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MUSIC PRODUCT AS A DURABLE GOOD AND ONLINE PIRACY

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Abstract. Music is typical experience good and the formats in which music is available; for example, CDs and cassettes or downloaded files are durable in nature. Using these two typical characteristics of the 'music product', in this paper, we develop an analytical framework to study the economic implications of online music piracy. On one hand, we show that no protection against piracy is never optimal for the legitimate music producer; on the other hand, we show that complete protection against piracy may not always be the best option; the decision on the degree of limiting piracy depends on the extent of the informational value of music downloads, cost of piracy and the quality of the downloaded music and as a result a partial protection can be optimal to the music producer.

1. Introduction

Music is typical experience good. One has to listen to it in order to appreciate (or dislike) it. Secondly, the formats in which music is available, for example CDs and cassettes, or digital music files are durable in nature; meaning if one buys it or downloads it from the internet one time, probably he/she is not required to buy (or download) it in future. Using these two typical characteristics of the 'music product' in this paper, we develop an analytical framework to capture some economic issues of online music piracy.

Online music in the form of digital music files (mostly in MP3 format) has been widespread on the internet. Downloading music files from internet sites, and file sharing systems (pioneered by Napster) have become quite popular among end users and online communities. Most often these activities are illegal resulting in widespread copyright violations.[1] Presently, this form of online music piracy is increasingly becoming dominant (more in developing countries where buying an original music CD is still costly) due to proliferation of the internet. Naturally, to limit the extent of this kind of music piracy, the record companies are making the end users and online communities a potential target for legal prosecution. Some cases of these natures have already been registered; the most famous among them is the lawsuit against Napster.[2]

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[1] Although these days there are legal sites (e.g. Apple's i-Tunes) from where one can download music by paying appropriate price.

[2] Napster came into existence in 1999 as one of the earliest online file-sharing services that allowed users to exchange and share music files freely. It was shut down in 2001 following a

It is true that over the past decade, the proliferation of the internet has offered the recording industry with a potentially low cost distribution channel that can reach out to an unlimited consumer base. However, the internet has also provided an additional domain for copyright infringing activity. With increased penetration of high-speed internet access such as broadband, coupled with sophistication of copying devices that allow individual users to "burn" music CDs at negligible cost, online downloads or sharing music files look set to become the prevailing form of music piracy in this digital age. According to estimates by the IFPI (International Federation of the Phonographic Industry) copyright infringing music files available online total 900 million as of January 2004. In the USA alone an estimated number of 30 to 40 million people download MP3 files.

The above statistics coincide with declining music sales in recent years, implying a possible causal relationship between piracy rates and legitimate demand as asserted by the industry. As such, it appears that enforcing protection is the answer to music piracy. Organizations representing the international recording industry such as the IFPI and Recording Industry Association of America (RIAA) have been active in their fight against piracy through various avenues. While the battle against commercial piracy continues, the music industry has also recognized this growing threat of online piracy. This growing focus on online piracy is evident in its lawsuits against internet file-sharing services or networks in the past few years. In recent months, the recording industry has started to take legal action against individual file-sharers and end users who actively download and distribute music online using peer-to-peer (P2P) technologies such as the popular Kazaa network, a move that is subject to much controversy.

Despite the claims made by the recording industry, empirical research and studies have suggested that the damage inflicted by music piracy may be overstated.[3] The debate is particularly intense in the area of online piracy. Defendants of P2P technologies argue that the predicament of the industry should not be attributed to file-sharing, and that recording companies should adopt technology to their advantage instead of trying to shut down the P2P business and hurting consumer interests. Some argue free music downloads as an excellent marketing tool instead of a threat to the music industry. A research by Pew Internet & American Life Project in 2000 identifies 16% of online music users, or 15 million Americans as "Song Samplers" who listen to music on their computer but do not save them. Although piracy is generally perceived to have an adverse impact on music sales through displacing demand, these findings also suggest a positive informational role of music downloads through providing a means of sampling, which can induce legitimate demand.[4] Music sampling effects generally refer to the positive influences of end-user piracy on demand, through offering consumers a choice to "experience" the product before buying it. The presence of music downloads provide consumers with a low or zero cost means of obtaining information about the product (music).

lawsuit filed against it by Recording Industry Association of America (RIAA). It has since made a comeback as a legitimate online music store offering music downloads to users on a pay-per-download or subscription basis.

[3]For an empirical investigation on this issue see Hui and Png (2003).

[4]Sampling music through downloads is somewhat analogous to listening to the radio, with the added advantage that the consumer can do so at his own will and time. An argument used to explain the success story of Apple i-Tunes where sampling online is legal.

Subsequently, some consumers who sampled the product may be willing to purchase the original, thus increasing the demand for the original firm.[5]

Given this scenario, the objective of this paper is to study the economic implications of online music piracy. We mainly concentrate on end-user internet piracy, where the pirates are either the members of the file sharing online community or the end users who download music from various internet sites. We develop a theoretical model to examine the desirable degree of protection enforcement for the original music producer under this environment. We consider a two-period framework considering the music product as a durable good by taking into account the sampling effect of online music downloads on the consumer utility. The informational externality arises due to sampling, influence legitimate demand by enhancing consumer's utility.[6] In this context, on one hand, we show that no protection against piracy is never optimal for the legitimate music producer; on the other hand, we show that complete protection against piracy may not always be the best option; the decision on the degree of limiting piracy depends on the extent of the informational value of music downloads, cost of piracy and the quality of the downloaded music for which a partial protection may be desirable sometime to the music producer.

In a related research, Peitz and Waelbroeck (2006) also show that file sharing technologies (P2P networks) can improve the matching between products and buyers (hence higher willingness to pay for the original product), and the so called matching effect can dominate the loss in revenue effect to the record companies (labels) arising due to the existence of file sharing by the potential music buyers. As a result label's profits can be higher with file sharing networks (P2P) than without. However, in their study the feature of music product as a durable good is absent. We believe this particular feature is indeed an important characteristic of the music product (or any digital product for that matter), which does influence the economic outcome and should be incorporated in the analytical framework.[7]

The plan of the paper is as follows. In the next section, we set up our basic model. The main analysis is done and results are obtained in section 3. Section 4 concludes with some remarks.

2. The Model

Consider a two-period model and a durable-good monopolist (say, the record company); where the durable good being the music product in the form of CDs and cassettes. The monopolist produces the music product at zero marginal cost[8] and maximizes its profit over two periods.[9] On the demand side, there is a continuum of consumers indexed by X, $X \in [\theta_L, \theta_H]$, where $\theta_H > \theta_L \geq 0$. The value of X

[5]A good survey on these issues can be found in Peitz and Waelbroeck (2004).

[6]As Peitz and Waelbroeck (2004) says this information transformation technology is rather different from traditional ads/promotions, as consumers, not firms, spend time and resources. In a sense, new internet distribution technologies are information-pull technologies and traditional marketing and promotions information-push technologies. See also the work of Duchene and Waelbroeck (2004) on this issue.

[7]In particular, one can show that in our framework without the assumption of durability of the music product, protection against piracy is always optimal for the music producer. This is not necessarily the case, as we will show, under the scenario when the music product is assumed to be durable.

[8]It is important to note that the firm will incur a fixed cost to produce a music product (such as a new record), however, the cost of duplicating the master copy is assumed to be negligible.

[9]In reality the period lengths could be a number of years.

measures a consumer's valuation for the music product, and her willingness to pay for it. Consumers' valuations are uniformly distributed over the interval $[\theta_L, \theta_H]$ and the size of the market is normalized to 1. Consumers arrive in the first period only, living for a total of two periods denoted by t, $t = 1, 2$. As music is an experience good, consumers have imperfect information about the music prior to consuming it. We define quality of music as comprising three components: technical quality, tangible quality such as packaging, and intangible quality like music style or genre. In this model, consumers are fully aware of the technical and tangible qualities of the product; hence, their lack of information is associated with the intangible aspects of music, for example, a consumer will not be sure if he will enjoy the music in a particular CD/cassette until he actually listens to it. This is where music sampling from some other source, like internet, can come to help.

Now initially, due to imperfect information, consumers form expectations regarding the music product, conditional on all available information, such as advertisements and promotions, before making the choice whether to buy the product at price P, or just download the product from the internet, or not consume it at all. Since music is a durable product, consumers buy a maximum of one unit of the original product throughout the two periods, i.e. repeat purchases of originals are ruled out in this model. For simplicity, we also assume that there is no secondary market for the product.[10]

A consumer enjoys a one-period utility of αX from consuming the original product, with $0 < \alpha \leq 1$. This is to take into consideration the fact that the consumer may not like the music as much as he thought he would. If $\alpha = 1$, the purchased music meets up to his expectations. If $\alpha < 1$, the music only partially meets up to his expectation.

On the other hand, the utility derived from consuming a copy by downloading is qX per period.

Assumption 1: We assume $0 \leq q < 1$ and $q < \alpha$.

This is because downloads are imperfect substitutes for originals (e.g. music tracks are usually of inferior quality, some tracks may be even missing).[11] q is also bounded away from 1.[12]

Generally, we can summarize a consumer's one period utility for period t as follows:

$$U = \begin{cases} \alpha X - P_t, \text{ if buys the original at } t \\ qX, \text{ if listens to the downloaded version} \\ 0, \text{ if does not consume the product} \end{cases}$$

In the forthcoming analysis, we consider three scenarios: first, when end-user music piracy is non-existent or deterred through protection efforts; second, when end-user piracy is accommodated in the market and piracy is costless; third, when partial protection is implemented in the form of imposing a cost on end-user internet piracy (arising mainly due to legal prosecution by the record companies or making it technically difficult to copy by putting electronic lock).

[10] In reality also there are not many resale markets for music products.

[11] q can be defined as follows. Write $q = \alpha\theta$, with $0 \leq \theta < 1$, where θ denotes the degree of inferior quality. Thus $q < \alpha$.

[12] See Lemma 1 latter for the exact upper bound of q.

3. Analysis

3.1. **No Piracy (Full Protection).** Consider that the music is protected and there is no piracy. This may be due to the protection efforts of the firm or government, such as through developing effective copy protection technology, stringent monitoring or copyright enforcement laws. For simplicity, we assume that the firm incurs zero protection cost. Therefore, the consumer only has a few consumption choices. In particular, the consumer has three options over the two periods; buy the original product in period 1; buy the original in period 2; or not consume the product at all. Consequently, the firm will face a smaller market (potential customers) in the second period, since consumers who have bought the product in period 1 will not purchase it in period 2. This results in a lower price for the original product in period 2. In our model, the length of period 1 could be few years so that in period 2, generally there is a decline in the price of old products as new products arrive in the market. Therefore, besides choosing whether to buy the product, a consumer also considers when to consume or buy the product, depending on his valuation towards it. A consumer will choose to purchase the original product if his utility derived from buying the product is higher than, or at least equal to, the utility associated with not consuming the product. Accordingly, a consumer's utility function is defined as:

$$U = \begin{cases} 2\alpha X - P_{N,1}, \text{ if buys the original at } t = 1 \\ \alpha X - P_{N,2}, \text{ if buys the original at } t = 2 \\ 0, \text{ if does not consume at all} \end{cases}$$

where the subscript N denotes the case where there is no piracy.

Assumption 2: We assume $\frac{1}{2} \leq \alpha \leq 1$. The consumer would not even consider purchasing the song unless he is fairly sure that the music would be to his liking.

3.1.1. *Analysis.*

The marginal consumer X_1, who is indifferent between buying the original product in the first period and buying it in the second period, is given by:

$$2\alpha X_1 - P_{N,1} = \alpha X_1 - P_{N,2} \qquad \Rightarrow \qquad X_1 = \frac{P_{N,1} - P_{N,2}}{\alpha}$$

With the market size held static, only consumers who choose not to buy the product in the first period may purchase it in the second. The marginal consumer X_2 , who is indifferent between buying the original product in the second period and not consuming the product at all, is given by:

$$\alpha X_2 - P_{N,2} = 0 \qquad \Rightarrow \qquad X_2 = \frac{P_{N,2}}{\alpha}$$

The demand for the original product in period 1, $D_{N,1}$, is:

$$D_{N,1} = \int_{X_1}^{\theta_H} \frac{1}{\theta_H - \theta_L} dx = \frac{\alpha\theta_H - P_{N,1} + P_{N,2}}{\alpha(\theta_H - \theta_L)}$$

The original firm's profit in period 1, $\pi_{N,1}$, is:

$$\pi_{N,1} = P_{N,1} D_{N,1} = P_{N,1} \left(\frac{\alpha\theta_H - P_{N,1} + P_{N,2}}{\alpha(\theta_H - \theta_L)} \right)$$

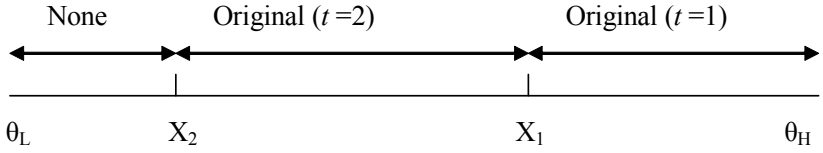

FIGURE 1. Distribution of Consumers (no piracy)

The demand for the original product in period 2, $D_{N,2}$, is:

$$D_{N,2} = \int_{X_2}^{X_1} \frac{1}{\theta_H - \theta_L} dx = \frac{P_{N,1} - 2P_{N,2}}{\alpha(\theta_H - \theta_L)}$$

The firm's profit in period 2, $\pi_{N,2}$, is given by:

$$\pi_{N,2} = P_{N,2} D_{N,2} = P_{N,2} \left(\frac{P_{N,1} - 2P_{N,2}}{\alpha(\theta_H - \theta_L)} \right)$$

We now solve the firm's profit maximization problem using backward induction. In the second period, the firm sets price $P_{N,2}$, such that:

$$\frac{\partial \pi_{N,2}}{\partial P_{N,2}} = \frac{P_{N,1} - 4P_{N,2}}{\alpha(\theta_H - \theta_L)} = 0$$

Solving, we obtain the second period's price as a function of the first-period price:

$$P_{N,2}(P_{N,1}) = \frac{P_{N,1}}{4}$$

Similarly, we express the other variables in terms of $P_{N,1}$ to get:

$$\begin{aligned} D_{N,2}(P_{N,1}) &= \frac{P_{N,1}}{2\alpha(\theta_H - \theta_L)} \\ \pi_{N,2}(P_{N,2}) &= \frac{P_{N,1}^2}{8\alpha(\theta_H - \theta_L)} \\ D_{N,1}(P_{N,1}) &= \frac{4\alpha\theta_H - 3P_{N,1}}{4\alpha(\theta_H - \theta_L)} \\ \pi_{N,1}(P_{N,1}) &= P_{N,1} \left(\frac{4\alpha\theta_H - 3P_{N,1}}{4\alpha(\theta_H - \theta_L)} \right) \end{aligned}$$

The firm sets its profit-maximizing prices based on the total profit for both periods, π_N, which is given by:

$$\begin{aligned} \pi_N(P_{N,1}) &= \pi_{N,1}(P_{N,1}) + \pi_{N,2}(P_{N,2}) \\ &= P_{N,1} \left(\frac{4\alpha\theta_H - 3P_{N,1}}{4\alpha(\theta_H - \theta_L)} \right) + \frac{P_{N,1}^2}{8\alpha(\theta_H - \theta_L)} \end{aligned}$$

Thus, the original producer sets a first-period price that solves:

$$\max_{P_{N,1}} \ \pi_N(P_{N,1})$$

Solving for the profit-maximizing prices, we get:

$$P^*_{N,1} = \frac{4\alpha\theta_H}{5} \quad (1)$$

$$P^*_{N,2} = \frac{\alpha\theta_H}{5} \quad (2)$$

The first and second period demands are:

$$D^*_{N,1} = \frac{2\theta_H}{5(\theta_H - \theta_L)} \quad (3)$$

$$D^*_{N,2} = \frac{2\theta_H}{5(\theta_H - \theta_L)} \quad (4)$$

Total legitimate demand is:

$$D^*_{N,1} + D^*_{N,2} = \frac{4\theta_H}{5(\theta_H - \theta_L)} \quad (5)$$

Hence, the firm's total profit is:

$$\pi^*_N = \frac{2\alpha\theta^2_H}{5(\theta_H - \theta_L)} \quad (6)$$

Observe from equations (1) and (2) that $P^*_{N,1} > P^*_{N,2}$, which is consistent with a typical two-period durable good monopoly.

3.2. **Free Piracy (No Protection).** We now attempt to capture the effects of information externality of music sampling by considering the case of end-user piracy. Here file sharing and downloading from the internet is accommodated and the music firm undertakes zero protection. We also assume that there is no cost for downloading or file sharing, in other words, piracy is costless to the consumers. Now, as piracy is tolerated by the firm, music downloads play an informational role by conveying information regarding the original product to pirating consumers (only) through lower quality copies in the first period. Consumers are given a choice to "experience" the product before buying it. With increased information, some consumers who chose to download in the first period may be more willing to buy the original in the second period, provided that the extra information revealed increases the consumer's benefit of buying an original. Here, the original producer implicitly assumes that those who buy the product in the second period necessarily sampled in the first period.

Assumption 3: If the consumer buys the original in the second period, we assume $\alpha = 1$ at period 2. The consumer has listened to the sample and there is no uncertainty as to whether the music would meet up to his/her expectation.

Hence, the consumer who sampled in the first period and chooses to purchase the original in the second period receives a one period benefit of X from the original and an additional benefit of qX from the sampling of music in the previous period. q also acts as a proxy for the degree of the positive sampling effect on legitimate demand, or the informational value of the sample. If $q = 0$, the demand for music is not affected by the presence of music sampling. Here, we assume that this benefit associated with the ability to "sample" the product before buying it to be homogenous across all consumers, and accrues exclusively to the consumer who samples the product before buying it. The idea of sampling is to learn about certain qualities of the concerned music and takes a decision whether to buy the original

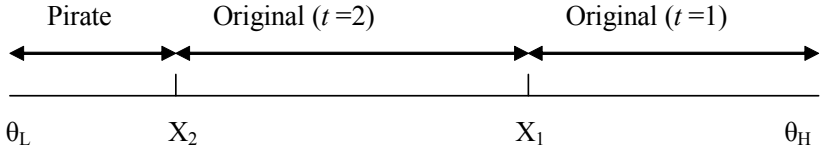

FIGURE 2. Distribution of Consumers (piracy allowed)

product in future or not. A consumer purchases the legitimate product if buying the product provides a higher utility as compared to pirating and not consuming the product.

Now, a consumer's consumption choice over the two periods are: purchase the original in the first period; download the product in the first period and buy the original in the second; listen only the downloaded version in both periods.

A consumer's utility function is thus defined as:

$$U = \begin{cases} 2\alpha X - P_{A,1}, \text{ if buys the original at } t = 1 \\ (1+q)X - P_{A,2}, \text{ if buys the original at } t = 2 \\ 2qX, \text{ if consumes the downloaded product in both periods} \end{cases}$$

Assumption 4: $\alpha \geq \frac{1}{2} + \frac{5q}{8}$.

This assumption guarantees that all the equilibrium prices and demands are positive in the following analysis.[13]

Lemma 1. *The exact upper bound of q is $\frac{4}{5}$.*

Proof. This follows from assumptions 2 and 4. Assumption 4 is $\alpha \geq \frac{1}{2} + \frac{5q}{8}$, while Assumption 2 is $\frac{1}{2} \leq \alpha \leq 1$.Thus we must have $\frac{1}{2} + \frac{5q}{8} \leq 1$, that is $\frac{5q}{8} \leq \frac{1}{2}$, or $q \leq \frac{4}{5}$. □

From Lemma 1, the values that q can take are $0 \leq q \leq \frac{4}{5} < 1$. Now, from Assumption 4, we see that as q goes from 0 to $\frac{4}{5}$, α goes from $\frac{1}{2}$ to 1 monotonically. This covers the whole range of completely and thus justifies Assumption 4 as well.

3.2.1. *Analysis.* The marginal consumer X_1, who is indifferent between buying the original in the first period and buying it in the second period, is given by:

$$2\alpha X_1 - P_{A,1} = (1+q)X_1 - P_{A,2} \quad \Rightarrow \quad X_1 = \frac{P_{A,1} - P_{A,2}}{2\alpha - 1 - q}$$

The marginal consumer X_2, who is indifferent between buying the original in the second period (i.e. downloading the track in period one) and consuming the downloaded version in both periods, is given by:

$$(1+q)X_2 - P_{A,2} = 2qX_2 \quad \Rightarrow \quad X_2 = \frac{P_{A,2}}{1-q}$$

[13]Actually it is sufficient that $\alpha > \frac{3}{8} + \frac{5q}{8}$ for all equilibrium prices and demands to be positive. $\alpha \geq \frac{1}{2} + \frac{5q}{8}$ is a bit stronger as $\frac{1}{2} > \frac{3}{8}$. See Lemma 1 for the reason why the stronger assumption is used.

The demand for the original product in period 1, $D_{A,1}$, is:

$$D_{A,1} = \int_{X_1}^{\theta_H} \frac{1}{\theta_H - \theta_L} dx = \frac{\theta_H(2\alpha - 1 - q) - (P_{A,1} - P_{A,2})}{(2\alpha - 1 - q)(\theta_H - \theta_L)}$$

The firm's profit in the first period, $\pi_{A,1}$, is:

$$\pi_{A,1} = P_{A,1} D_{A,1} = P_{A,1} \left(\frac{\theta_H(2\alpha - 1 - q) - (P_{A,1} - P_{A,2})}{(2\alpha - 1 - q)(\theta_H - \theta_L)} \right)$$

Similarly, the original firm's demand and profit in period 2 are given by:

$$\begin{aligned} D_{A,2} &= \int_{X_2}^{X_1} \frac{1}{\theta_H - \theta_L} dx = \frac{P_{A,1}(1-q) + P_{A,2}(q-\alpha)}{(2\alpha - 1 - q)(1-q)(\theta_H - \theta_L)} \\ \pi_{A,2} &= P_{A,2} D_{A,2} = P_{A,2} \left(\frac{P_{A,1}(1-q) + P_{A,2}(q-\alpha)}{(2\alpha - 1 - q)(1-q)(\theta_H - \theta_L)} \right) \end{aligned}$$

Maximizing $\pi_{A,2}$ with respect to $P_{A,2}$, we obtain the following:

$$\begin{aligned} P_{A,2}(P_{A,1}) &= \frac{(1-q)P_{A,1}}{4(\alpha - q)} \\ D_{A,2}(P_{A,1}) &= \frac{P_{A,1}}{2(2\alpha - 1 - q)(\theta_H - \theta_L)} \\ \pi_{A,2}(P_{A,1}) &= \frac{(1-q)P_{A,1}^2}{8(\alpha - q)(2\alpha - 1 - q)(\theta_H - \theta_L)} \\ D_{A,1}(P_{A,1}) &= \frac{4\theta_H(\alpha - q)(2\alpha - 1 - q) - P_{A,1}^2(4\alpha - 3q - 1)}{4(\alpha - q)(2\alpha - 1 - q)(\theta_H - \theta_L)} \\ \pi_{A,1}(P_{A,1}) &= P_{A,1} \left(\frac{4\theta_H(\alpha - q)(2\alpha - 1 - q) - P_{A,1}^2(4\alpha - 3q - 1)}{4(\alpha - q)(2\alpha - 1 - q)(\theta_H - \theta_L)} \right) \end{aligned}$$

The firm's total profit is thus:

$$\begin{aligned} \pi_A(P_{A,1}) &= \frac{(1-q)P_{A,1}^2}{8(\alpha - q)(2\alpha - 1 - q)(\theta_H - \theta_L)} \\ &\quad + P_{A,1} \left(\frac{4\theta_H(\alpha - q)(2\alpha - 1 - q) - P_{A,1}^2(4\alpha - 3q - 1)}{4(\alpha - q)(2\alpha - 1 - q)(\theta_H - \theta_L)} \right) \end{aligned}$$

Solving for the profit-maximizing prices, we get:

$$P_{A,1}^* = \frac{4\theta_H(\alpha - q)(2\alpha - 1 - q)}{8\alpha - 5q - 3} \tag{7}$$

$$P_{A,2}^* = \frac{\theta_H(1-q)(2\alpha - 1 - q)}{8\alpha - 5q - 3} \tag{8}$$

The respective demands for the original product are:

$$D_{A,1}^* = \frac{2\theta_H(2\alpha - 1 - q)}{(8\alpha - 5q - 3)(\theta_H - \theta_L)} \tag{9}$$

$$D_{A,2}^* = \frac{2\theta_H(\alpha - q)}{(8\alpha - 5q - 3)(\theta_H - \theta_L)} \tag{10}$$

Total demand for the original product is thus:

$$D_A^* = D_{A,1}^* + D_{A,2}^* = \frac{2\theta_H(3\alpha - 2q - 1)}{(8\alpha - 5q - 3)(\theta_H - \theta_L)} \tag{11}$$

The firm's total profit is:

$$\pi_A^* = \frac{2\theta_H^2(\alpha - q)(2\alpha - 1 - q)}{(8\alpha - 5q - 3)(\theta_H - \theta_L)} \tag{12}$$

Proposition 1. *Free piracy in time period 1 increases legitimate demand for the music producer in time period 2, and thus* $D_{A,2}^* \geq D_{A,1}^*$.

Proof. Directly from equations (9) and (10), to prove the propostion we need to check if $2\alpha - 1 - q \leq \alpha - q$. Simple manipulations reveal that this is equivalent to $\alpha \leq 1$, which is consistent with Assumption 2. □

This result is interesting since it is contrary to the usual result obtained for a durable good monopolist, where demand usually falls in subsequent periods as it is well known from the Coase Conjecture. Here the demand enhancement in the subsequent period (i.e. in period 2) as an effect of sampling music in the previous period does take place. Thus the impact of music sampling here mitigates the Coasean effect to some extent. However, $P_{A,1}^* > P_{A,2}^*$.[14] Thus, the net effect of sampling on the producers' surplus is ambiguous.

3.3. **Costly Piracy (Partial Protection).** We now consider the third case where partial protection (in the form of fines and lawsuits or simply an embedded electronic lock) is enforced such that consumers who pirate the product will incur a cost c, for every product he/she pirates. c can also be interpreted as the expected cost i.e. the probability of getting caught multiplied by the fine. In the absence lawsuits and monitoring, this cost can also be interpreted as the opportunity cost of time, since searching for a particular music in the internet can be time consuming.

Here, a consumer has four consumption choices over the two periods: buy the original product in the first period; download the product in the first period and buy the original in the second; download it in the first period and consume the pirated product in both periods; and not consume the product at all in any period. A consumer's utility function is defined as follows:

$$U = \begin{cases} 2\alpha X - P_{C,1}, \text{ if buys the original at } t = 1 \\ (1+q)X - c - P_{C,2}, \text{ if buys the original at } t = 2 \\ 2qX - c, \text{ if consumes the downloaded product in both periods}^{15} \\ 0, \text{ if does not consume the product at all} \end{cases}$$

Assumption 5: We assume $0 < c < P_{C,1}$. Otherwise, the net utility from downloading and not buying at all is always dominated by the net utility of buying the original product in period 1 since $q < \alpha$.[16]

[14] This is proved in Appendix A.

[16] We also acknowledge that an alternative analysis can be done under the assumption $c > P_{C,1}$.

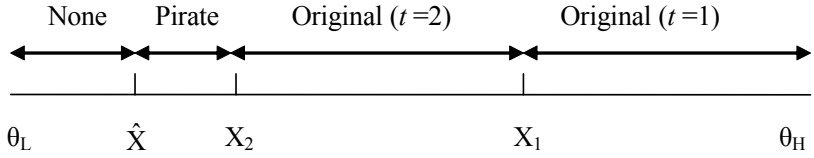

FIGURE 3. Distribution of Consumers (piracy is costly)

An analysis similar to the above gives us the following. The prices for the original products in period 1 and 2 are:

$$P^*_{C,1} = \frac{4\theta_H(2\alpha-1-q)(\alpha-q)+2(2\alpha-1-q)c}{4(\alpha-q)(8\alpha-5q-3)} \tag{13}$$

$$P^*_{C,2} = \frac{(1-q)(4\theta_H(2\alpha-1-q)(\alpha-q)-(4\alpha-1-3q)c)}{4(\alpha-q)(8\alpha-5q-3)} \tag{14}$$

From (13) and (14), we observe that $P^*_{C,1} > P^*_{C,2}$.

The demands for the original product in the two periods are, respectively:

$$D^*_{C,1} = \frac{8\theta_H(2\alpha-1-q)^2(\alpha-q)+(4\alpha-1-3q)^2c}{4(2\alpha-1-q)(\alpha-q)(8\alpha-5q-3)(\theta_H-\theta_L)} \tag{15}$$

$$D^*_{C,2} = \frac{4\theta_H(2\alpha-1-q)(\alpha-q)-(4\alpha-1-3q)c}{2(2\alpha-1-q)(8\alpha-5q-3)(\theta_H-\theta_L)} \tag{16}$$

The total demand for the original product is thus:

$$D^*_C = D^*_{C,1} + D^*_{C,2} = \frac{8\theta_H(3\alpha-1-2q)(\alpha-q)+(4\alpha-1-3q)c}{4(\alpha-q)(8\alpha-5q-3)(\theta_H-\theta_L)} \tag{17}$$

The firm's total profit is:

$$\pi^*_C = \frac{16\theta_H(2\alpha-1-q)^2(\alpha-q)\left[(\alpha-q)\theta_H+c\right]+(4\alpha-1-3q)c^2}{8(\alpha-q)(2\alpha-1-q)(8\alpha-5q-3)(\theta_H-\theta_L)} \tag{18}$$

From these equations, it is easy to see the following:

Proposition 2. *(i) $P^*_{C,1}$ and $D^*_{C,1}$ are increasing in c; $P^*_{C,2}$ and $D^*_{C,2}$ are decreasing in c.(ii) D^*_C is increasing in c; π^*_C is increasing in c.*

Intuitively, as the cost of piracy increases, the demand for downloads in period 1 will fall, while the demand for originals in the same period rises. Since first-period samplers form the only source of demand in period 2, it follows that an increase in c indirectly results in a lower demand in the second period, through reducing the number of pirates in the first. However, it is interesting to note that, in aggregate, total demand and profit are increasing in c.

3.4. **The Optimal Policy of the Music Producer.** Now we are ready to compare the profits of the music producer under the three possible scenarios.

Proposition 3. *Allowing free piracy is never optimal to the original music producer.*

Proof. A detailed proof of the fact that $\pi^*_C \geq \pi^*_A$ and $\pi^*_N \geq \pi^*_A$ is given in Appendix B. □

Although allowing free piracy boosts the second period demand because more people sample in period 1, this effect is secondary as there is a significant fall in demand and prices of the good in period 1 due to free piracy. This direct effect dominates the secondary effect and as a result allowing free piracy is never optimal.

Proposition 4. *(i) Full protection is optimal to the original music producer when the cost of piracy is low. (ii) Partial protection is optimal to the original music when the cost of piracy is relatively high.*

Proof. See Appendix B. □

When the cost of piracy is low there will be a lot piracy in period 1, which results in a significant fall in demand and prices of the good in period 1. Thus, in this situation full protection will be optimal for the monopolist. Whereas when the cost of piracy is high, the monopolist does not have to bother about a large amount of piracy in period 1 as this would not happen anyway. If some piracy happens that will actually help in boosting the demand in period 2 to a certain extent as a result of the sampling effect. So the monopolist would find it profitable to employ partial protection in period 1 rather than full protection where no positive sampling effect on demand in period 2 can take place. When piracy takes place in a limited manner (as opposed to large scale) in period 1 then the positive effect on demand in period 2 dominates the negative effect of revenue loss of the monopolist.

4. Conclusion

In this two-period model of music piracy, we model the music product as a durable good and introduce the feature of informational externality, or the positive effects of internet piracy on the legitimate demand. We find that allowing no protection is never optimal for the legitimate music producer. Some form of protection, partial or full, is always desirable to the music producer in an environment where piracy is not costless. The optimal policy for the music producer depends critically on the informational value of music downloads, the cost of piracy and the quality of the downloaded music. We also emphasize that the aspect of durability of the music product also play an important role.

Although internet piracy displaces some legitimate demand, it also facilitates sampling, which reveals valuable information regarding the nature of the original product. This in turn produces positive influences on legitimate demand in the second period. Thus the impact of music sampling here mitigates the Coasean effect to some extent. Music is a typical experience good: consumers need information on the characteristics of new songs before making their purchasing decisions. Thus to examine the net effects of internet piracy on the original firm's profitability both the negative and positive impacts have to be evaluated.

Our analysis of online music sampling can be extended in several areas. Firstly, we have not factored in the costs of enforcing tight DRM (Digital Rights Management) and the feasibility of such measures. In reality, firms do incur costs and the expenditure on such technological protection may require a sizeable investment. Furthermore, a difficulty in developing technical protection solutions is that consumer devices must be easy to use. Otherwise, it is possible that consumers will just choose not to purchase the CD at all. In addition, getting significant content protection machinery with uniform standards would require a coordinated effort.

Even then, no technological protection is impossible to break. The lawsuits filed by the recording industry will also waste a lot of resources.

Secondly, we have been looking at the interests of only the consumers and that of the recording industry. We can also look at the effects of sampling on the artists, especially those up-and-coming artists. The traditional way for the recording industry to provide information on music products is through promotion and advertisement, which involves large fixed costs so that only a handful of artists (with a large potential audience) are profitable to market. With the internet, independent new artists who are not so well known now have a low-cost method of distributing and promoting their music. They can provide sample tracks online and consumers can listen to them for free. And if the consumers actually like it, they can then download the whole track at an affordable rate. Thus sampling can actually stimulate the public's interest in music. In fact, if this effect is taken into consideration, then we have argued that the producers need not lose out under sampling. Online sampling need not be viewed as a form of competition. The recording industry can view it as just as another channel through which music downloads can be promoted. And instead of limiting themselves to selling CDs through record stores, downloads can also be sold on music sites, like Apple's i-Tunes. By embracing online distribution, it is not necessarily the case that the traditional market will be threatened to a large extent. It is possible that many music fans (especially the younger ones) would prefer to download legal digital music files and have their own personal 'record collections'. However, there are also many people, including online music consumers, who still prefer CDs for their packaging and the complementary material that comes with it such as a printed booklet (with lyrics, pictures, song and artist information) and CD case. Furthermore, sampling can act as an alternative source of information transmission, saving a lot on promotion and marketing. Thus, the recording industry should use consumer-friendly DRM instead which allow flexible usage and allow online music sampling and capture the benefits associated with it.

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Appendix A.

Equations (7) and (8) are

$$P^*_{A,1} = \frac{4\theta_H(\alpha - q)(2\alpha - 1 - q)}{8\alpha - 5q - 3} \tag{19}$$

$$P^*_{A,2} = \frac{\theta_H(1 - q)(2\alpha - 1 - q)}{8\alpha - 5q - 3} \tag{20}$$

To show that $P^*_{A,1} > P^*_{A,2}$ we need to check that $4(\alpha - q) > (1 - q)$. Manipulating, this is equivalent to $\alpha \geq \frac{1}{4} + \frac{3q}{4}$, which is consistent with Assumption 4, $\alpha \geq \frac{1}{2} + \frac{5q}{8}$.

Appendix B.

Proof of Proposition 3.

From (12) and (18), after simplification, we can show that $\pi_C^* \geq \pi_A^* \Leftrightarrow 16(2\alpha - 1 - q)^2(\alpha - q)\theta_H c + (4\alpha - 3q - 1)^2 c^2 > 0$, which is always true.

Secondly, comparing (6) and (12), again after some simplification, we can show that $\pi_N^* \geq \pi_A^*$ is equivalent to $(1-\alpha)(5q-2\alpha) - 5q(\alpha - q) \leq 0$. Define $(1-\alpha)(5q - 2\alpha) - 5q(\alpha - q) \equiv f(q)$, so that we need to show that $f(q) \leq 0$ for all relevant α and q. Notice that $f(q)$ is convex, i.e. $f''(q) > 0$, and $f(0) < 0$. The lower bound for q is 0, and from Assumption 4 the upper bound for q is $\frac{8}{5}\left(\alpha - \frac{1}{2}\right)$. It is simple to check that $f\left(\frac{8}{5}\left(\alpha - \frac{1}{2}\right)\right) < 0$ for all $\alpha \in \left[\frac{1}{2}, 1\right]$. Thus, the convexity of f now implies that $f(q) < 0$ over the relevant range of values of α and q. Hence $\pi_N^* \geq \pi_A^*$.

Proof of Proposition 4.

We need to compare π_N^* and π_C^*. Note that π_N^* is independent of c, while in proposition 2 it was noted that π_C^* is increasing in c. Thus, to prove that $\pi_N^* > \pi_C^*$ for small values of c while the opposite holds for large values of c, we first calculate π_C^* assuming $c = 0$. Substituting $c = 0$ into equation (18) and simplifying, we find that π_C^* takes the value $\frac{2\theta_H^2(\alpha-q)(2\alpha-1-q)}{(8\alpha-5q-3)(\theta_H-\theta_L)}$ when $c = 0$. Compare this with the value of π_N^* given in equation (6); $\frac{2\theta_H^2\alpha}{5(\theta_H-\theta_L)}$. The former is smaller than the latter if $\frac{(\alpha-q)(2\alpha-1-q)}{(8\alpha-5q-3)} < \frac{\alpha}{5}$, which with little effort reduces to the requirement that $2\alpha(\alpha - 1) < 5q(2\alpha - 1 - q)$. But, since $\alpha < 1$, the left-hand-side is negative, while by assumption the right-hand-side is positive. Thus the requirement is met, and so we know that $\pi_N^* > \pi_C^*$ when $c = 0$.

Finally, since π_C^* is increasing and convex in c, while π_N^* is independent of c, there must exist a sufficiently large value of c for which $\pi_N^* < \pi_C^*$. In short, there exists a c^* such that $c > c^*$ implies $\pi_C^* > \pi_N^*$ and $c < c^*$ implies $\pi_C^* < \pi_N^*$.

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