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The Music Market in the Age of Download

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Keywords: File-sharing, Copyright, Sample Effect, Mp3, Concert

JEL Classification: L86, 084

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The music market in the age of Download*

Iacopo Grassi†

Abstract

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This version: April 2007

1 Introduction

The first years of this century have been characterized by the final success of Internet and digital technology as main way to exchange and preserve any kind of knowledge. If, on the one hand, the growing simplicity in communications has allowed an unpredictable development in many sectors of the modern society, on the other hand, new forms of technological piracy and copyright violation appeared, in particular from end-users.

In this context the phenomenon most capturing media attention in the last years is the sharing of music files on the Internet. In 1999 the term *file sharing* itself was unknown to most people; in 2001 Michael Greene, then president of the National Academy of Recording Arts and Sciences, declared "The most insidious virus in our midst is the illegal downloading of music on the Net" [1]. In the meantime Napster had appeared to shock the recording industry.

*I received useful comments from Gabriella Aubry, Claudia Cantabene, Umberto Iolli, Riccardo Martina, Giacomo Valletta, and Marco Venuti. All remaining errors are mine.

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[1] Cited in Clement (2003).

Napster was a software that allowed people to share on the net their music folder, without the filter of a central computer. Napster appeared at the right time: the digitization of music was complete, after the cd had completely replaced LPs and tapes, most households had a computer in developed countries, and most of these computers were connected to the Internet. Although most of the recording companies immediately understood the danger deriving from file sharing software, two years were needed to stop the service: Napster went live on June 1st, 1999; on December 7th 1999 the Recording Industry Association of America (RIAA) sued Napster for copyright infringement; on July 11th 2001 Napster was permanently shut down. During these two years file sharing became a massive activity and far more efficient software was being programmed, the music business completely changed.

According to the recording industry the unprecedented decrease in music sales, which started in the year 2001, following more than a decade of constant growth in the market size[2], is due to the diffusion in the use of peer-to-peer software for the sharing of compressed music files, mp3 in particular : such file is a digital encoding format developed in 1991, it allows a great reduction of the amount of data required to represent audio, with a reasonable loss of sound quality.

The aim of this paper is to provide some useful insights to the analysis of any market where a copyrighted good which can be pirated is produced, in particular I analyze the music market, since in such a market end-user piracy has been massive.

The first result I obtain after the analysis of sampling, is the definition of criteria and conditions that evidence when free download can have a positive effect on the profits of the recording companies, and how such a situation is highly improbable in the case of the music sector.

Surprisingly the increasing economic theoretical literature that in last years has analyzed the file-sharing and piracy problem, has ignored how the strategy and the profit of the firms can change, if the monopolist itself enters the low quality market. The second part of this paper fills this gap, investigating whether the firm can react the piracy entering in the new market, and when this strategy can increase the firm profits compared both with a no-copying world and the case it decides not to enter the new market.

Moreover music market presents an interesting distinction on the supply side between the recording company, that produces the music, and the artist, who writes it. The final result of this paper is to note, in contrast with part of the literature, that file sharing can undermine the contrast between recording companies and artists.

1.1 Related literature

Piracy and copyright violation is not a recent phenomenon: since the invention of the photocopier, the diffusion of technologies of mechanical reproduction

[2]Data on the sales of American music market are available from the Recording Industry Association of America (RIAA).

paved the way to a growing number of copies of goods. For example publishing and record industries were first pirated by the photocopier and the tape recorder. The economic literature on information reproductions from journals, books, and music recoding (Liebowitz 1985, Besen and Kirby 1989, Varian 2000) shows that publishers may earn higher profits when copies are allowed, under the assumption that they can price discriminate between users. Moreover photocopies or recorded tapes are not perfect reproductions of the original, but lower quality substitutes.

The record industry has not been the only industry to suffer piracy due to digitization: another industry to suffer a massive piracy of its products is the software industry. In this sector the consequence of piracy is not necessarily negative to the firm: some economic literature (Katz and Shapiro 1985, Takeyama 1994, Shy and Thiesse 1999) has been arguing that piracy can create a positive externality effect. If the value of a software is increasing with the number of users, software piracy may exert a positive effect on profits. Firm's earnings need not be reduced as a result of piracy as long as the demand for legal copies is enhanced by the distribution of illegal copies.

Some literature on piracy (Shy and Thiesse 1999, Banerjee 2003, 2006) consider the case where a pirate firm enters the market. The main problems with file sharing is that end-user piracy "changes the rules", since in this case the objective of the pirate is not to maximize his own profits, but simply to share the file.

Hence in the last years a growing theoretical literature has examined end user copying and download, trying an analysis of file-sharing, and the general result is that the possibility to copy leads to lower firms profits, but that under some circumstances the downloading could increase firms profits, or at least not necessary conduct to the bankruptcy of the recording industry. Recent contributions centrad on file sharing and peer to peer are Gayer and Shy (2003, 2005).

Gopal et al. (2005) and Peitz and Waelbroeck (2005) show that, under some circumstances, pirated firms can increase their revenue in the presence of free download. In particular Peitz and Waelbroeck (2005) examine the role of sampling in the music sector: having the chance to listen to new artists downloading their songs from the net, the consumers can decide to purchase cds and albums that they would otherwise have never known. Such a circumstance might have a positive effect on the profits of the record firms.

Finally Gayer and Shy (2006) introduce the conflict between publisher and artist in the literature. According to their paper file sharing enlarges the conflict between artists and publishers, in account of the difference in the source of their profits: principally cd sales for the first, revenue from concerts for the latter.

My contribution adds to this literature: starting from the description of the Italian markets of music and Home Video, I built a model able to explain the consequences of the appearance of a pirate low quality good in the music market.

The remainder of the paper is organized as follows: section 2 describes the Italian markets of Music and Home Video; section 3 sets up the basic model; section 4 extends the model to an intertemporal framework with two periods;

section 5 includes in the analysis the case of a firm deciding to enter itself in the low quality good market; section 6 modifies the basic model introducing the distinction between artist and recording company; section 7 concludes.

2 The Italian Markets of Music and Home Video

The data on the sales of the Italian music market are available on a yearly basis from *Federazione Industrie Musicali Italiane (FIMI)*, the organization that represents firms operating in the industry. The public data set of the FIMI covers 92% of the market, and therefore is representative of the sector.

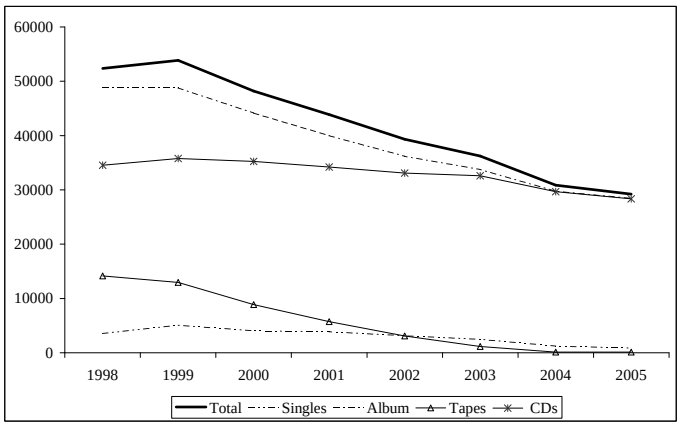
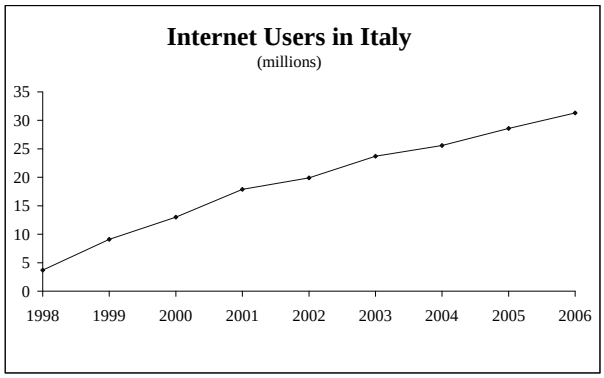


Figure 1: Italian Music Market (Thousands of Copies). Source FIMI

During the 90s the Italian music market constantly grew in size. On the contrary an analysis of the sales in the same sector from 1998 to 2005 shows a dramatic decrease in the number of musical support sold, decreasing from an historical maximum of almost 54 millions of units in 1999, to little more than 29 millions in 2005. (See Table 1)

Comparing this data with the number of Internet users[3] (passed in the same period in Italy from 3,7 millions in 1998 to 31,3 millions in 2006) and with the penetration of the broad band (still not existent in 1998, over 8 millions of lines in 2006), it is possible to understand the reason why the recording industries are greatly worried about the diffusion in the use of peer-to-peer software for file sharing.

[3]Official data on Internet users and Internet penetration in Italy are achievable from *Autorità per le Garanzie nelle Comunicazioni (AGCOM)*. All the data cited in this paragraph are reported in Appendix A.



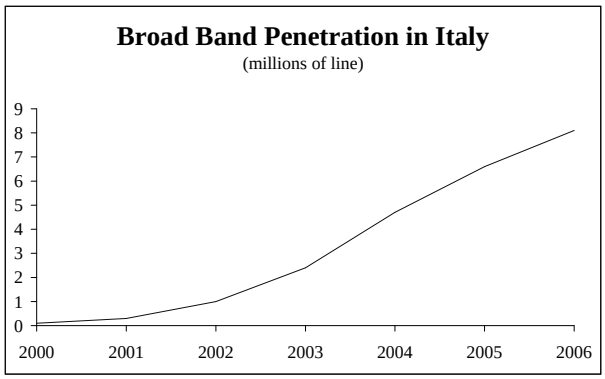


Figure 2: Internet Penetration in Italy. Source AGCOM.

According to the recording industry such an incredible decrease in a market that for a decade had been in constant expansion, is caused by the use of these softwares. The alarm the music sector is crying out is brutal: if not vigorously contrasted and fought, this phenomenon could drive in few years to the complete annihilation of the industry and in order to solve this problem the publishers appeal to the simplest solution: completely stop Internet downloading and peer to peer use.

Such a pessimistic warning from one of the most important industries of the modern society, needs to be carefully examined. Can file sharing, an elite phenomenon put into practice by people with a high level of education, destroy a sector of the economy?

It is possible to note from Table 1, that since 1998, before the creation of

Napster, the first and probably most famous file sharing software, the Italian music market was formed for the 93% by albums, while the sales of singles had a marginal role in the market. The album market was then formed for the 70% by cds, for the 28% by audiotapes and for the rest by the small submarket of LP.

	1998	1999	2000	2001	2002	2003	2004	2005
Singles	3554	5093	4043	3898	3143	2477	1231	875
Tapes	14157	12945	8883	5729	3096	1149	117	117
CDs	34554	35765	35228	34206	33081	32589	29654	28340
Album	48794	48766	44142	39981	36203	33771	29758	28449
Total	52348	53859	48185	43849	39346	36248	30885	29215

Table 1: Italian Music Market (Thousands of Copies). Source FIMI.

If we extract the data about the cd submarket from the general data of the market, we note that while the overall sales pass from the historical maximum of 54859 thousands of units sold in 1999 to 29215 thousands (a decrease of over 45%), the cd sales decrease of 20% passing from 35765 thousands of units sold, to 28340 thousands units. The dramatic reduction does not come from the submarket of cd, but from the one of tapes, that in 2004 disappears altogether. It is not simply the demand of music to change, but more specifically the kind of supports the householders purchase: in 2005 the consumers do not buy anymore an obsolete format like the audiotape, nor the singles; the 97,7% of the market value is determined by the cds sold.

The structure of the Home Video industry is very similar to the one of the recording industry[4], even if 30% of the market is formed by the renting of movies, which in Italy is not allowed for the audio cd market. As in the industry of music, in this sector a digital technology (dvd format) has replaced an older and less efficient magnetic technology (vhs tapes) and, as a consequence, the tape submarket began to decrease but, unlike the other sector, the overall size of market continued to increase. Therefore in both the sectors the disappearance of the magnetic format does not seem to be caused by the diffusion of peer to peer software, but simply by the technological obsolescence of the good.

The impressive growth that the dvd market is having in the last years seems to be very similar to the analogue growth of the cd market in the nineties. Is it just a mere coincidence? Probably not

The appearance of a better format in a market like the one of the music or the video determines a typical *"replacement effect"*. Since the new format permits a better fruition of the good, consumers tend to replace their collections with the new format: in the nineties compact discs replaced LPs, and the recording industries could resell their historical archives. Great hits of the past had been repurposed, allowing the market (and the profits of the firms) to increase.

[4]The data on the sales of italian Home Video market are available from *Unione Italiana Editoria Audiovisiva (UNIVIDEO).*

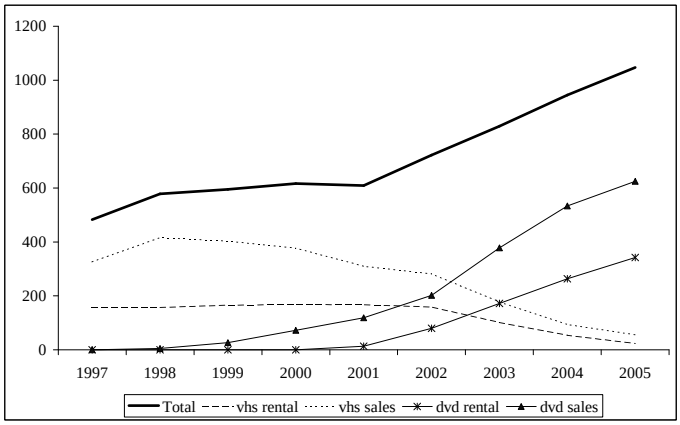


Figure 3: Italian Home Video Market(Value in Euro). Source UNIVIDEO.

Something similar is now happening in the Home Video market: consumers are replacing their collections of old vhs, with the digital format. Nevertheless this format gives an inconvenience to the producers. While the audio and video tapes after some time lose their original quality, and sound or video result compromised, every digital technology, as cd or dvd, is virtually eternal. It is an evident case of monopolist who acts in n periods, producing at t_1 a good that is sold and produce to t_n as well: the main competitor of the monopolist is itself. When the replacement effect is over, the market can not grow anymore to the previous rates. In this context it is interesting to note that in the USA[5] the dvd market (rents and sales) from the 2004 to 2005 grew just of the 6%, while in the two previous years had grown of the 42% and 38%. Moreover in the period 2004 -2005 for the first time the video market in the USA has decreased its size.

In Italy the video market still results to be exploding, but the Home Video industry as well begins to be seriously worried by file sharing. The growing speed of the broad band, and the impressive expansion in the use of personal computers, make now possible the on-line sharing not just of audio files, but of movies as well. Motion picture firms are afraid to live in a very short time the same crisis of the recording industry caused by the end of the replacement effect and the erosion of the profits by pirates. Is such a warning justified? Is really Internet killing the digital goods markets?

In the next paragraph I propose a theoretical model in order to explain the consequences of the appearance of a pirate low quality good on the pirated firm

[5]The data on the sales of american Home Video market are available from *Motion Picture Association of America (MPAA).*

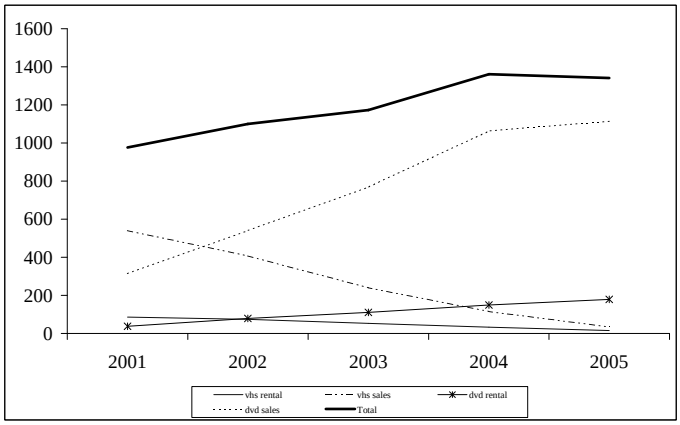


Figure 4: USA Home Video Market. Source MPAA.

strategy.

3 The model

3.1 Model setup: the no-copying world

In this section I propose a theoretical model of file-sharing piracy. Although the market I refer to is the music market, such model is generalizable and able to explain the consequences of the appearance of a pirate substitute of different quality in any market where an original good produced under copyright protection.

In this model I assume that the demand for cds comes from a continuum of consumers, whose uniform distribution is indexed by θ, with $\theta \in [0, 1]$ and, following most of the literature on quality of products and piracy[6], the utility function of the consumers is given by:

$$U = \text{MAX} \begin{cases} \theta - p \\ 0 \end{cases} \tag{1}$$

Where θ is the valuation that the consumer gives to the good, in this case the cd, and p is the price set by the monopolist. Each consumer has a completely anaelastic demand for one unit of the good, hence each individual demands either one unit of the good or nothing.

[6]For an introduction to the literature see Tirole (1988).

Without loss of generalization the variable production cost of a digital good can be considered zero. Furthermore I consider an installed monopolist, which allows us to avoid incorporating the fixed cost of production and to concentrate on the cases where the "annihilation" of the industry is due to the presence of a pirate good, and not to technological constraints.

The presence of a pirate good, that is the possibility for most of the consumers to download for free a copy of the cd using P2P file sharing programs, modifies the music market and the utility of the consumers.

Following Besen and Kirby (1989), originals and copies are imperfect substitutes and the valuation of a copy is equal to the valuation of an original, discounted by the factor β.

In the case that consumers may obtain a copy of the good downloading it from the net, the utility becomes:

$$U = \text{MAX} \begin{cases} \theta - p \\ \beta\theta - w \\ 0 \end{cases} \tag{2}$$

where, as in the no-copying case θ is uniformly distributed between 0 and 1, p is the price set by the monopolist and w is the price of the copy, for example the expected value of the penalty for violating copyright plus the price of Internet connections.

Let me consider first the case where it is not possible for the final user to copy the good, and the utility of each consumer is described by condition 1.

If p is the price set by the monopolist, the consumer i indifferent between buying and not buying the good is the one such that: $\theta_i = p$.

It is easy to show that, given the uniform distribution of the consumers, the demand of cd, is the following:

$$D_{cd}(p) = \int_{\theta_i}^{1} 1 d\theta = 1 - p \tag{3}$$

Since the objective function of the monopolist is given by $\pi = p(1-p)$, maximizing we obtain the usual monopoly equilibrium given by:

$$p_{cd}^{NC} = \frac{1}{2}; \qquad D_{cd}^{NC} = \frac{1}{2}; \qquad \pi_{cd}^{NC} = \frac{1}{4} \tag{4}$$

where the apex NC is referred to the fact that this is the no-copying equilibrium.

3.2 The copying world

3.2.1 The corner solutions

The no-copying assumption reflects the technological constrains existing in the music market until the mid 90s. Such constrains have been dramatically removed by the vast diffusion of re-production technologies (such as cd recorders),

peer-to-peer distribution software on the internet and, in the case of the recording industry, mp3 music files.

When it is possible to obtain a pirate copy of the good the utility of each consumer is described by condition 2.

In such a case there are two possible corner solutions. If for any consumer to hold is the condition:

$$\beta\theta - w > \theta - p \tag{5}$$

no matter the price that the firm sets, the industry is annihilated since in the market there are only pirates. Obviously such a scenario is the worst for the recording companies, and the one they want to avoid[7].

Moreover in the economic literature on piracy it is usually supposed that $0 \leq \beta \leq 1$. The main problem is that such an assumption can seem unrealistic in the music market as it is today. Since the objective functionality of the mp3 music format (a file designed to greatly reduce the amount of data required to represent audio, yet still to play like a faithful reproduction of the original), for some groups of people nowadays the valuation of a downloaded pirate file can be greater than the valuation of the original format.

The benefits from mp3 have determined the increasing success and diffusion of this kind of file, and the creation of the market of mp3 music players. Nowadays many consumers, in particular the *under-thirty*, who represent an important target in the music market, prefer the low quality but easily transportable mp3 file, to the high quality sound of an *old* CD. In such a case the annihilation of the market could become a concrete scenario.

The other possible corner solution is the one that is realized if for any consumer the following condition holds:

$$\theta - p > \beta\theta - w \tag{6}$$

In such a case the firm acts as monopolist even if a low quality substitute exist. Unfortunately this optimistic case does not seem to describe the actual situation in the in the music sector, rather the scenario of the early 90s, when mp3 had been invented, but downloading from the Internet was still hard and expensive[8]. Nevertheless it can describe those markets, for example the DVDs'

[7]If the annihilation case described by condition 5 would be the concrete situation of the market, no price strategy is available to the firm in order to obtain revenues. Hence the record publisher has to change its business model, for example increasing the quality of the produced good or entering into the new low quality good market. This is exactly the strategy that record firm seems to be putting in practice in last years developing a legal market of mp3, as main alternative to the illegal peer to peer system. It is interesting to note that in the motion picture market some firms are recently selling movies in Divx format at a very low price in order to react to the diffusion of file sharing in the movie industry. Divx is a low quality video format.

[8]A growing empirical literature is trying to understand where the music market is going. Liebowitz (2004, 2005b)is worried about the prospects of the recording industry, while Zentner (2003) and Peitz and Waelbroeck (2004), basing their papers on cross section data-set from the early period of file-sharing (1998-2000), conclude that Internet piracy may undermine the music business, but they do not conclude that the industry will be annihilated, rather that

or the fashion', where a substantial difference in quality between the original good and the substitute good protects the first from the "pirates".

3.2.2 The internal solution

From now on we assume that there are always buyers both of the original good (the cd) , and the copy (the mp3 file)[9]. In such a case two marginal consumers exists: the consumer i indifferent between the cd and the mp3 file, and the consumer j indifferent between the mp3 file and nothing.

For i we have:

$$\theta_i - p = \beta\theta_i - w \Rightarrow \theta_i = \frac{p-w}{1-\beta} \tag{7}$$

For j we have:

$$\beta\theta_j - w = 0 \Rightarrow \theta_j = \frac{w}{\beta} \tag{8}$$

Assuming the existence of some buyers of the original good, means that $1 > \theta_i$, i.e. from 7 that for the consumers of the good $p < w + 1 - \beta$; assuming the existence of some buyers of the copy, means that $\theta_i > \theta_j$, i.e. from 8 that for the consumers of the copy $w < \beta p$.

In this case the demand of the original good becomes

$$D_{cd}(p,w) = \int_{\theta_i}^{1} 1 d\theta = 1 - \frac{p-w}{1-\beta} = \frac{1-\beta-p+w}{1-\beta} \tag{9}$$

While the demand for the pirate substitute is given by

$$D_{mp3}(w,p) = \int_{\theta_j}^{\theta_i} 1 d\theta = \frac{\beta p - w}{\beta(1-\beta)} \tag{10}$$

The equilibrium of the market in the case the firm maximizes its profit and there is copying is:

$$p_{cd}^C = \frac{1-\beta+w}{2}; \qquad D_{cd}^C = \frac{1-\beta+w}{2(1-\beta)}; \qquad \pi_{cd}^C = \frac{(1-\beta+w)^2}{4(1-\beta)} \tag{11}$$

In absence of a substitute good ($\beta = 0$; $w = 0$), the profit of the firm coincides with the one under condition 4, and for $\beta \geq 1$ we have the bankruptcy of the firm. Moreover it is possible to show[10] that in the case where both the types of consumers exist, it is always $\pi_x^C < \pi_x^{NC}$, i.e. the profit of a recording company in a world where there is the sharing of file in Internet, given by 11, is

profits are decreasing. On the contrary the highly criticized paper by Oberholzer and Strumpf (2004) concludes that downloads have an effect on sales which is statistically indistinguishable from zero. Other empirical researches on the effects of file sharing on the music market are Boorstin (2004) and Blackburn (2004)

[9]In this context is possible to suppose that exists a group of people with difficult access to the new technology, or with very high learning costs.

[10]See Appendix.

always smaller than the profit in a no copying world, given by 4. In example if we analyze the relevant case where $w = 0$, that can describe a situation where there is free downloading, we easily see that, for $\beta > 0$, $\frac{1-\beta}{4} < \frac{1}{4}$

Hence we can state the following intuitive proposition:

Proposition 1. The entrance in the market of a competitor producing an illegal substitute good, violating the copyright, causes a decrease of the profits of the firm, that is directly proportional to the substitutability between the original good and the copy (β).

Nevertheless file-sharing advocates sustain that the profit or recording companies might not decrease, but even increase, because file-sharing would be used just to sample between artists. According to them, after such a sampling the consumers would purchase the favorite cds, and the market might be enlarged. In the next paragraph I analyze such an hypothesis, proposing a model of sampling.

4 A model of sampling

In the previous paragraph I have considered a simple monopoly pricing problem with piracy. In this section I propose a theoretical model of sampling extending the analysis to an intertemporal framework with two periods in order to point out under which conditions the *sample effect*, i.e. the supposed increase in the demand of the music market due to the possibility to test music with the mp3 files, do matter for the strategy and the profits of the recording industry.

In order to point out the sample effect I assume that a fraction λ of the consumers that purchase mp3 files in the first period, decides to purchase cds in the second. In other words there is a positive externality on the original good demand and, as a consequence of the existence of a pirate substitute, an increase in the total number of listeners of music in the first period, increases the number of consumers that in the second period purchase cds. Moreover I assume that there is not a residual demand of cds, i.e. consumers that purchase cds in the first period, purchase in the second as well.

Setting the prices, the monopolist has to consider the sample effect on the demand of the second period. Hence the objective function is:

$$\pi = p^1_{cd} D^1_{cd} + p^2_{cd} D^2_{cd} + p_2 \lambda D^1_{mp3} \tag{12}$$

where the apexes indicates the timing. Substituting the demands of the two kinds of goods (described by conditions 9 and 10) in the objective function and solving[11] we obtain the value of the profit in such an intertemporal framework.

In the previous paragraph I obtained the equilibrium profits in the no-copying world, described by condition 4. In such a case, considering as in this

[11] See Appendix.

paragraph two periods and the absence of a residual demand[12], we had that the profit of the monopolist are equal to $\frac{1}{2}$.

Hence we can compare the profits of the firm in the two cases both with and without the copying, i.e. with and without the sample effect, analyzing for which values of λ, β and w the profits in a world where there is file-sharing are equal to $\frac{1}{2}$.

In particular, considering the relevant case where $w = 0$, we can analyze the effect of free downloading on the profits of the recording company obtaining that the firm does not lose money because of file-sharing if and only if:

$$\lambda = 2\beta \tag{13}$$

Since by definition it is $0 < \lambda < 1$ and $0 < \beta < 1$ we can represent such a case in the following picture:

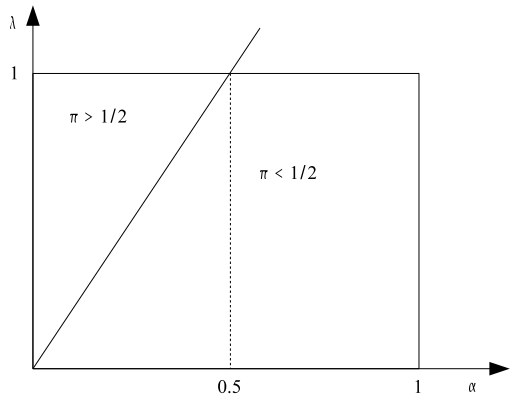


Figure 5:

Such a line describes the combinations of λ and β that allow to the firm not to lose profits, in a world where it is possible to download for free. The area above the line represents the combinations of the values that allow to the firm to increase its profits, the opposite happens for the values that lies in the area under the line.

Proposition 2. Combinations of λ and β that allow to the firm to increase its profit in case of free download do exist if and only if $\beta < 1/2$, i.e. if the substitutability between the original good and pirate good is very low.

According to my model, in the music market the file-sharing does not seem to guarantee a positive externality on the demand of cds big enough to compensate the substitution effect due to the mp3 files. Sample effect should increase

[12]That is assuming that consumers who purchase cds in the first periods purchase in the second as well.

the sales more than the existence of a free substitute decrease, and this seems to be improbable.

Such a situation might realize just with binding assumptions on the value of the parameters, or for some class of artist, for example the beginners, who might be advantaged by an increase in the fans, more than the lose in the sale damaged them. Moreover most of the profits of the beginners come from the live performance, rather than cd sales, hence the positive externality should be enlarged and the sample effect could plays a central role.

Nevertheless, in a world hyperconnected where anyone can be himself producer, recording companies and more in general publisher of any digital good, have to re-think their role and their business: in order not going bankrupt firms have to modify their strategy.

5 The firm enters the low quality good market

The reaction of the recording sector to the massive piracy from end users at the beginning of this decade was, at the best, hysterical. Many suedes were intended against producers of file-sharing software[13] and even single downloaders, while at the same time a global advertising campaign tried to make feel guilty people used to download music files from Internet. Nevertheless such a strategy did not obtain a great success and the road to start had to be different: the recording firms began to sell themselves a low quality compressed music file, and the success of virtual shops like I-Tunes has been enormous.

Such a strategy is not so different from the one of newspapers that decide to make available on line a free version of the articles, obtaining revenue from the advertising or on-line subscriptions.

Hence in the case the firm decides to compete with the pirate producing itself a low quality good, the utility of consumers is given by:

$$U = \text{MAX} \begin{cases} \theta - p \\ \alpha\theta - q \\ \beta\theta - w \\ 0 \end{cases} \tag{14}$$

where, as usual it is assumed that θ is uniformly distributed between 0 and 1, while α is the discounted factor of the legal low quality good and q is its price. Since the legal substitute and the pirate good are basically the same good, but the latter is a copy, it is valid for all the consumers that $\alpha > \beta$ in any case.

In order to avoid corner solutions, I continue assuming that buyers of all the goods always exist, hence there are three marginal consumers: the consumer i indifferent between the original good and the low quality legal substitute, the consumer j indifferent between the low quality legal substitute and the low

[13]The most famous is the trial *Riaa vs. Napster*, that the Recording Industry Association of America intended against the society producer of the first file sharing software, Napster.

quality pirate substitute, and the consumer s indifferent between the latter and nothing[14]. For i we have $\theta_i = \frac{p-q}{1-\alpha}$; for j, $\theta_j = \frac{q-w}{\alpha-\beta}$; for s, $\theta_s = \frac{w}{\beta}$

In such a case the demand for the original good becomes

$$D_x(p,q) = \int_{\theta_i}^{1} 1 d\theta = 1 - \frac{p-q}{1-\alpha} = \frac{1-\alpha-p+q}{1-\alpha} \tag{15}$$

While the demand for the low quality legal substitute is

$$D_L(q,p,w) = \int_{\theta_j}^{\theta_i} d\theta = \frac{p-q}{1-\alpha} - \frac{q-w}{\alpha-\beta} = \frac{(\alpha-\beta)p-(1-\beta)q+(1-\alpha)w}{(1-\alpha)(\alpha-\beta)} \tag{16}$$

Finally the demand for the pirate substitute is:

$$D_S(w,q) = \int_{\theta_s}^{\theta_j} d\theta = \frac{q-w}{\alpha-\beta} - \frac{w}{\beta} = \frac{\beta(q-w)-(\alpha-\beta)w}{\beta(\alpha-\beta)} \tag{17}$$

The profit of the firm, that acts as a multiproduct monopolist is given by $\pi(p,q) = pD_x + qD_L$. Substituting the expressions 15 and 16 and maximizing we obtain the following equilibrium[15]:

$$p = \frac{1-\beta+w}{2}; q = \frac{\alpha-\beta+w}{2}; \qquad \pi^C_{x,L} = \frac{(\alpha-\beta)(1-\beta+2w)+w^2}{4(\alpha-\beta)} \tag{18}$$

where the subindexes x, L indicates that the profit of the firm depends both on the original good and the legal substitute.

5.1 The discussion of the model

Entering the new market is a possible strategy of the firm, when it has been pirated. Comparing the profits in the 18 and 11 give us the value of α and β that make this strategy profitable. Analogously comparing the profits in the 18 and 4 give us the locus of value of α and β such that the profit is the same both without low quality substitute and with both pirate and legal substitute. After such comparisons are made we can state the following proposition[16]:

Proposition 3. In a copying world, that is in a world where the pirate substitute exists, it is always profitable to the firm entering the low quality market.

[14] Assuming the existence of some buyers of any good, means that $1 > \theta_i > \theta_j > \theta_s$, such conditions are verified if $p < 1 + q - \alpha$, $q < \frac{(\alpha-\beta)p+(1-\alpha)w}{1,\beta}$ and $w < MIN(\frac{\beta}{\alpha}q; \beta p)$.

[15] Substituting the expressions 15 and 16 in the objective function gives us:

$$\pi(p,q) = p\left(1 - \frac{p-q}{1-\alpha}\right) + q\frac{(\alpha-\beta)p-(1-\beta)q+(1-\alpha)w}{(1-\alpha)(\alpha-\beta)}$$

Differentiating it with respect to p and q gives is the two focs: $\frac{\delta\pi}{\delta p} = 0 \Rightarrow p = \frac{1-\alpha+2q}{2}$ and $\frac{\delta\pi}{\delta q} = 0 \Rightarrow q = \frac{(1-\alpha)w+2(\alpha-\beta)p}{2(1-\beta)}$ that lead us to the equilibrium expressed in the 18.

[16] See Appendix for the proof.

In some circumstances entering the substitute market might even increase the profit of the firm, respect to the no-copying world.

The following expression:

$$\alpha = \beta - \frac{w^2}{2w - \beta} \tag{19}$$

describes the family of curves in the locus α, β that allows to the firm not to lose money respect to the case the low quality substitute does not exist.

If $w = 0$ the firm always loses money, in fact the profit in the condition 18 becomes $\frac{1-\beta}{4}$ that is always minor than $\frac{1}{4}$.

On the contrary if $w > 0$ the family of curves is represented in the following pictures. By the constraints, the relevant area is $\alpha < 1$; $\beta < 1$; $\alpha > \beta$.

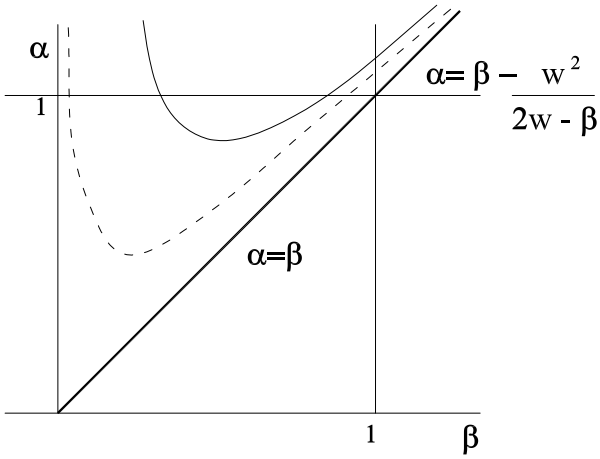


Figure 6:

Every curve in the picture represents the locus of the combinations of values of α and β that let the profits of the firm unchanged respect to the no-copying case. When w increases the curve moves above. In such a picture all the points under one curve represents value of α and β that allow to the firm to increase its profits. Hence, while the firm always loses money in the case just an illegal substitute exist, in the case it enters the new substitute market it can increase the profit.

Moreover w may represent the decision variable choose by the political maker. In fact in the case the pirate copy is illegal, as it is for the file sharing of pirated mp3 files, it represents the expected value of the penalty for violating copyright. As we can see from the picture, when w grows the area of increased profit for the firm is bigger.

The appearance of a substitute good in the market will be obviously opposed by the firm because, as we examined, it causes a decreasing in its profits. In fact any time a substitute copied good appeared, the owners of the copyright started to assert the impossibility to survive the attack of the "pirates": this happened with the photocopiers in the 60s, the audiotapes in the 70s, the videotapes in the 80s and the cd recorders in the 90s; it is likewise happening now with the recording industry and the illegal sharing of mp3 files.

Nevertheless, the annihilation of the industry depends on the substitutability between the goods (β), and the price of the low quality good (w). The latter can depend on the enforcement, which is the expected value of the penalty. Hence in any case when a substitute good appears, it is optimal for the firm to appeal to an increase in the enforcement of the law in order to raise the probability of the criminal (in the file sharing case the downloader) to be caught: in this way w increases, and the firm can start making monopolistic profits again.

In the historical cases mentioned above the pirated industries were not annihilated by the substitute good[17], even if those industries had to partially change their model of business: for example nowadays most movies are produced (and thought) for the home video market rather than for theaters. Nevertheless, the substitutability between a photocopied and an original book is smaller then the one between a cd and an mp3 file (in the latter β is bigger), while copying a videotape is not as easy as downloading a file from the internet (w is smaller).

Many factors can influence the value of β, and this is particular relevant in the music market: if the consumers valuation of the pirate good increases, for example because of the diffusion of mp3 players, or if the consumers valuation of the original good decreases, for example because an anti piracy policy of the firm decreases the quality of the cd, the valuation of the substitute good can increase and be bigger than the valuation of the original good.

The problem for the firm do exist if the quality of the substitute good is too high, i.e.,in the terms of this model, when $\beta > 1$; in such a case the firm is forced to change its business in order not be annihilated.

5.2 The effect of an increasing quality in the substitute good

In the economic literature on piracy it is usually supposed that the valuation of the substitute good is minor than the valuation of the original; in the terms of this model it is assumed that $0 \leq \beta \leq 1$. The main problem is that, in the age of Internet, such an assumption can seem unrealistic for many sectors and in particular for the music market as it is today.

The benefits from mp3 have determined an increasing success and diffusion of this kind of file, and the creation of the market of mp3 music players. Nowadays many consumers, particularly the *under-thirty*, who represent an important target in the music market, prefer the low quality but easily transportable mp3 file, to the high quality sound of an *old* CD. In such a case the annihilation of

[17]Liebowitz (1985) shows that photocopying was even beneficial to the industry.

the market could become a concrete scenario, since if a better format do exist at a smaller price, the condition that hold is the annihilation condition described by formula 5.

Such a condition does not hold anymore if the firm enter the new low quality substitute market. In such a case the demand for the original good disappears and, since it is always $\alpha > \beta$ the utility function of the consumer becomes:

$$U = \text{MAX} \begin{cases} \alpha\theta - q \\ \beta\theta - w \\ 0 \end{cases} \tag{20}$$

Now two marginal consumers exist, $\theta_j = \frac{q-w}{\alpha-\beta}$ and $\theta_s = \frac{w}{\beta}$, hence the demand of the legal low quality good is:

$$D_L(q,w) = \int_{\theta_j}^{1} d\theta = 1 - \frac{q-w}{\alpha-\beta} = \frac{\alpha-\beta-q+w}{\alpha-\beta} \tag{21}$$

While the equilibrium in the market is the following:

$$p_L^C = \frac{\alpha-\beta+w}{2}; \qquad D_L^C = \frac{\alpha-\beta+w}{2(\alpha-\beta)}; \qquad \pi_L^C = \frac{(\alpha-\beta+w)^2}{4(\alpha-\beta)} \tag{22}$$

where the index C indicates the fact that we are in a copying world, while the subindex L indicates that the equilibrium depends just on the sales of the legal low quality good.

Since $\alpha - \beta > 0$ in such a case the profit of the firm are always positive. Hence we can state the following proposition:

Proposition 4. Anytime that a firm is pirated by a different quality substitute, it can enter itself the new substitute market in order not going bankrupt.

6 Artist and recording company

Until now I have considered the producer of music as a single subject, but in the music sector there is typically a distinction between the recording company, that produces the cd, and the artist, who writes the music.

Moreover such a distinction is reflected in the profits of the two subjects, hence in this paragraph I consider two sides in the music market: the legal supports sold[18], and the live performances of the artists. The growing diffusion of peer-to-peer file sharing programs (as Napster or e-mule) has shocked the first

[18]In the rest of the paper I refer just to the cd market, but it is possible to include in the analysis any supports, as old fashioned vinyls, audiotapes and legal mp3, without any change in the model.

part of this market causing a sensible decrease in its dimension that might cause the annihilation of the industry[19]. But, while the profit of the firm depends on the number of cds sold, the profit of the artist depends both on the number of cds sold and the earning from live performances, the latter depending on the total audience listening to the cd of the artist, no matter if such cd is the original or a pirated copy. Hence for the artist there is a trade-off between the profits from concerts and the profits from cd sales: such a situation can potentially generate a conflict between the artist and the publisher.

According to the basic model presented in paragraph 3, we have that the profit of the firm in a no-copying world are given by:

$$\pi_{cd}^{m} = \gamma \frac{1}{4} \tag{23}$$

Where γ is the fraction of profit that the firm earns, while the profits that the artist obtains from the cd are the complement $1 - \gamma$, and the index m is referred to the fact that the monopolist maximizes its own profit.

The price p_{cd}^{m} maximizes the profit of the firm, but does not the profit of the artist. In fact the latter comes both from cd and concerts. In other words the price set by the monopolist has consequence on the audience of the artist: I assume that the number of people going to the concert depends on the number of people listening to the artist's music, hence for the artist might be better loss money on the revenue from cd in order to enlarge his audience and earn from live performances.

In order to point out the effect that listening to the cd has on the earnings of the artist coming from the live performance, I assume that a fraction ϕ of consumers who listen to the record (the audience of the artist), decides to go to one concert. In this context ϕ plays the same role played by λ in the previous paragraph, and hence is a measure of the sample effect.

Let me assume that the utility of each consumer to listen to a concert is analogue to the utility to listen to a record, described in the condition 1, and hence is given by.

$$U = \text{MAX} \begin{cases} \theta - p_c \\ 0 \end{cases} \tag{24}$$

If p_c is the price of a concert, the consumer indifferent between going or not to the concert is the consumer c such that $\theta_c = p_c$. Given the uniform distribution of consumers, and being $A = D_m$ the audience (that in this case is given by the cd buyers), the demand of concert will be:

$$D_c(p_c) = \int_{\theta_c}^{\phi A} 1 d\theta = \phi(1 - p_m) - p_c \tag{25}$$

When the monopolist acts as shown in equilibrium 4, we have that $D_c = \phi \frac{1}{2} - p_c$

In such a case the price set by the artist for the concert, the demand of concert and the total profits of the artist will be:

[19] See for example Liebowitz (2004, 2005a).

$$p_c^m = \frac{\phi}{4}; \qquad D_c^m = \frac{\phi}{4}; \qquad \pi_A^m = (1-\gamma)\frac{1}{4} + \phi^2\frac{1}{16} \tag{26}$$

If the artist could set the price in order to maximize his own total profits, the equilibrium expressed in the conditions 4 and 26 changes.

In this case the objective function of the artist, to maximize with respect to both the price of the cd p_{cd} and the price of the concert p_c, is given by:

$$\pi^A = (1-\gamma)\cdot p_{cd}\cdot D_{cd} + p_c \cdot D_c \tag{27}$$

Hence the prices of the cd and the concert that maximize the profit of the artist are the following[20]:

$$p_{cd}^A = \frac{2(1-\gamma)-\phi^2}{4(1-\gamma)-\phi^2}; \qquad p_c^A = \frac{\phi(1-\gamma)}{4(1-\gamma)-\phi^2} \tag{28}$$

where the index A is referred to the fact that now it is the artist to maximize his own profit.

Proceeding, the demand of cds and concerts are:

$$D_{cd}^A = \frac{2(1-\gamma)}{4(1-\gamma)-\phi^2}; \qquad D_c^A = \frac{\phi(1-\gamma)}{4(1-\gamma)-\phi^2} \tag{29}$$

Finally the profits of the monopolist and of the artist are:

$$\pi_m^A = \gamma\frac{[2(1-\gamma)-\phi^2]\cdot[2(1-\gamma)]}{[4(1-\gamma)-\phi^2]^2}; \qquad \pi_A^A = \frac{(1-\gamma)^2}{4(1-\gamma)-\phi^2} \tag{30}$$

Since $0<\phi<1$ and $0<\gamma<1$ by assumption, it is easy to show, comparing the equilibrium described in 4, and 26 with the one described in 28, 29and 30, that $p_{cd}^m > p_{cd}^A$, $D_{cd}^m < D_{cd}^A$, $p_c^m < p_c^A$, $D_c^m < D_c^A$.

Comparing the profits of the firm and of the artist we have that $\pi_m^m > \pi_m^A$ and $\pi_A^m < \pi_A^A$.

In particular the difference between the two possible profits of the artist $\pi_A^A - \pi_A^m$, that I indicate with $\Delta\pi_A^{N.C.}$ is given by:

$$\Delta\pi_A^{N.C.} = \pi_A^A - \pi_A^m = \frac{\lambda^4}{16[4(1-\gamma)-\lambda^2]} \tag{31}$$

where the $N.C.$ indexes that such a condition is valid in a no-copying world[21].

The potential conflict of interests between the artist and the recording company is not a new phenomenon in the market of music, but a consequence of the structure of the earnings in such a market, and it does not exist just in the case that there is not any effect of cd sales on the audience ($\phi = 0$). The source

[20] Expressing the objective function of the artist described in 27 respect to the prices of the cd and the concert gives us $\pi^A = (1-\gamma)\cdot p_{cd}\cdot(1-p_{cd}) + p_c\cdot[\phi(1-p_{cd}) - p_c]$. Maximizing with respect to p_{cd} and p_c we obtain the following reaction function: $p_{cd} = \frac{1}{2} - \frac{\phi}{1-\gamma}\frac{p_c}{2}$ and $p_c = \frac{\gamma(1-pcd)}{2}$, that lead to the result expressed in 28.

[21] Analogously for the firm we have that $\Delta\pi_m^{N.C.} = \pi_m^m - \pi_m^A = \frac{\gamma\lambda^4}{4[4(1-\gamma)-\lambda^2]^2}$

of the conflict lies in the fact that the artist is not interested just in cd sales, but wishes his audience to be as wide as possible, and this does not depend on file sharing. The file sharing might alter such a situation.

6.1 The copying world case

In the paragraph 2.2.2 we saw that the presence of an illegal low quality substitute modifies the demand of cds, and creates a demand for the new good, that we described with conditions 9 and 10.

In this paragraph it is important to underline that in the case that a pirate substitute exists, the audience of the artist is modified and is given by both the buyers of the cd and the pirates who prefer the illegal substitute:

$$A = D_{cd} + Dmp3 = 1 - \frac{p_{cd} - w}{1 - \beta} + \frac{\beta p_{cd} - w}{\beta(1 - \beta)} = 1 - \frac{w}{\beta} \tag{32}$$

Hence, in such a case, the total demand of concert does not depend on the price of the original cd, but by the price of the mp3 ($\frac{w}{\beta}$): if $0 < \beta < 1$ the marginal consumer relevant in the definition of the audience is θj, the individual indifferent between purchasing or not the illegal file.

Proceeding as in the no-copying case, and being θ_c the consumer indifferent between going or not going to the concert such that $\theta_c = p_c$, it is possible to obtain the demand of concert, that is given by:

$$D_c(p_c) = \int_{\theta_c}^{\phi A} 1 d\theta = \phi \left(1 - \frac{w}{\beta}\right) - p_c \tag{33}$$

Hence the price and the demand in the market of concert, after that the artist has maximized his profits will be:

$$p_c^m = \frac{\phi}{2}\left(1 - \frac{w}{\beta}\right) D_c^m = \frac{\phi}{2}\left(1 - \frac{w}{\beta}\right) \tag{34}$$

While the total profits of the artist will be:

$$\pi_A^m = (1 - \gamma)\frac{(1 - \beta + w)^2}{4(1 - \beta)} + \frac{\phi}{4}\left(1 - \frac{w}{\beta}\right)^2 \tag{35}$$

If we reconsider the objective function of the artist (that as in the no-copying case is given by $\pi^A = (1 - \gamma) \cdot p_{cd} \cdot D_{cd} + p_c \cdot D_c$), in order to suppose that the artist is to maximize it, we have:

$$\pi^A = (1 - \gamma) \cdot p_{cd} \cdot \left(1 - \frac{p_{cd} - w}{1 - \beta}\right) + p_c \cdot \left[\phi \left(1 - \frac{w}{\beta}\right) - p_c\right] \tag{36}$$

In order to point out the optimal prices for the artist we have to maximize such function but, since the audience of the concert is independent from the prices of the cd, (as shown with condition 32 and figure 1), the equilibrium in both markets results unchanged with respect to the case where the firm is to

fix them. Hence we can state the following proposition:

Proposition 5. While a conflict of interests does exist between the artist and the producer in a no-copying world, such a conflict disappears in the presence of free download

The latter result, that depends on the assumption on the demand of concert and the profit of artist and recording company, is in contrast with the literature (Gayer and Shy (2006)) which on the contrary underlines a growing contrast between the two subjects.

7 Conclusion

The growing diffusion of personal computers and Internet in the world can lead to a rise in copyright infringement for any kind of digital good. The main case for this emerging problem is the download of audio file, in the mp3 format, by means of file sharing peer-to-peer networks.

Recording companies sustain that their business is annihilated by the peer-to-peer system, while advocates of online file sharing argue that file sharing should be unrestricted: the music is an experience good and such software allows consumers to try it out before purchasing. This chance for the consumer, due to the presence of a low quality substitute, can increase the overall profits of the industry.

These two statements represent the extremes of the presented model: the structure of consumer preferences, the technological constraint of the sector and the substitutability between the legal and the illegal good, determine where an industry is, and what direction it is taking.

Since a high degree of substitutability exists between a cd and an mp3 file, which in addition presents low downloading costs, I show that the outlook for the recording industry is quite worrying. Furthermore the sample effect does not seem to play a central role in this industry: even in case of high level of sampling, if there is a high substitutability between mp3s and cds ($\alpha > 1/2$), the firm loses money.

In a digital world, where a good can reach the consumer without the intermediation of a publisher, there is little purpose for the traditional recording industry, nevertheless I show that the annihilation condition often cried out by the firms, i.e. a scenario where the pirated sector collapse going bankrupt, is never the equilibrium of the market, since the firm can always enter itself the substitute segment producing a good (for example selling itself mp3 files), that is of higher quality with respect to the one presents in the market.

Finally I have investigated the relation between artists and recording company, the two main subjects on the supply side of the music industry, in this paper I shaw that the file sharing can undermine their contrast.

Further research should invest the complementarity between the digital good sector and other markets: if, on the one hand, the piracy has decreased the dimension of the music market, on the other hand industries that sold the machines used by the pirates have increased their business, and for example the market of the MP3 players has been invented from nothing. Probably the "big enemy" of the recording industry is not the final consumers, that occasionally can act as a pirate, but the industries that are cannibalizing music market profits.

Appendix A

Italian Music Market (Thousands of Copies).

	1998	1999	2000	2001	2002	2003	2004	2005
Singles	3554	5093	4043	3898	3143	2477	1231	875
Tapes	14157	12945	8883	5729	3096	1149	117	117
CDs	34554	35765	35228	34206	33081	32589	29654	28340
Album	48794	48766	44142	39981	36203	33771	29758	28449
Total	52348	53859	48185	43849	39346	36248	30885	29215

Source FIMI

Internet Users in Italy (Millions)

	1998	1999	2000	2001	2002	2003	2004	2005
Internet Users	3,7	9,1	13	17,9	19,9	23,7	25,6	28,6

Source AGCOM.

Broad Band in Italy (Mill. of Lines)

	2000	2001	2002	2003	2004	2005	2006
Broad Band	0,1	0,3	1	2,4	4,7	6,6	8,1

Note: Estimated data for year 2006

Source AGCOM.

Italian Home Video Market (Est.Value in Mil.of euro)

	1997	1998	1999	2000	2001	2002	2003	2004	2005
VHS Rental	157	157,4	165	168	167	159	101,4	53,7	23,1
Vhs Sales	326	416	403	377	310	281,5	178,2	94,1	56
DVD Rental	0	0	0	0	13	80,1	171,8	263,5	342,6
DVD Sales	0	4,6	27	72	119	201,6	378,2	533,9	624,8
Total	483	578	595	617	609	722,2	829,6	945,2	1047,3

Source UNIVIDEO

USA Home Video Market (Thousands of Copies)

	2001	2002	2003	2004	2005
VHS Rental	86,2	73,6	53,2	33	14,9
Vhs Sales	539,6	407,5	240,2	115,7	33,7
DVD Rental	37,1	79,3	110,9	149,1	178,4
DVD Sales	313,9	539,9	768,2	1063,2	1114,2
Total	976,8	1100,3	1172,5	1361	1341,2

Source MPAA

Appendix B

Proof of Proposition 1:

I show that, in the scenario described in the paragraph 2.2.2, if exist consumers both of the original good and the pirated copy, the firm always lose money.

In fact if both the consumers exist it must be that $w < \beta p$, i.e. $w < \frac{\beta(1-\beta)}{2-\beta}$. Moreover we have that $\beta < 1$.

The profit in the copying world is bigger than the profit in the no-copying if and only if $\frac{(1-\beta+w)^2}{1-\beta} \geq \frac{1}{4}$, such an inequality, in the space w, β, is verified in the area above the curve $w = \sqrt{1-\beta}(1-\sqrt{1-\beta})$ but, as we can see in the picture, such an area is superior respect to the relevant constraint on w.

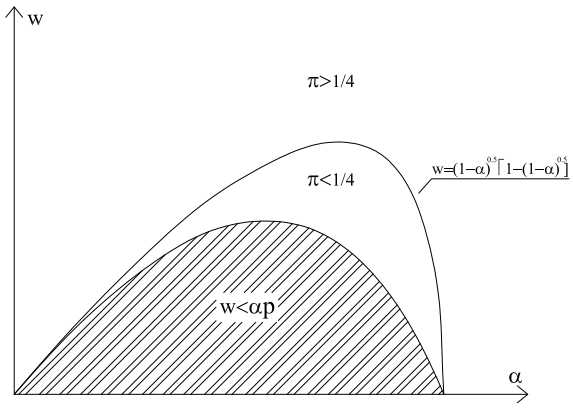


Figure 7:

Proof of Proposition 2:

I show that the locus of values of λ and β such that the profit of the recording company with free file-sharing and the profit without file-sharing are equal is given by $\lambda = 2\beta$.

The objective function of the firm in an intertemporal framework with two periods is given by $\pi = p^1_{cd} D^1_{cd} + p^2_{cd} D^2_{cd} + p_2 \lambda D^1_{mp3}$. The demand of cds in the two period is $D^i_{cd} = \frac{1-\beta-p_i+w}{1-\beta}$, with $i = \{1, 2\}$, the demand of mp3 in the first period is $D^1_{mp3} = \frac{\beta p_1 - w}{\beta(1-\beta)}$. Substituting such demands in the objective function of the firm we obtain:

$$\pi = p_1 \frac{1-\beta-p_1+w}{1-\beta} + p_2 \frac{1-\beta-p_2+w}{1-\beta} + p_2 \lambda \frac{\beta p_1 - w}{\beta(1-\beta)}$$

maximizing with respect to the two prices we have the following focs:

$$\frac{\delta \pi}{\delta p_1} = 0 \Rightarrow \frac{1-\beta-2p_1+w+\lambda p_2}{1-\beta} = 0$$
$$\frac{\delta \pi}{\delta p_2} = 0 \Rightarrow \frac{\beta(1-\beta-2p_2+w) - \lambda(w-\beta p_1)}{\beta(1-\beta)} = 0$$

Solving for p_1 and p_2 we have the following prices:

$$p_1 = \frac{w\lambda^2 - \beta(1-\beta+w)\lambda - 2\beta w - 2\beta(1-\beta)}{\beta(\lambda^2-4)}$$
$$p_2 = -\frac{[(\beta-2)w - \beta(1-\beta)]\lambda + 2\beta + 2\beta(1-\beta)}{\beta(\lambda^2-4)}$$

Substituting such prices in the objective function fo the firm led us to the following value of the profit:

$$\pi = \frac{\lambda\beta(w+1-\beta)[\beta(w+1-\beta)-2w] + 2\beta^2(w+1-\beta)^2 + \lambda^2 w(1-\beta)(w-\beta)}{\beta^2[(4-\lambda)^2(1-\beta)]}$$

If we impose the equality between such a profit with $\frac{1}{2}$ (that is the profit the firm obtains in two periods in a no-copying world), in the space $[\beta, \lambda]$ we have the family of curves, function of w, for which the profits with file-sharing are the same that the profits without file-sharing. In particular if we consider the relevant case where $w = 0$, that describes a scenario where there is free downloading from the Internet, we have that such a family collapse to the following curve:

$$\frac{1-\beta}{2-\beta} = \frac{1}{2} \Rightarrow \lambda = 2\beta$$

Proof of Proposition 3:

I show that, in case all kinds of consumers exist, it is always profitable to the pirated firm enter the new low quality segment of the market, and that such a strategy might increase the profit respect to the no-copying world.

In fact we have that $\pi_{x,L}^C \geq \pi_x^C$ if and only if

$$\frac{(\alpha-\beta)(1-\beta+2w)+w^2}{4(\alpha-\beta)} \geq \frac{(1-\beta+w)^2}{4(1-\beta)}$$

. That is true if and only if:

$$\frac{(\alpha-\beta)(1-\beta+2w)}{\alpha-\beta} + \frac{w^2}{\alpha-\beta} \geq \frac{(1-\beta)^2}{1-\beta} + \frac{2w(1-\beta)}{1-\beta} + \frac{w^2}{1-\beta} \Rightarrow$$

$$\Rightarrow 1-\beta+2w+\frac{w^2}{\alpha-\beta} \geq 1-\beta+2w+\frac{w^2}{1-\beta} \Rightarrow$$

$$\Rightarrow \frac{w^2}{\alpha-\beta} \geq \frac{w^2}{1-\beta}$$

that is verified if $\alpha \leq 1$, that in the case both types of consumers exist is always true. Just in the case $w = 0$, i.e. in the case of free downloading, the two profits are equal.

Analogously comparing the profits in the 18 and 4 give us the locus of value of α and β such that the profit is the same both without low quality substitute and with both pirate and legal substitute. From

$$\frac{(\alpha-\beta)(1-\beta+2w)+w^2}{4(\alpha-\beta)} = \frac{1}{4}$$

we have

$$(\alpha-\beta)(1-\beta+2w)+w^2 = \alpha-\beta \Rightarrow$$

$$\Rightarrow (\alpha-\beta)(1-\beta+2w-1) = -w^2$$

that gives us following locus:

$$\alpha = \beta - \frac{w^2}{2w-\beta}$$

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