analogic master tape copied on a CD. Thus the quality of the CD produced were far from the quality that could have been obtained by remastering digitally the whole album [24]. The same phenomenon occurred recently with the DVD Audio. The main innovation of these DVD is to introduce a 5-channels surround system. Taking full advantage of this technology would require a particular technique of recording and mastering. Our interview revealed that most of the DVD Audio released by the majors are, in fact, stereo masters processed through a software simulating 5-channels. The same kind of problem happens with the DVD-Video. While some firms really took advantage of the improvements brought by the DVD, some restricted the "innovation" to the sole transfer of the movie on the DVD, without improving the quality of the movie, nor including bonus or other "goodies" that make the DVD so attractive. In this case, the only difference between a DVD and a VHS tape is that one is flatter and circle shaped. In any case, these kind of "a minima "adaptation of a digital goods to a new standard can't be considered as innovations.

It seems, therefore, that the "conventional wisdom" that monopolies are a bad for a good, and that *in fine* the loss of welfare will be fully compensated by the increase of innovation, tends to underestimate some of the effects associated with this solution. First of all, if the market concentration is high, the monopoly may also be a monopsony as well. In this situation, due to a double price distortion, the loss in welfare is worse than the one usually associated with a monopoly. Also, if the monopoly is well protected, the incentive to innovate may be much lower than what is usually expected.

5.3 IPR protection systems as barrier to entry

> Sustainability is the cornerstone of a successful enterprise. This requires the constant erection of barriers to entry. The most prominent barriers to entry are market share, competition, strategic alliances and intellectual property protection. You need to understand all four to keep your competitors at bay. (Online resources, Larta University [25])

[24] This remastering process is obviously much more costly

[25] Larta University is a think tank for technology businesses. `http://www.lartauniversity.org`

The recent technological progress lowered significantly the costs associated with production [26] and distribution [27] of digital goods. The consequence of that is that the barriers to entry, mentioned above, have also greatly decreased. This disappearance of barriers to entry may certainly help to explain the extent of unethical copying, including both piracy and softlifting: due to the low cost of distribution, anybody can compete with the majors for the distribution of the digital goods, and, a lot of people are willing to distribute digital goods, for both monetary and non-monetary reasons.

This phenomenon is not restricted to distribution, as more and more firms are entering the market of creation as well. Apple iTunes Music Store, the leader in legal music downloading, is not only distributing the songs of the recording industry, but has also introduced a software package allowing independent musicians and small labels to distribute their music on the Music Store. C|NET has also recently introduced the possibility for independent musicians to distribute their work on the Download.com website. Therefore, the recording industry is facing an increasing competition, both legal and illegal (piracy and softlifting), in the creation and the distribution of digital goods.

Thus, this in not surprising that the firms producing digital goods are now demanding an increased IPR protection systems, as the barriers to entry become weaker. The reason behind that is that IPR protection systems can be used by the firms as strategic barriers to entry. The problem is that, if the increase in the level of IPR protection allows firms to be sufficiently protected, this policy will hinder any subsequent growth of innovation.

Macdonald (2004) shows that patents are acquiring a strategic value increasingly independent of innovation. He also shows that patents are in fact part of an "innovation myth" that links directly R&D and innovation. Over the last years the patent has indeed acquired some intrinsic strategic value, and this, consequently, broke the link between patent and innovation. For example, as companies are now ranked in terms of how many patents they are granted annually, Macdonald (2004) states that revenues are being sunk into legal costs instead of R&D. As the IPR protection system increases, patents become more and more valuable. Thus a great amount of resources are devoted to the patent system itself instead of being used for other activities, as for example innovation:

> Resources that could have been used to further innovation have been diverted to the patent problem. Engineers and scientists such as myself who could have been creating new software, instead are focusing on analysing

[26] 10 years ago, the price of a studio digital recorder was at least 200,000 Euros. A regular personal computer, that costs not more that 2,000 Euros can now do the same job, with the same quality.
[27] See p. 15.

> patents, applying for patents, and preparing defenses. Revenues are being sunk into legal costs instead of into research and development.
> (Evidence of Douglas Brotz, Principal Scientist, Adobe Software, 1994)

More precisely, Macdonald (2004) states that:

> The incentive to innovate is reduced and may disappear altogether as firms sell on the right to innovate much as futures traders sell the right to buy commodities without any expectation that commodities will ever be delivered.

One of the main reason of the increasing value of patents for the firms is that patents can be used as strong barrier to entry. Indeed, firms that develop patent strategies are increasing their monopoly power far beyond the point they were supposed to reach with IPR protections. One of these strategies is to "patent around": instead of patenting the sole invention, firms patent each technical step leading to this invention in order to prevent competitors to produce a substitute invention. There is also considerable evidence that firms use "decoy patents" to direct competitors into unprofitable fields of research: these decoy patents are common in order to mislead competitors and make them believe that the firm is doing research in an unexpected area. As competitors are pushed towards unprofitable fields of research, the impact on innovation is undoubtedly negative. What is more, these two types of strategies show that the patent system protects firms from competition a lot more than expected. Consequently, this may lead to a decrease of innovation due to the fact that firms are overprotected, and also because patent strategies may hinder innovation of competitors.

Patents are not the only way for firms to create barriers to entry: copyright can be used as well to deter the entry of competitors. As stated by Warren-Boulton et al. (1994) and Zimmermann (1999), this is obviously the case in the software industry due to the network externalities: granting copyrights for interface specifications and de facto standards creates strong barriers to entry and prevent the development of complementary and substituted products.

What's more, this phenomenon is not restricted to the software industry: copyright also acts as barrier to entry in the music and movie industry. The is particularly striking in the recording industry: the five major companies detain the copyrights of most of the music ever released in the world. The problem is that music was never created from scratch. A piece of music is a combination of creativity and influences, and it's often very difficult to separate the two. By detaining most of the copyrights, the majors detain in fact "the influences". This is obviously a strong barrier to entry, as they can sue any competitor releasing a song where the "influences" are too evident [28]. They won't obvi-

[28] This unfortunately also happens when the influences are less evident. The band

ously act the same if the new song, full of influences, is released by one of their artists.

In order to fully apprehend the importance of the copyright as a barrier to entry, it is worth mentioning a few additional examples. Covers, for instance, always played an important part in the history of music. As stated above, most of the song are created by modifying other songs, and what's more, some covers became more popular that the original. The current strong copyright protection obviously decreases the possibility of creating covers. The same phenomenon is taking place with the electronic music as it makes an intensive use of remixes and samples. The only "safe" way to do this kind of music is to sign a contract with a major, as otherwise the probability of being sued by the majors for copyright violation is very high.

All this shows that copyrights create very strong barriers to entry [29] , as, most of the time, a piece of music is based on other pieces of music protected by copyright. What's more the barrier to entry is so high that the incentive for the major to innovate is very low: new release will always be based on previously copyrighted products, and the gain in copyright induced by the production of a new song is marginal in comparison to the stock of copyrighted material already owned by the firms.

Here, it is worth mentioning that if blues music had been, at the time as protected, by copyright as the music is nowadays, the rock would certainly never have been born [30] .

Since IPR protection systems can be used as strong barriers to entry by the firms, and consequently decrease the incentive for these firms to innovate, it seems that increasing the level of protection is likely to have the exact opposite effect as the one it's supposed to have: innovation will tend to decrease:

> The monopoly power created by copyright may also reduce the copyright holder's incentives to innovate. Because the monopolist has already appro-

"The Verve" was sued for using a sample of 10 seconds of one of the Rolling Stones songs. Even though the sample was used in as a background effect and the two songs were completely different, they still lost the case and all their royalties on the song.

[29] One can also notice that copyrights last longer than patents: 95 years in USA and 50 years in Europe. Boldrin and Levine (2001, 2002) show that in the USA copyright *de facto* lasts for ever.

[30] The example of the blues is particularly interesting. The contracts signed by the bluesmen with the "race record" companies were probably the worst that ever existed. Most of the bluesmen never got any royalties in reward for their work, and most of them died in misery. Nevertheless, the blues scene was extremely productive. It seems thus that playing music is an intrinsic motivation that is sufficient enough to innovate.

> priated much of the consumer surplus, what does she have to gain from innovating, and what does she have to lose from not innovating?. (Ku, 2002)

Ku (2002) and Litman (2004) argue against copyright protection for digital works because the economics of digital technology undercut prior assumptions about the efficacy of a private property regime as a remedy to the public goods nature of information. The two interests served by copyright are indeed the creation and the dissemination of works to the public. In his article, Ku (2002), questions the conventional wisdom that these interests are aligned, and shows that the arguments for copyright are primarily arguments for protecting the distributors of content in a world in which "middlemen" are no longer necessary. Copyright is no longer needed to encourage distribution because consumers, themselves, build and fund the distribution channels for digital content. The same kind of arguments can be found in Litman (2004):

> Until recently, most means of mass dissemination required a significant capital investment. The lion's share of the economic proceeds of copyrights were therefore channeled to publishers and distributors, and the law was designed to facilitate that. Digital distribution invites us to reconsider all of the assumptions underlying that model.

5.4 Beyond IPRs: towards new mechanisms inciting innovation

As stated above, increasing the level of IPR protections doesn't seem to be the most efficient way to increase innovation. Nevertheless, this idea is still popular among economists and managers. Beyond the question of the desirability of this increase, lies the question of the feasibility of such a policy.

As was shown in section 2, the current laws related to IPR don't manage to prevent softlifting. Thus, one can think that no change in the law will actually decrease softlifting unless the law is enforced and softlifters are sued. Such an enforcement will be terribly costly and would only eliminate the tip of the iceberg: unencrypted Internet softlifting. The rest of the softlifting, e.g. the direct exchanges between consumers, will remain unchanged as neither the governments nor the firms can monitor and prevent these exchanges.

Therefore, increasing the level of IPR protection would require, in addition to a change in the law, the creation of technological systems that would be able to increase the possibility of monitoring and preventing softlifting. Unfortunately, as stated in section 3.1, it's very likely that consumers will manage to disable these systems. This, in turn, will lead to a competition between the governement/industry and the consumers and will create a loss of welfare (see section 4). To summarise, increasing the IPR protection level would induce high costs in addition to a loss of welfare.

It is worth mentioning that the question of increasing the level of IPR protection wouldn't even be raised if the digital goods were actually public goods. The fact that there might be a limit in their publiness gives the impression that it's worth trying to make them become private.

There are not many goods that are considered as pure public goods: public lightning and national defence/nuclear dissuasion, are probably the only examples everybody agrees on. Nevertheless the publicness of these goods is not total: there is always a case where the publicness of these goods reaches a limit. Nuclear dissuasion is seen as pure public good and is therefore non-excludable and non-rival. But this is not necessarily true. One can imagine an extreme case where, when the war is about to be declared, the government decide to deport all the citizens who didn't pay enough taxes. Likewise, if we consider the case of a small country, nuclear dissuasion in not necessarily non rival: in an extreme case the country can be so overpopulated that it's physically impossible to fit in any additional person, and nuclear dissuasion is therefore a rival good [31] .

Since there is a limit in the publicness of nuclear dissuasion, why is it considered as public? The explanation could be that their publicness is limited only in extreme cases, and therefore reducing their publicness would be extremely costly. For example the cost of deporting all the non-tax payers would be so high that this is not even considered as an option, thus it results in the fact that nuclear dissuasion is seen as non-excludable.

Therefore, what defines a public good is not the fact that this good is actually public, but rather the fact that making this good private would be too costly:

> A good is public if it's less costly to impose [to the consumers] the obligation of using it [the good] than to set up a system of monitoring allowing to exclude from the usage of this good the people that didn't pay. (Laffont, 1988) [32]

It seems, therefore, that the fact that digital goods are not completely public doesn't matter: as it would be extremely costly to make these goods private, they should thus be considered as pure public goods.

An efficient provision of digital goods would then require a governmental intervention. As a matter of fact, this idea has already been used for quite some time by some governments who decided to impose taxes on blank media: first on audio tapes in the 70's, then on VCR tapes in the 80's, on CD-R in the 80's, and currently on most of the blank digital media. This kind of policy

[31] One could also find extreme cases for the public lightning and thus show that the publicness of public lightning, or any other pure public good is not total.
[32] See also Rayna (2002).

takes into account the public nature of digital goods, and triggers innovation via subsidies given to the creators of digital goods.

Ku (2002); Litman (2004); Chen and Png (2003) support this kind of policy. They suggest that a tax-subsidies system should be introduced in order to incite innovation and solve the piracy problem. Ku (2002) shows that this kind of system would even increase the financial rewards received by the artists and consequently would increase the incentive to innovate. Chen and Png (2003) show that a tax on the copying medium is welfare superior to the penalty. Compared with the penalty, the tax has indeed less effect on the legitimate price and leads the publisher to reduce the amount spent on detection of softlifters.

Therefore, governmental intervention seems to be an efficient mechanism that could be used to solve the problem of piracy, and to trigger innovation.

However, some recent theoretical results tend to show that, despite the publicness of digital goods, there might be a solution to the problem that doesn't involve neither IPRs not state intervention.

Boldrin and Levine (2002) show that the fact that digital goods/innovations are not totally nonrival can lead, by pricing ideas, to an efficient provision of innovation in a competitive environment, a "perfectly competitive innovation". The argument here is that since the digital goods/innovations are not completely nonrival - they can't be consumed and copied at the same time - it takes time (depending on the copying technology) for an idea/good newly created to be spread among the consumers. What's more the first unit of the digital good is always embodied into either something or someone. Thus the first unit of the digital good is a pure private good and consequently can have a price higher than zero, even in a perfectly competitive environment. The market value of the innovation corresponds, in fact, to the market value of the first unit of the new product. This equals, in turn, to the net discounted value of the future stream of consumption services it generates. Boldrin and Levine (2002) show that, due to the rivalness, this value is high enough to incite innovation and that perfectly competitive Arrow-Debreu markets function optimally. In this situation, IPRs are either unnecessary or, if they affect allocations, harmful to social efficiency. Creativity and innovation are properly priced in competitive equilibrium, and socially efficient outcomes are obtained without the contrivance of IPRs. What is more this result holds even if the copying technology improves: when the good/innovation tends to be nonrival, their result holds, as long as a minuscule amount of rivalry still exists.

Quah (2002) extends the previous model. He shows how intellectual assets that are nonrival but finitely expansible can be supported in Arrow-Debreu competitive equilibrium. The optimal allocation then sets dissemination of in-

tellectual assets to be totally unrestricted except by technological constraints.

What's more, Quah (2002) shows that this scheme can be used to interpret the Open Source Software movement. This last point is obviously very interesting. It explains why, despite the absence of any IPR protection, the Open Source movement has been able to innovate continuously.

Thus, according to these last research results, as long as it is possible to price ideas (because of nonrivalness or finite expandability), a perfect competitive process will lead to a an efficient supply of innovation, and IPR protections are useless.

Conclusion

In this article, we showed that current IPR protection systems fail to protect the digital goods industry. Due to the nature of these goods - they tend to be public goods - a phenomenon of softlifting exists among the consumers (we show that this can be seen as the usual free-riding behaviour), and the extent of softlifting behaviour is such that IPRs are virtually unenforceable.

The conventional wisdom related to innovation predicts that in such a situation the innovation process in the digital goods industry should stop, or at least decrease. We show that, on the contrary, piracy pushes firms to innovate. First of all, innovations in the anti-piracy protection systems are required in order to decrease the publicness of the digital goods. Secondly, we point out that, due to technological limitations, the original digital good and a copy of this good are not always perfect substitutes, as the quality of the copy may be lower than the original. Thus firms are incited to innovate in order to maintain a difference of quality between the original and the copy. These innovations tend to restore the market power of the firms. Unfortunately, we show that this increase in market power only lasts for a short period of time, as protections are always "cracked", and as the technological progress always reduces the quality gap between the original and the copy.

Therefore, piracy, by decreasing the market power of the firms place them in a highly competitive environment. Firms are pushed to innovate continuously in order to gain market power, and the positive economic profits associated with it.

Our next step was to show that even if piracy triggers innovation, quality of innovation produced may be insufficient. Indeed we consider that a part of the innovation caused by piracy is in fact useless. The innovation related to anti-piracy protection systems doesn't increase the social welfare, and wouldn't

even exist if the digital goods were either completely private or completely public. On the other hand we show that the innovation related to quality tend to increase the global welfare, and thus is a "useful" innovation.

As the level of innovation triggered by piracy may not be sufficient, we then try to establish what could be a good policy to solve this inefficiency problem. We first show that, despite the fact that increasing the level of IPR protection is often seen as the best solution, this increase, in addition to harming competition and decreasing welfare, could also decrease the incentive to innovate. More particularly, we show that the current protection system increases the market concentration ratio. The consequence of that is that these protections not only create monopolies, but that these monopolies are often a monopsony at the same time. Thus instead of one market distortion, high levels of protection in fact result in a double market distortion.

Last but not least, we show that IPR protections, such as patent and copyright, can be used by the firms as strong barriers to entry. Thus IPRs acquire an intrinsic strategic value and become independent of innovation. The link between IPR protection system and innovation becomes consequently weaker. What's more, we show that when firms are too well protected, their incentive to innovate decreases.

Finally, we show that for the same reasons that firms can't prevent piracy, it would be too costly, from a social point of view, to reinforce IPR laws and to try to enforce them. Therefore, even though digital goods are not pure public goods, they should be considered as such: it is indeed more expensive to try to exclude people from the consumption of these goods, than to force consumers to consume these goods. Thus we show that a system of taxing digital blank media, that is associated with subsidies given to the creators of digital goods, can be a sufficient incentive to achieve an efficient level of innovation. In this last part we also discuss recent research work showing that due to the fact that digital goods are only quasi-nonrival, it is possible to reach an efficient level of innovation in a perfectly competitive market without IPR protection system.

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