Università Carlo Cattaneo Castellanza, LIUC

Paper presented at

Workshop on the Law and Economics of Intellectual Property and Information Technology

July 22-23, 2005

Details and Other Papers downloadable at
http://www.liuc.it/ricerca/istitutoeconomia/laweconomicsjuly2005/program.asp

Network Externalities, File Sharing and Digit\al Music Piracy

Antonella Ardizzone, IULM

Introduction

There are a lot of settings in which the value of a product or a service for its consumers increases as the number of other people using it becomes larger. In these cases *network externalities* can create benefits such as demand-side and supply-side economies of scale: people can obtain advantages to use an interchangeable complementary product, or to communicate in an easier way with other people or machines; moreover, the quality of the product can increase with the number of users, the firms can save production costs using mass production, etc.

Some of these forces operate also in the case of *file sharing systems*: the larger the network is, the larger the possibility to find the file a consumer is searching for is. No one would choose a network to which only a few consumers belong, above all if it is risky.

Peer to peer file-sharing is illegal but the number of people in the world using it is huge. According to Harris-Interactive (2002), Pew Internet Report and Peitz and Waelbroeck's (2004) calculations, the number of music downloaders is 39.73 millions. As it is showed in table 1 there was a slowdown in music downloads in 2002 after the dramatic increase in 2001 (+45% in 2001 and +8% in 2002).

Table 1: Evolution of music downloaders.

Year	Number of internet users (mln)	% of music downloaders	Number of music downloaders (mln)	Growth rate
2002	137	29	39.73	8%
2001	127	29	36.83	45%
2000	121	21	25.41	-

Sorce: (Harris Interactive).

File sharing is illegal from a notional point of view because of the violation of copyrights over songs, films and programs but not on the practical point of view: it's not illegal itself to put files online! In fact, in 2003, the District of Columbia Court of Appeal rejected the Recording Industry Association of America (RIAA) request to obtain from Internet Service Providers identification

codes of users suspected of "online piracy"[1]. In Holland the leader file-sharing, Kazaa, and in Norway "DVD Jon" (to copy DVD, by decrypting), have been absolved[2]. The record companies are pressing to obtain an enforcement of controls and a more rigid interpretation of current laws about copyrights because they according to their point of view file-sharing decreases sales, but in the Internet control powers are more limited, possibilities of overcoming new obstacles by technology innovations is larger and also laws about these issues are not commonly interpreted in the same way in all countries. This means that practically the risk for users is not always high (in terms of frequency and intensity of legal prosecution).

Nowadays there are lots of illegal file-sharing programmes like Kazaa, WinMx, Emule, Lime Wire Basic, Grokster, Imesh but also for profit (record companies owned or not) file-sharing programmes like Sony Connect.

Why so much illegal file-sharing programmes instead of one? Only one program would offer the biggest theoretical network externalities but no one would pay the cost of compatibility (also if they would be quite zero) and such an action would not be passed unobserved by authorities. So, consumers form expectation about the network size and then choose the preferred one.

Consumers can choose four different strategies, depending on the size of the network, the personal risk aversion factor, the non monetary or monetary using costs, the probability of legal prosecution and their willingness to pay. First, they can buy files and music in shops; second, they can choose to buy it online in legal sites (I-Tunes, Napster or Sony Connect, for example); third, they can use peer to peer file-sharing systems; fourth, they can free-ride and copy CD or DVD from other people (who used legal or illegal systems). Only the first two strategies are legal ones.

In general, network externalities imply that it could be difficult to identify market equilibria because they depend on consumer expectation about the network size (the "bandwagon effect" will then drive the path); multiple equilibria can be possible and the equilibrium or equilibria may not be socially optimal.

We expect that the most likely equilibrium is a separation one: some consumers will use illegal systems and others the legal one. As the network size increases, the willingness to pay, the risk of prosecution and the "troubles" of the file sharing programmes decreases. Without legal persecution, the unique equilibrium will be that all the people who have a pc and a connection to the Internet will join the illegal network and when the risk of persecution is maximum (all the people "pirates" will be identified and prosecuted) the illegal networks will die, also if the size of the network is the maximum one. A lot of intermediate equilibria between these two can arise, depending on the

[1] http://www.p2p-zone.com/underground/archive/index.php/t-18933.html, Peer-To-Peer News, The Week In Review, March 6th, '04.
[2] http://www.p2p-zone.com/underground/showthread.php?p=234746#post234746, Why file sharing will never die, Peer-To-Peer News, The Week In Review, June 2nd, '05.

changing in the strategic parameters. They are the most likely ones (as we can observe in reality) but they may not be stable over time and efficient.

The most important litterature about network externalities during the eighties has focused its attention on the influence they cause on incentives to switch to a new technology. *Farrell and Saloner* (1986) identified the concepts of "excess inertia" and "excess momentum", respectively the excessive reluctance to adopt a new superior technology and the excessive incentive to switch to a new technology (from a social welfare point of view). They analyzed how the equilibria can change when firms adopt anticompetitive behaviour such as product preannouncements and limit pricing. They also demonstrated (1985) that, when there is perfect information about the eagerness of each firm to switch to a new technology, coordination (through communication) between them eliminates symmetric excess inertia where the preferences of the firms coincide, and increases inertia where the preferences differ.

Katz and Shapiro (1986) focused their work mainly on how technology adoption (and standardization) depends on whether technologies have a "sponsor" (a firm who has controls on the property rights and so makes investments to support technology adoption). They also analyzed (1985) compatibility incentives and equilibria that can arise with fulfilled expectations in the cases of complete compatibility, complete incompatibility and partial compatibility. A lot of different equilibria are possible. They also can be inefficient ones: both in the case when compatibility is reached trough the adoption of an industry standard or the construction of an adapter, there can be excess or insufficient incentives from a social welfare point of view (if side payments are allowed or not).

Matutes and Regibeau (1988) extended the analysis of network externalities to an environment where the firms don't sell a single good (as Farrell and Saloner and Katz and Shapiro assumed) but every component of a complete system. In this case product compatibility can increase variety (contrary to previous results) and the share of the market served at any given prices. Social surplus is always larger when firms sell compatible components although compatibility leads to higher prices. Admitting the possibility to bundle the components (1992), equilibrium implies again, for a large range of parameters, compatibility but firms will offer discounted prices to consumers who decide to buy all the components from the same firm, even though it would be better to agree not to offer it ("prisoner dilemma" game). When such a "mixed bundling" is admitted, firms have excessive propensity to bundle.

Finally, *Ellison and Fudenberg* (2000) examine the reasons of excessive supply of backward incompatibility of software upgrades and the network effects on consumers.

In the last few years the massive diffusion of file sharing between users and the complaints of publishers has interested economist, who started to study this occurrence. There is a great deal of empirical research but not much academic research.

R. Krishnan, M. D. Smith and R. Telang (2003) analyze the peer to peer (P2P) architectures and applications, the significant economic characteristics of these networks and compare them to similar characteristics in the economics literature. According to their point of view, P2P networks have some characteristics in common with public and club goods but not all the results of the literature about them is applicable because they are a different class of products. In these networks there is a free riding problem between the users that increase with the number of users and reduce the performance of the network, but altruism can mitigate this effect. They underline the need for further research in this area because economic and social analysis is still in a nascent stage.

More empirical studies are available. S. *Liebowitz* (2003) evaluates the "annihilation hypothesis": "the controversy about the fear by the recording industry that great damage, perhaps even mortal damage, will be done to them if they do not stop on line trading of music files". Using empirical data he concludes that there is no evidence in support of this hypothesis (so the harm will not be fatal) while it is uncontroversial that file sharing causes profits to fall for the recording industry, but more empirical data is needed.

An analysis of off line piracy is proposed by *K-L Hui and I. Png*. Using data on piracy for music CDs over the period 1994-1998, they find that the demand for music CDs decreased with piracy, suggesting that the positive effect (increase in demand for CDs because of sampling) is overcame by the negative effect on sales (but it is less than estimated by the industry). What is more interesting is that they found evidence that publishers would have raised prices in the absence of piracy, so the revenue loss would have been higher.

But the most recent analysis on empirical data on line piracy has been published by *M. Peitz and P. Waelbroeck* in 2004. They used data on music downloads gathered in 16 countries for the period 2000-2001 (because the massive use of file sharing technologies only appeared in the second half of 1999 with the creation of Napster). Their conclusions are: internet piracy could have caused a 10% reduction in CD sales worldwide in 2001, but only 2% in 2002 (despite of the increasing number of people downloading music). The decrease in sales was 8,9% in 2002 and economic growth accounted for 2,45%, so internet piracy has not played a decisive role in 2002 CDs sales decline. The possible reason is that the diffusion of fast internet connections caused an increase in others on line leisure activities than downloading music files, so activities like instant messaging, looking for news, jobs and hobby information, creating on line contents, watching video clips and movies, playing videogames, purchasing products are supposed to have substituted more traditional

form of entertainment like CD downloads. They argue also that file sharing may have positive effects on CD sales because they may save on marketing and promotion costs.

The article is organized as follows. Section 1 spells out the details of the model used. Section 2 will contain the analysis of the new equilibrium. Section 3 discusses the impact of government imposed tariffs on blank CD's, a commonly used way to transfer part of the increased consumer surplus to the firm. In section 4 the introduction of a legal network, introduced by the firm itself, will be analyzed. This is also a very current issue, while we see that music companies try to win back market share by introducing their own networks, like I-Tunes. We conclude in section 5.

1. The Model

1.1 Consumers

There are A consumers in the market (with A normalized to 1) and these consumers are homogeneous in their valuation of a CD (where the number of songs on a CD is normalized to 1), attaching a value of V to it. They do differ in how they care about the quality of music. This is characterized by r and is uniformly distributed between 0 and 1 with density 1, where an increasing r denotes a higher willingness to pay for quality. The consumer utility if a CD is bought is:

(1.) $U_f(r) = V + r - P$

If this is positive, the consumer will enter the market. In the case of the monopolist who sets price P a total of $V + 1 - P$ consumers will enter.

(2.) $P = V + 1 - Q$ where $0 \le Q \le 1$.

1.2 Firm

In the initial situation there is only one firm in the market, the monopolist. He is the only firm where music can be bought (because of copyright). The firm acts as a monopolist. In this example there are no fixed costs, and marginal cost are denoted by c. In information markets the marginal costs are low: we will see that this will have significant implications on market equilibria.
The monopolist maximizes profit. Its profit-function is denoted by:

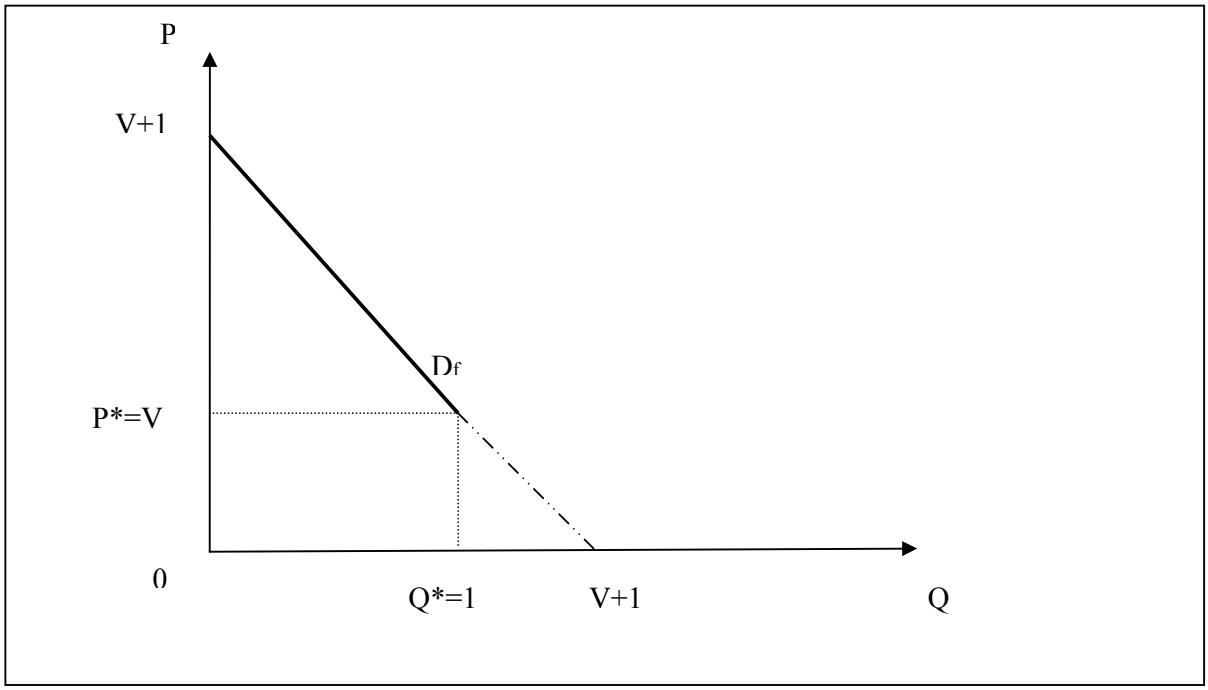
(3.) $\pi = (P - c)Q$

From this follows that:

(4.) $P^* = V$ $(Q^* = 1)$ given that $V \ge c$.

So, according the hypotheses of this model, the monopolist covers all the market, as Figure 1 shows.

Figure 1: the monopolist demand



1.3 Network

Suddenly a competitor enters the market. This competitor is no flesh and bone competitor, but takes the form of a computer program. With this P2P software music can be downloaded from other users. However, in order to download music, there must be other users to download from. This is a pure example of network externalities; the value of the network for the consumer rises as more consumers join the network.

Also, the network has zero fixed costs, as it can be downloaded for free, and no marginal cost, because there is no money charged if music is downloaded from another consumer. This would look like a utopia - maximum surplus at zero costs - if consumers would not derive disutility from using the network. This disutility is composed of several variables such as: legal risk of being caught (since it is said that downloading is illegal), the time it takes to download something, etc. and it is further called disutility of 'risk' $\lambda \in \Re^+$. λ is defined as the difference between λ_n and λ_f, where λ_n and λ_f are the risks attached to the illegal network and the firm, respectively. λ_f is taken to be equal to zero. The surplus, if the network is joined, is denoted by:

$$(5.) \quad U_n(r) = V + rx^e - \lambda$$

where it can be assumed that $V > \lambda$ so that (5.) is strictly positive.

The term $x^e \in [0,1]$ denotes the expected network externality. It is stated in this way because a consumer cannot derive a greater utility from the network (if λ was zero) than from the firm, if the firm would give its goods away without charging a price. As the network gets larger (expected size is denoted by x^e), a consumer is able to enjoy a larger proportion of the value that he attaches to the good. When more consumers are connected to the network, each individual derives more utility from the network. In reality, the network externality would be expressed in a larger choice and availability of music, but because this is a one-good model, it expresses the larger availability of one unit music (the more people have it, the quicker it can be downloaded and the better the quality is).

2 The Analysis

The monopolist outcome (without network) will serve as a benchmark in this section. Therefore, the welfare in this outcome is measured first:

$$W(V,r) = \pi + \int_0^1 (r)dr = V - c + \frac{1}{2}$$

2.1 New equilibrium

The timing in this model is like the following: first the network is introduced and an exogenous λ is given. After this, consumers make an expectation of the size of the network. Following this is the action of the monopolist who sets its prices. Then the consumers make their buying decisions by comparing the surpluses they can derive by both two possibilities. The equilibrium that follows from this must be one where expectations are fulfilled. Therefore, in this section this equilibrium will be discussed.

Instead of one group of consumers buying CD's, there are now two groups of consumers active: there are consumers that go to the network and consumers that buy at the firm.

Consumers join the network up to a point where they are indifferent between the network and the firm so: $V + rx^e - \lambda = V + r - P$. This leads to the following:

(6.) $$q_n(P, x^e) = \frac{P - \lambda}{1 - x^e}$$

The new (residual) demand function for the monopolist is:

(7.) $$q_f(P, x^e) = \Pr\left(r \geq \frac{P-\lambda}{1-x^e}\right) = 1 - \left(\frac{P-\lambda}{1-x^e}\right)$$

From the new profit function:

$$\pi = (P-c)q_f = (P-c)\left[1 - \left(\frac{P-\lambda}{1-x^e}\right)\right]$$

The optimal price is:

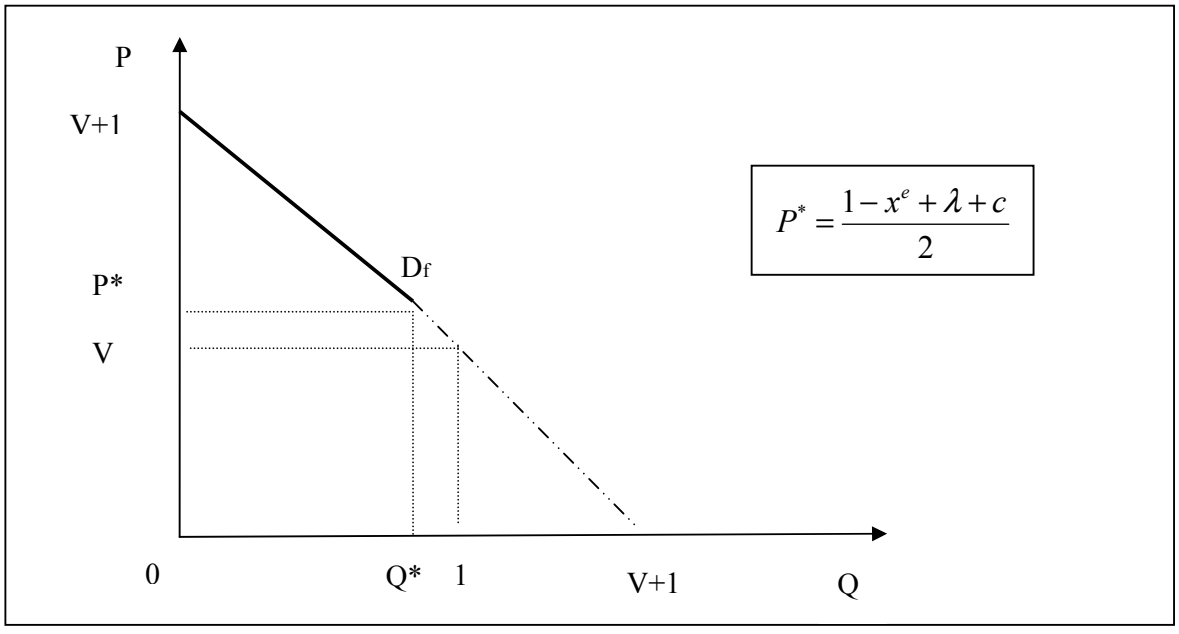
(8.) $$P^* = \frac{1 - x^e + \lambda + c}{2}$$

And:

$$q_f^* = \frac{1}{2} - \frac{1}{2}\left(\frac{c-\lambda}{1-x^e}\right)$$

So, when the expected number of users increases the price decreases and, on the contrary, it raises with the disutility of the risk and the marginal cost. The more the network is attractive for its users, the more the firm's price is competitive.

Figure 2: monopolist demand after the entry of the network



In the dotted part of the line there are pirates and not buying customers. The more the willingness to pay for music quality (r) is near to the price, the less the monopolist can enlarge the market, the more harmful is the effect of P2P on monopolist sales. In fact, if the price is near to the reservation price of a lot of consumers, there will be only a few people switching to the firm in case of a reduction of the price or an increase of the disutility of the risk. The more the price is far from the

willingness to pay, the more pirates will join the network (but a lot of them would stay out of the market if they could not share music). *The firm would obtain an advantage inducing an increase of* λ *but it is possible that only a few pirates would buy the CD*[3].

In fulfilled expectations equilibrium it must be that $x^e = q_n$. If the optimal price is taken as an input for the network demand function, the following is the result:

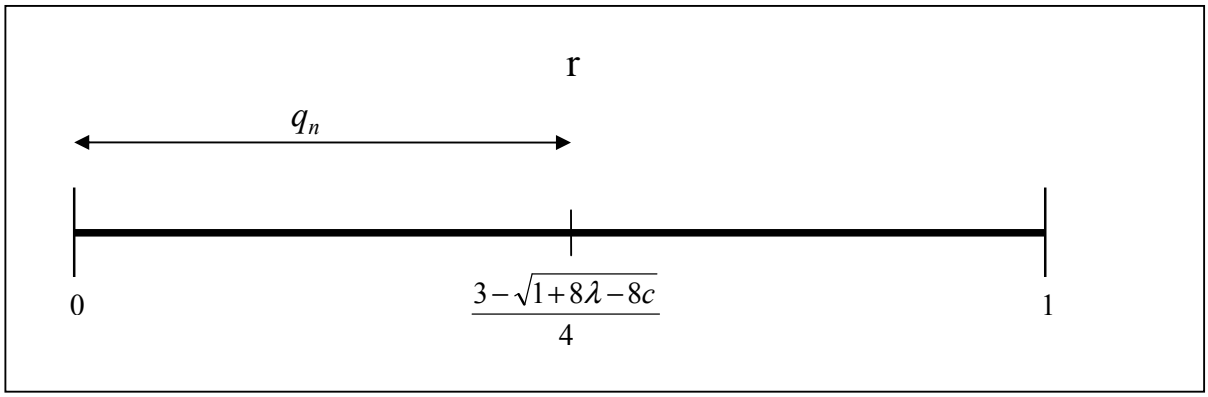
$$V + x - \frac{1 - x + \lambda + c}{2} = V + x^2 - \lambda \rightarrow -2x^2 + 3x + \lambda - c - 1 = 0$$

Since this is a quadratic function, the following network size, given optimal price, is begotten:

(9.) $$q_n^* = \frac{3 - \sqrt{1 + 8\lambda - 8c}}{4}.$$

Figure 3 shows the results derived above.

Figure 3: division of r



Proposition 1*: When the disutility of using the network is equal to the marginal cost of the monopolist, both will equally share total demand. If* $\lambda > c$*, the monopolist market share is larger than the network (and vice-versa).*

Proof:

As can be seen in Figure 3 and in (9.), when λ and c are zero or equal, the demand for the network will be $\frac{1}{2}$, which is the same as the demand for the network (since this is equal to $1 - q_n$).

In fact, the majority of pirates[4], thinking that is not likely to be prosecuted, considers the risk

[3] See Maffioletti, Ramello, 2004.

4 See IFPI, "Digital music report",2004 and AC Nielsen, "Pirateria e mercato discografico in Italia",2004.

practically null, and being hard pc and internet users, considers also quite null the disutility of searching for extra bonus traks, texts, covers, etc…In information product markets the production cost of the last unit is so low that it can be considered null. Therefore the actual situation of this market can be depicted like this: half the consumers *using a pc and the internet* download music for free, the other half buys CD's[5].

Instead, if $\lambda > c$, the root of equation 9 assumes a higher value and so the final result (the network demand) is lower than the one obtained in case they equally share the market.

***Proposition 2**: If Proposition 1 holds, then profit for the monopolist will be 0,125 and thus independent of the valuation V.*

Proof:

Profit for the monopolist can now be described by:

$$(10.) \quad \pi = (P^* - c)(1 - q_n) = \frac{1}{32}(1 + \sqrt{1 - 8c + 8\lambda})(1 - 4c + 4\lambda + \sqrt{1 - 8c + 8\lambda})$$

If it holds that $c = \lambda$, then profit will be $\frac{1}{32}(2)(2) = \frac{1}{8}$ which is, under certain conditions, considerably lower compared to the profit in the benchmark situation, where $P^* = V$ and profits were equal to $V - c$. However, when λ increases to V, the firm's profits will increase until they are on the level of the benchmark situation (monopoly).

***Proposition 3**: Consumer surplus will increase because of introduction of the network.*

Proof:

In the initial there was a consumer surplus of 0,5. In the new situation however, this has increased. Total consumer surplus is defined by the consumer surplus of the users of the network and the consumer surplus of those who buy from the firm. In function, this looks like the following:

$$(11.) \quad CS = \frac{1}{32}\left[13 + 32V - 26\lambda - 3\sqrt{1 + 8\lambda - 8c} + 2\lambda\sqrt{1 + 8\lambda - 8c} + c(2 + 6\sqrt{1 + 8\lambda - 8c})\right]$$

If the assumption of $c = \lambda$ is used again, more clarity is reached. Total consumer surplus is then:

$$CS(c = \lambda) = \frac{5}{16} - \frac{c}{4} + V - \frac{3\lambda}{4}$$

---

[5] But we have also to remember that there a lot of P2P users who have a too low reservation price to buy music. Understanding how many they are would mean understanding more about the actual harm of digital music piracy on sales.

If holds that $\lambda > V - \frac{3}{16}$, consumers will be worse off in the new situation. However, this is a very extreme outcome, since in this outcome where $c = \lambda$, this would mean that the marginal costs are also quite large. Therefore it can be assumed that consumer surplus will increase because of the network.

3 Extension 1: the introduction of a tax on blank CDs

Until now it was assumed that there were no zero fixed costs associated with using the network, as it can be downloaded for free, and no marginal cost, because there is no money charged if music is downloaded from another consumer.

However, the situation changes when the firm lobbies for an (extra) tariff on blank CD's, as is seen in reality[6]. In this new situation, the government introduces a tariff over blank CD's prices to protect the monopolist from the (illegal) network (in addition to legal prosecution of on line and off line pirates). The revenues for the tariff are then given to the firm as to reimburse it for the loss in profit.

Because of this, the marginal cost of using the network cannot be considered zero. This assumption is reasonable if the government admits that the network causes losses in monopoly profits but it's difficult or impossible (because of privacy laws, technological problems,etc) to prosecute the users in an effective way and if it is assumed that all (or quite all) blank CDs are used to copy sogns infringing copyright laws. So, this could be a way to obtain more respect for the law and can partly pay damages to recording industry by giving them the part of revenues that arises from this tariff.

The revenues on blank CD sales are:

(12.) $R = (p + T)q_n$

where T is the tariff on blank CDs and q_n (the size of the illegal network) the total quantity sold.

The share of revenues (Tq_n) will go to the monopolist and increases profits. In this extension, it is assumed that every user of the network will (still) buy a blank CD.

The effect on consumer surplus is negative. The users of the network are worse off because of the lower value of the network; the surplus of customers who buy legal CDs is unchanged.

The consumer surplus of users of the network decreases from (5.) to:

(13.) $U_n(r) = V + rx^e - \lambda - T$

[6] For exemple: legislative decree n. 68/03 in Italy. Incorporating an european directive, it has increased by about 50% the price of CDs, giving this tax to recording industry (to authors' and editors').

As for the monopolist, its profit changes to:

(14.) $\pi = (P - c) \cdot (1 - q_n) + q_n T$

In this new situation, q_n will be lower, thus increasing direct profit. The second effect is the tariff that also increases profit for the monopolist.

Proposition 4*: The imposition (or an increase) of a tariff on blank CDs will increase the number of consumers that go to the firm.*

Proposition 5*: The imposition (or an increase) of a tariff on blank CDs will increase optimal price for the firm.*

Proof:

The new network demand function is denoted by:

(15.) $$q_n(P, x^e) = \frac{P - \lambda - T}{(1 - x^e)}$$

From this a new optimal price equation can be deducted:

(16.) $$P^* = \frac{1 - x^e + \lambda + c + T}{2}$$

This surprising equation shows that as the tariff increases, not only does the price increase because of the decrease in the network externality (proof follows below), also the size of the tariff makes that the firm can ask higher prices.

Finally, the model can be solved by imposing fulfilled expectations: $q_n = x^e$.

(17.) $$q_n = \frac{3 - \sqrt{1 + 8\lambda - 8c + 8T}}{4}$$

Also here the restriction holds that $0 \le q_n \le 1$. From this follows that if it is assumed that $c = \lambda$, the tariff T must be $0 \le T \le 1$.

Equation (17.) shows that the tariff has a negative impact on the size of the network and on the users' welfare. When the social planner does not take into account the welfare implications of the people who use the network (for example because he views them as people engaged in criminal activities), his views will be that the introduction of the tariff on blank CDs always increases social welfare. When all consumer surplus is taken into account, the total welfare will decrease (with respect to the situation without tariff) as long as the decrease in consumer surplus is higher than the gain in profit.

(18.) $$\pi(c=\lambda)=\frac{1}{16}\left[(1+\sqrt{1+8T}-4T(-4+\sqrt{1+8T})\right]$$

Proposition 6*: When marginal costs are near V, profit will increase in comparison with the initial situation after introduction of a tariff.*

Proof:

Equation (18.) shows the profit, given that $c=\lambda$, for a certain T. With this assumption the restriction for T was found that $0 \le T \le 1$. The profit without tariff was 0,125. If $T=1$, profit will increase to 0,5. Thus profit in the tariff situation will be higher than the initial situation without network if $V-c<0{,}5$. When λ decreases $(c>\lambda)$, T can be larger than 1 and profits will increase more.

4 Extension 2: the firm introduces its own network

In a reaction to the new competitor the firm decides to build up its own network. This network is different from the other in the sense that people have to pay to download songs. On the other hand the use of this network is legal and quality of the songs is guaranteed. There are of course still disadvantages like the fact that you do not have a real CD in your possession and you still have to wait for the songs to be downloaded.

The firm sets its price below its initial monopoly price at P_I. This induces people to choose for the network. The firm's network has a λ_I below λ. The new network does not work in the same way as the peer-to-peer network does: it does not need to have a large number of users to function. This means that there are no network effects. The firm tries to maximize profits and experiences trouble of the competing network. It can reduce this by having a large network of its own, at the expense of its CD sales. This network, in contrast with the other one, has costs involved of c_I. The firm will also have to invest in the technological infrastructure (considered sunk costs).

Proposition 7*: By introducing a network of its own the firm will have no CD sales if $P_I+\lambda_I \le P$ and, the other way around, there will only be CD sales if $P_I+\lambda_I \ge P$. CD sales and the firm's network can only coexist if $P_I+\lambda_I=P$, dividing the firm's market share.*

Proof:

The newly introduced network competes with both the illegal network and the firm itself. Consumers join the illegal network up to a point where they are indifferent between this network and the new network introduced by the firm:

$V + r \cdot x^e - \lambda = V + r - P_I - \lambda_I$

This leads to the following: equation (6.) changes to:

$q_n(P, x^e) = \frac{P_I + \lambda_I - \lambda}{1 - x^e}$.

Consumers join the new network up to a point where they are indifferent between this network and the firm:

$V + r - P_I - \lambda_I = V + r - P$

or

$P_I + \lambda_I = P$

This means that either the firm has no sales or the new network has none[7], dependent on the P_I it charges and the λ_I involved with the firm's network. As you can see $P_I + \lambda_I$ is constant, since every consumer has the same λ_I. Instead of writing $P_I + \lambda_I$, one can just use a new variable to see that equation (9.), the network demand, stays the same.

There are, however, ways to limit the size of the illegal network. First, *if the costs of the firm's network are lower than the costs involved in selling CD's*, q_n^* will be lower. The firm will actually only introduce a new network if the firm's profits will rise.

$\pi_I = (1 - q_n) \cdot (P_I - c_I)$ is larger than the original $\pi_f = (1 - q_n) \cdot (P - c)$ in equation (10) if $c_I < c$ and $(P_I - c_I) = (P - c)$. Assuming that $c_I = 0$ in the firm's network, P_I can even be smaller than $(P - c)$, making it easier to satisfy $P_I + \lambda_I \leq P$. If this is not the case then there would not exist a firm's network, simply because no one would join.

To see why this is, go back to Equation (9.): $q_n^* = \frac{3 - \sqrt{1 + 8 \cdot \lambda - 8 \cdot c}}{4}$. Take λ as the difference between λ_n and λ_I. To minimize the size of the competing network, the firm will try to minimize its costs and to maximize λ (wich has been defined as the difference $\lambda_f - \lambda_n$).

Proposition 8*: The firm can increase its market share by introducing a network of its own with zero costs. Its profits will increase when the decrease in costs is larger than the decrease in* λ.

[7] Remember that consumers involved are considered to have a pc and a connection to the internet.

Proof:

If c_I =0 and $\lambda_I = \lambda_n$ the firm's network will be of a size of $\frac{1}{2}$ and the competing network will also have a size of $\frac{1}{2}$. When the firm maximizes λ by minimizing λ_I to zero, the competing network will decrease to a size of $\frac{3-\sqrt{1+8\lambda}}{4}$. The firm will have a market share of $1-\frac{3-\sqrt{1+8\lambda}}{4}$. Rewriting gives that the firm's newly introduced network will have a size between $\frac{1}{2}$ and $\frac{1+\sqrt{1+8\lambda}}{4}$ in case of c_I equal to zero. When the monopolist is able to reduce the size of q_n^*, P_I can be smaller than $(P-c)$ keeping profits on the same level.

More general: The market share of the competing network is reduced only if the decrease in costs is larger than the decrease in λ.

Second, *by influencing people's λ_n the firm is able to influence the size of the illegal network and thus its own sales*. The monopolist can do this by, for instance, trying to get people prosecuted when they make use of the illegal network.

Combining the extension in chapter 3 and the one described above the firm can increase its profits by introducing a new network and charge a P_I of just below $P-\lambda_I$. In this way it will sell no CD's at all and demand shifts to the new network. Profits will increase because now all consumers will have to buy blank CD's, instead of only the proportion that's in the illegal network. So the firm will have sales on the one hand and collect the tariff from every consumer on the other hand. Profits will increase by even $T(1-q_n)$ more. *But, as before said, we have to verify by empirical analisys how many pirates stop to use the illegal network to buy CDs and how many go out of the market*.

5 Conclusion

We find that a peer to peer file-sharing network has negative impacts on a firm's profit, but it is necessary to evaluate the size of the losses. Are all pirates people who would otherwise stay out of the market? Would pirates buy music if the probability of prosecution would be high? Only an empirical analisys can give some answers.

The size of the network is dependent on the risk involved in joining the network and the firm's production costs (where it is assumed that firms change its pricing behavior after the network's

entry). The higher the risk involved with the network, the smaller it will be and vice-versa. The higher the firm's costs, the larger the network will be. When the risk and firm's costs are equal, the market will be shared. Consumer surplus will increase, in contrast with producer surplus, because of the introduction of the network.

A government can react on the illegal network and the lower revenues a firm receives. Introducing a tariff on blank CD's will increase firm's profits. It will also reduce the size of the peer to peer network. The introduction of the tariff has the following (negative) effects on consumer surplus:

- Users that stay in the network have to pay a tariff, so their surplus decreases;
- Some other users of the network will leave the network because of the tariff and now buy from the monopolist (their surplus decreases because otherwise they would be in the network, since that was their first best choice).
- Some other users of the network will leave the network because some other users have left and thus created a lesser network externality. Their surplus will also be lower in this situation, because going to the monopolist was their second best choice.
- The firm increases its market power and thus increases its price. The consumers that go to the network now will have to pay more.

Firm profits will always increase with respect to the situation without tariffs and will, under certain conditions where the marginal costs are quite high, even increase with respect to the situation without the network.

Another way for the firm to react on the introduction of a peer to peer network is introducing a network of its own. Consumers will, in this case, have to pay for downloading songs. Assumed is that the network has lower costs involved than the production of CD's has. By introducing this new network, the firm is able to reduce the size of the competing network and thus increase its profits. A surprising result is that the introduction of the network leads to a new situation where there will be no CD sales at all. The firm is able to increase its market share when the decrease in costs is larger than the decrease in the relative risk. Another way to limit the peer to peer network's size is to increase people's risk involved in joining that network. The firm can do this by for instance trying to get people prosecuted for making use of this network…

References

Devetag G. (2003), "Coordination and Information in Critical Mass Games: An Experimental Study", Experimental Economics, 6, 53-73.

Economides N., and C. Himmelberg. 1995. "Critical Mass and Network Size with Application to the U.S. Fax Market," New York University, Salomon Brothers Working Paper S/95/26 (August). Available from http://www.SSRN.com

Farrell J. and Saloner G. (1996), "Installed base and compatibility: innovation, product, preannouncements and predation", American Economic Review 76, 940-955.

Gatta V., (2004), "Does the price encourage music piracy?", Master Thesis in Econometric & Management Science – Quantitative Marketing, Rotterdam University, Holland.

Hui K.-L. and Png I.P.L. (2003), "Piracy and the legitimate demand for recorded music", Contribuitions to Economic Analysis & Policy, Vol. 2: No.1, Article 11.

IFPI, "The recording industry world sales", 2005.

IFPI, "Digital music Report", 2005.

Katz M.L. and Shapiro C. (1985), "Network externalities, competition and compatibility", American Economic Review 75, 424-440.

Italian Legislative Decree n. 68/03 available on: http://gazzette.comune.jesi.an.it/2003/87/13.htm.

Liebowitz S. (2003), "Will MP3 Downloads annihilate the recording industry? The evidence so far", in Gary Libercap (ed.), Advances in the study of Entrepreneurship, innovation, and economic growth, JAI Press.

Liebowitz S.J.(2004), "File sharing: Creative destruction or just plain destruction?", Center for the Analysis of Property Rights Working Paper No. 04-03.

Maffioletti A. e Ramello G.B. (2004), "Should We Put Them in Jail ? Copyright Infringement, Penalties and Consumer Behaviour: Insights from Experimental Data", Review of Economic Research on Copyright Issues, 1, 81-95.

Matutes C. and Regibeau P. (1988): "Mix and Match": product compatibility without network externalities, Rand Journal of Economics 19-2, 221-234 and
(1992): "Compatibility and building of complementary goods in a duopoly", Journal of industrial Economics 40-1, 37-54.

Peitz M. and Waelbroeck P. (2004), "The effects of internet piracy on CD sales: cross-section evidence", CESIifo working paper No. 1122, Category 9: industrial organisation.

Peppal L., Richards D. J. and Norman G. (2002), "Industrial organization, Contemporary theory and practice", South-Western.

Romer P. (2002), "When Should We Use Intellectual Property Rights?", American Economic Review 92, 2, 213-6.

Ramello G.B. e F. Silva (1999), "Dal vinile a Internet", Edizione Fondazione Giovanni Agnelli, Torino.

Ramello, G.B.(1997), "Copyright e pirateria nel mercato fonografico", L'industria, 18, 2, 317-339.

Schwartz J. (2004), "Recording Industry is Accusing 532 People of Music Piracy", The New York Times, January 21.

Zentner A. (2003), "Measuring the Effect of Online Music Piracy on Music Sales", University of Chicago, working paper.

Web Sites:
International Federation of Phonographic Industries (IFPI): www.ifpi.org
Recording Industry Association of America (RIAA): www.riaa.org