How Do Pirated Recordings Affect the Profits of Record Companies?

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Abstract

The emergence of pirated recordings may harm creators and record companies because consumers may buy fewer original recordings. However, as we show in this paper, this negative effect may be overcompensated by a positive effect due to a peripheral commodity: consumers who buy pirated recordings may be more likely to go to the concerts by recordings artists. The primary objective of this paper is to investigate related issues by introducing revenue of peripheral commodity and the existence of pirated product. We demonstrate that the presence of piracy may reduce the revenues of creators and record companies, but pirated products can increase the number of consumers who buy a peripheral commodity. We compare the negative impact of piracy on the original product and the positive impact of piracy on the peripheral commodity, showing that the latter effect dominates former effect and that piracy will lead to higher profit. In addition, we consider the impact of the quality of pirated recordings on the revenue of record companies. We find that when piracy occurs; first, stricter government enforcement will both increase sales and profits of the original record company, and also reduce the pirated recordings sales. Second, higher quality of pirated recordings will increase profits of the record company.

Keywords: Pirated Recordings; Pirated Quality; Profits; Government Enforcement

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I. Introduction

The major portion of the music industry income is from record sales and concert revenues, but this is affected by piracy, which is a rapidly growing phenomenon. Industry representatives largely attribute the recent drop in music sales to a rise in piracy since piracy reduces sales on the original recording market. But, they did not consider the potential revenue from piracy. Our argument goes that when consumers buy pirated recordings they can make more informed purchasing decisions of peripheral commodities, and so the record companies may actually receive some benefit from piracy. In this paper, we formalize this argument.

Pirated recordings appear indeed to harm the creators and record companies because consumers will buy fewer original recordings. However, greater circulation of recording allows more consumers to find out information on the music and may draw more consumers to go to concerts. We present a simple monopoly model which takes piracy into consideration. We first discuss the impacts of piracy on market competition, output and price of the original product. We then investigate the effect of piracy that may attract more consumers to buy a peripheral commodity (concert tickets). We will compare the negative impact of piracy on sales of original recordings and the positive impact of piracy on the peripheral commodity. We show that the latter effect dominates former effect and that piracy will lead to increased profit.

Assume that pirates can enter/exit the market freely. As long as piracy exists, positive profit and the activity of piracy will continue. We also believe that it is not likely that the original recordings and pirated recordings have the same quality; indeed, it is quite often the case that pirated recordings are inferior to the original recordings. This paper shows that an improvement of pirated quality will increase profits of the record companies.

Related literature

The past literature related to piracy can be summarized as follows. Earlier studies on piracy such as Novos and Waldman (1984), Johnson (1985), Liebowitz (1985) and Besen and Kirby (1989) focus on photocopying. These papers show that even if consumer preferences for journals and books do not exhibit network externalities, publishers may still have higher profits when photocopying of originals is allowed. A growing theoretical literature analyzes end-user copying, as presented in the survey by Peitz and Waelbroeck (2006a). In this literature, the general result is that a free copy may lead to lower firm profits since some consumers use the free copy as a substitute for the original. But in the context of computer software, it has then been shown that the result no longer necessarily holds if there are network effects. Conner and Rumelt (1991), Takeyama (1994), and Shy and Thisse (1999) conclude that when the product has a positive network externality, the existence of counterfeit products can have positive effects on both profit of the firm of the original product and consumer surplus. Peitz and Waelbroeck (2006b) show that the music industry may gain from free downloading, consumers are willing to pay more because the match between product characteristics and buyers' tastes is improved. In China, Russia or India, the number of P2P users was growing and music sales significantly grow up (Table 1. Sandulli (2007)).

The primary objective of this paper is to investigate related issues by introducing revenue from peripheral commodities and the existence of pirated recordings. We demonstrate that emergence of piracy may reduce the revenues of creators and record companies, but pirated product can increase purchases of peripheral commodities. We compare the negative impact of piracy on original recording with the positive impact of piracy on peripheral commodities, showing that the latter effect dominates former effect and that piracy will lead to increased profit. In addition, we will

consider the impact of the quality of pirated recordings on revenue of record companies.

The remainder of this paper is organized as follows. A vertical differentiation model is established in Section 2 to discuss consumer behavior and market demand. We first discuss the pricing policy for original firm without piracy. In Section 3, we investigate the behavior of both consumers and the original firm after piracy has emerged. Section 4 shows the effect of piracy on peripheral commodities and the effect of pirated price on profit of the original firm. Section 5 provides overall conclusions.

II. Basic Model

Market without piracy

(1) Revenue from sales of recordings:

We first describe the assumptions on the demand side in our model and discuss consumer behavior. In this section we analyze the case when an original firm monopolizes the record market in the absence of piracy and faces consumers who have different preferences for product quality. Assume that there is a continuum of consumer preference for product quality, which is indexed by θ, where $\theta \in [\underline{\theta}, \bar{\theta}]$. Here θ is assumed to follow a uniform distribution and each consumer can buy at most one unit of the product. We normalize the quality of the original product as 1. Under the above assumptions, a consumer has the following preferences:

$$U(\theta) = \begin{cases} \theta - p_m, & \text{if buying the original recording} \\ 0, & \text{if buying nothing} \end{cases} \tag{1}$$

where U should be thought of as the surplus derived from the consumption of the good.

The utility is separable in taste and price, where θ is the consumer's evaluation on the product, and P_m is the original recording price charged by the monopolist.

Let θ_m be the marginal consumer who is indifferent between buying the original recording and not buying. That is $U(\theta_m) = \theta_m - P_m = 0$, i.e., $\theta_m = P_m$. Therefore, we have the market demand faced by the monopolist as

$$D_m(P_m) = \bar{\theta} - P_m. \tag{2}$$

Assume the monopolist's unit cost of producing the recording to be c. Then the monopolist's profit π_m equals to $(P_m - c)D_m$. We find that the first-order condition of profit maximization for the original firm is

$$\frac{\partial \pi_m}{\partial P_m} = \bar{\theta} - 2P_m + c = 0. \tag{3}$$

From (3), the original record's optimal price is

$$P_m^o = \frac{\bar{\theta} + c}{2}. \tag{4}$$

The superscript "*o*" represents the variable of the original firm without piracy in the market. Other results following from (4) are

$$\theta_m = \frac{\bar{\theta} + c}{2}, \tag{5}$$

$$D_{m1}^o = \bar{\theta} - \frac{\bar{\theta} + c}{2} = \frac{\bar{\theta} - c}{2} < \frac{\bar{\theta}}{2}, \tag{6}$$

$$\pi_{m1}^o = (P_m - c) \times D_m = \frac{(\bar{\theta} - c)^2}{4}. \tag{7}$$

Note $D_{m1}^o < \bar{\theta}/2$ means that the amount of sales under monopoly will not be more than half of the number of consumers.

(2) Revenue from a peripheral commodity (revenue for the concert ticket sales)

We assume that the market for a peripheral commodity (concert) is monopolist and α percent of the consumers who buy original recordings will go to the concert, i.e. consumers would not go to the concert if they did not buy a recording. For

simplicity, assume ticket price $P = P_m$, total cost of the concert $TC = cD_{m2}$, and preference of concert is θ. The net utility of a consumer who goes to the concert is

$$U(\theta) = \begin{cases} \theta - p_m, & \text{if consumers go to the concert} \\ 0, & \text{if consumers don't go to the concert} \end{cases} \tag{8}$$

Therefore, we can obtain the demand for the concert as

$$D_{m2} = \alpha D_{m1}^{o} = \alpha(\frac{\bar{\theta} - c}{2}). \tag{9}$$

The profit of the concert is

$$\pi_{m2} = \alpha(P_m - c)D_{m1}^{o} = \alpha\frac{(\bar{\theta} - c)^2}{4}. \tag{10}$$

So we have total revenue for the record company equal to the revenue of recording sales plus revenue for the concert ticket sales:

$$\pi_1 = \pi_{m1} + \pi_{m2} = \frac{(1+\alpha)(\bar{\theta} + c)^2}{4}. \tag{11}$$

III. Market with piracy

(1) Revenue from recording sales:

In the previous section we considered the original firm without piracy in the market. This section goes one step further in investigating how piracy will affect the original firm when the original firm faces competition from piracy of its product. We assume that pirates can freely enter the market with no barrier and there exists no nonnegative pirated profit. Assume that the pirated recording's unit cost is b, and the market price of a pirated recording is a. Since pirates are at risk of being caught by the government, let ϕ represent the probability of being caught. That is, the probability that pirated recordings can be sold successfully in the market is $1-\phi$. The equilibrium of free entry requires that every pirate's expected revenue is equal to its unit cost, i.e., $(1-\phi)a = b$ or $a = b/(1-\phi)$. We know that the pirated price

increases with the probability ϕ that pirates are caught, i.e. government enforcement level ϕ will directly affect the pirated price a.

In the presence of pirated recordings, the net utility of consumer θ can be expressed as:

$$U(\theta)=\begin{cases}\theta-p_m, & \text{if buying the original recording}\\ q\theta-a, & \text{if buying pirated recording}\\ 0, & \text{if buying nothing}\end{cases} \tag{12}$$

Where q stands for the quality of the pirated recording, which is worse than the original one, i.e., $0<q<1$. From (8), the marginal consumer θ_c who is indifferent between buying the original recording and buying the pirated recording should satisfy the condition, $\theta_c - P_m = q\theta_c - a$. That is,

$$\theta_c = \frac{P_m - a}{1-q}. \tag{13}$$

Moreover, marginal consumer θ_x who is indifferent between buying the pirated recording and not buying will satisfy the condition $q\theta_x - a = 0$. That is,

$$\theta_x = \frac{a}{q}. \tag{14}$$

From (14), the marginal consumer θ_x is not affected by the price of the original. That is, when pirates appear in the market, total sales of the original and pirated recordings are constant, $\overline{\theta} - \theta_x = \overline{\theta} - a/q \equiv \overline{D}$.

From (13) and (14), the demands for the original recording and the pirated recording are respectively

$$D_m^c = \overline{\theta} - \theta_c = \frac{(1-q)\overline{\theta} - P_m + a}{1-q}, \tag{15}$$

$$D_c = \theta_c - \theta_x = \frac{qP_m - a}{q(1-q)}. \tag{16}$$

Figure 1 illustrates how piracy affects the demand faced by the original firm. The demand curve of the original without piracy, D_m, will shift to D_m^c when piracy

emerges. MR_m and MR_m^c are the corresponding marginal revenue curves of D_m and D_m^c.

From (16), piracy may occur ($D_c > 0$) if $qp_m - a > 0$. That is, piracy will appear when the quality of the pirated recording, q, is not too low or the market price of the pirated recording, a, is not too high. Therefore, as pirates enter the market, the demand curve faced by the original firm will rotate from D_m to D_m^c. In Figure 1, line AB shows the demand curve for original firm when piracy emerges in the market. The condition that pirates exist is $p_m > a/q$. Notice that if sales of the original product exceed $\overline{D}$, no pirates could emerge and the demand curve will remain as D_m. As a result, the original demand curve is kinked.[1]

When piracy occurs in the market, the profit function for the original firm is $\pi_m^c = (P_m - c)D_m^c = (P_m - c)(\overline{\theta} - \frac{P_m - a}{1-q})$ and each pirate has no excess expected profit due to free entry. Therefore, when piracy emerges in the market, the first order condition of profit-maximization for original firm is

$$\frac{\partial \pi_m^c}{\partial P_m} = \overline{\theta} - \frac{2P_m - a - c}{1-q} = 0, \tag{17}$$

From (17), the optimal price of original product under piracy is

$$P_m^c = \frac{(1-q)\overline{\theta} + a + c}{2}. \tag{18}$$

By (16), the situation of pirated recordings, $qP_m - a > 0$, can be rewritten as $q[(1-q)\overline{\theta} + c]/(2-q) \equiv \overline{a}$, and thus $\overline{a}$ is the highest possible price of pirated recordings. In any case of $a > \overline{a}$, pirates will exit the market. In addition, since government enforcement level ϕ will affect the pirated price a directly, the corresponding possible highest ϕ is $\overline{\phi} = 1 - b(2-q)/q[(1-q)\overline{\theta} + c]$ as $a = \overline{a}$. That

[1] For further details, refer to Tsai (2008).

is, piracy will not occur when the government enforcement level is higher than $\bar{\phi}$.

Following (18), we can also obtain the marginal consumer θ_c, sales of the original product D_m^c, profit of the original firm π_m^c, and sales of the pirated recordings D_c as follows:

$$\theta_c = \frac{(1-q)\bar{\theta} - a + c}{2(1-q)} > 0, \tag{19}$$

$$D_m^c = \frac{(1-q)\bar{\theta} + a - c}{2(1-q)}, \tag{20}$$

$$\pi_{m1}^c = (P_m^c - c)D_m^c = \frac{\left[(1-q)\bar{\theta} + (a-c)\right]^2}{4(1-q)}, \tag{21}$$

$$D_c = \frac{q\left[(1-q)\bar{\theta} + c\right] + (q-2)a}{2q(1-q)}. \tag{22}$$

From (20), (21) and (22), note that a higher price of pirated recording "a" will raise both sales and profit of the original firm, and lower the pirated recordings sales. Hence, if the government strengthens enforcement against piracy, the sales and profit of the original will increase.

(2) Revenue from a peripheral commodity (revenue for the concert ticket sales)

We assume that there α percent of the consumers who buy original recordings will go to the concert, and $\beta(q) = zq$ percent of the consumers who buy pirated recordings will go to the concert. This shows that percent of consumers who buy pirated recordings then go to a concert increases with the quality of pirated recordings. For simplicity, assume ticket price $P = P_m$, total cost of the concert $TC = c[\alpha D_{m1}^c + \beta D_c]$, and preference of the concert is θ. The net utility of consumer who goes to the concert is

$$U(\theta)=\begin{cases}\theta-p_m, & \text{if consumers go to the concert}\\ \\ 0, & \text{if consumers don't go to the concert}\end{cases} \tag{8a}$$

We can obtain the demand of the consumers who buy pirated recordings and then go to the concert as

$$D_{c2}=\beta D_c=zq\left\{\frac{q[(1-q)\bar{\theta}+c]+(q-2)a}{2q(1-q)}\right\}. \tag{23}$$

The profit from the concert is

$$\begin{aligned}\pi_{m2}^{c}&=(P_m-c)\left[\alpha D_{m1}^{c}+\beta D_c\right]\\ &=\left\{\alpha\left[\frac{(1-q)\bar{\theta}+(a-c)}{2(1-q)}\right]+zq\left[\frac{q\left[(1-q)\bar{\theta}+c\right]+(q-2)a}{2q(1-q)}\right]\right\}(\frac{\bar{\theta}-c}{2}).\end{aligned} \tag{24}$$

So we have total revenue for the record company equal to the revenue of recording sales plus the revenue for the concert ticket sales:

$$\begin{aligned}\pi_2=\pi_{m1}^{c}+\pi_{m2}^{c}&=\frac{\left[(1-q)\bar{\theta}+(a-c)\right]^2}{4(1-q)}\\ &+\left\{\alpha\left[\frac{(1-q)\bar{\theta}+(a-c)}{2(1-q)}\right]+zq\left[\frac{q\left[(1-q)\bar{\theta}+c\right]+(q-2)a}{2q(1-q)}\right]\right\}(\frac{\bar{\theta}-c}{2}).\end{aligned} \tag{25}$$

Comparing (18) with (4), we get

$$p_m^c-p_m^o=\frac{-q\bar{\theta}+a}{2}<0. \tag{26}$$

Equation (26) indicates that the original product price will be lower than that under monopoly when piracy emerges. The result is similar to the findings in the previous literature.

The difference between original recording sales in the market with and without piracy is

$$D_m^c-D_m^o=\frac{a-qc}{2(1-q)}>0. \tag{27}$$

Equation (27) indicates that the emergence of piracy will increase the original sales. This is because pirated quality is an endogenous variable.[2] We therefore obtain the following proposition.

***Proposition* 1: The emergence of piracy will increase the original recording sales.**

IV. Differential market price of the pirated recordings to the profit of the record company

(1). If the price of pirated recordings is the upper bound that allows the pirated recordings to exist in the market, as $a = \bar{a}$ (i.e. when the government enforcement level is the upper bound that allows the pirated recordings to exist in the market, as $\phi = \bar{\phi}$),

$$a = \bar{a} = \frac{q\left[(1-q)\bar{\theta} + c\right]}{2-q} = \frac{b}{(1-\bar{\phi})}. \tag{28}$$

Then the total profit of the record company with piracy in the market is

$$\pi_2\Big|_{a=\bar{a}} = \pi_{m1}^c + \pi_{m2}^c = \pi_{m1}^c + \pi_{m21}^c + \pi_{m22}^c$$

$$= \frac{\left[(1-q)\bar{\theta} + (\bar{a}-c)\right]^2}{4(1-q)} + \alpha\left[\frac{(1-q)\bar{\theta} + (\bar{a}-c)}{2(1-q)}\right]\left(\frac{\bar{\theta}-c}{2}\right) + zq\left[\frac{q\left[(1-q)\bar{\theta}+c\right] + (q-2)\bar{a}}{2q(1-q)}\right]\left(\frac{\bar{\theta}-c}{2}\right). \tag{29}$$

The total profit of the record company without piracy in the market is

$$\pi_1 = \pi_{m1} + \pi_{m2} = \frac{(\bar{\theta}-c)^2}{4} + \alpha\frac{(\bar{\theta}-c)^2}{4}. \tag{30}$$

Comparing (29) with (30) yields

$$\pi_2\Big|_{a=\bar{a}} - \pi_1 = (\pi_{m1}^c - \pi_{m1}) + (\pi_{m21}^c - \pi_{m2}) + \pi_{m22}^c. \tag{31}$$

The first term in the brace on the right-hand side of (31) indicates that the

[2] The proof is given in Appendix A. Here we only discuss the case of $a > qc$. For $a > (<)qc$, please refer to Tsai (2008, p.1-18).

recordings revenue of the record company with piracy in the market will be a loss. Equation (32) from Tsai (2008), and the profit of the original firm will be lower due to piracy.

$$(\pi_{m1}^{c}\Big|_{a=\bar{a}}-\pi_{m1})=\frac{\left[(1-q)\bar{\theta}+(\bar{a}-c)\right]^2}{4(1-q)}-\frac{(\bar{\theta}-c)^2}{4}=\frac{-q^2(\bar{\theta}-c)^2}{4(2-q)^2}<0. \quad (32)$$

The second term in the brace on the right-hand side of (31) indicates that the concert revenue of the record company with piracy in the market will increase. The main reason is that recording sales of the record company with piracy in the market increase, which will attract more consumers to go to the concert.

$$(\pi_{m21}^{c}\Big|_{a=\bar{a}}-\pi_{m2})=\alpha\left[\frac{(1-q)\bar{\theta}+(\bar{a}-c)}{2(1-q)}\right](\frac{\bar{\theta}-c}{2})-\alpha(\frac{\bar{\theta}-c}{2})^2=\frac{\alpha q(\bar{\theta}-c)^2}{4(2-q)}>0. \quad (33)$$

The third term on the right-hand side of (31) indicates that the pirated price $\bar{a}$ is too high. In this situation, consumers who go to the concert show their utility is higher, so they will not buy pirated recordings. The concert revenue that comes from consumers who have bought pirated recordings is zero.

$$\pi_{m22}^{c}\Big|_{a=\bar{a}}=zq\left[\frac{q\left[(1-q)\bar{\theta}+c\right]+(q-2)\bar{a}}{2q(1-q)}\right](\frac{\bar{\theta}-c}{2})=0. \quad (34)$$

The following result was obtained:

$$\pi_2\Big|_{a=\bar{a}}-\pi_1=\frac{-q^2(\bar{\theta}-c)^2}{4(2-q)^2}+\frac{\alpha q(\bar{\theta}-c)^2}{4(2-q)}=\frac{q(\bar{\theta}-c)^2}{4(2-q)}\left[\alpha-\frac{q}{(2-q)}\right]. \quad (35)$$

The sign of (35) is undetermined, and it is positive (negative) if $\alpha>(<)q/(2-q)$. Comparing (35) with (32), we find that Equation (35) takes into account the effect of peripheral commodity, so the profit of the original firm will be ambiguous. We therefore obtain the following proposition.

***Proposition 2*: Given quality (q), when the percentage (α) of consumers who buy original recordings and then go to a concert is higher, it implies**

that the total profit of the record company with piracy in the market is larger than the total profit of the record company without piracy in the market $\pi_2\big|_{a=\bar{a}} > \pi_1$.

***Proposition 3*: Given the percentage** (α) **of consumers who buy original recordings and then go to a concert, if** $q > (<) 2\alpha/(1+\alpha)$**, it implies that the total profit of the record company with piracy in the market is lower (larger) than the total profit of the record company without piracy in the market** $\pi_2\big|_{a=\bar{a}} < \pi_1$**,** $(\pi_2\big|_{a=\bar{a}} > \pi_1)$.

As mentioned above, we know that when the government enforcement level is the upper bound that allows pirated recordings to exist in the market, if the quality of the pirated recordings is higher it will lower the profit of original firm. This result is in accord with intuition, if the quality of the pirated recordings is higher then it will make more consumers buy the pirated recordings.

(2). If the price of pirated recordings is lower than the upper bound that allows pirated recordings to exist in the market, as $a < \bar{a}$ (i.e. when the government enforcement level is lower than the upper bound that allows pirated recordings to exist in the market, as $\phi < \bar{\phi}$), the total profit of the record company with piracy in the market is:

$$\pi_2 = \frac{\left[(1-q)\bar{\theta} + (a-c)\right]^2}{4(1-q)} + \alpha\left[\frac{(1-q)\bar{\theta} + (a-c)}{2(1-q)}\right]\left(\frac{\bar{\theta}-c}{2}\right) + zq\left[\frac{q\left[(1-q)\bar{\theta}+c\right] + (q-2)a}{2q(1-q)}\right]\left(\frac{\bar{\theta}-c}{2}\right). \tag{36}$$

The total profit of the record company without piracy in the market is:

$$\pi_1 = \pi_{m1} + \pi_{m2} = \frac{(\bar{\theta}-c)^2}{4} + \alpha\frac{(\bar{\theta}-c)^2}{4}. \tag{37}$$

Comparing (36) with (37) yields

$$\pi_2 - \pi_1 = (\pi_{m1}^c - \pi_{m1}) + (\pi_{m21}^c - \pi_{m2}) + \pi_{m22}^c. \tag{38}$$

The first term in the brace on the right-hand side of (38) indicates that the

recordings revenue of the record company with piracy in the market may be larger (smaller) than that without piracy,

$$(\pi_{m1}^{c} - \pi_{m1}) = \frac{\left[-q\bar{\theta}^2 + qc^2 + 2a(\bar{\theta} - c) + a^2 - 2q\bar{\theta}a + q^2\bar{\theta}^2\right]}{4(1-q)} \gtrless 0 . \quad (39)$$

Let a^* satisfy $(-q\bar{\theta}^2 + qc^2 + 2a(\bar{\theta} - c) + a^2 - 2q\bar{\theta}a + q^2\bar{\theta}^2 = 0)$. That is,

$$a^* = -(\bar{\theta} - c - q\bar{\theta}) \pm \sqrt{(\bar{\theta} - c - q\bar{\theta})^2 + q(\bar{\theta}^2 - c^2 - q\bar{\theta}^2)} . \quad (40)$$

We take $a^* = -(\bar{\theta} - c - q\bar{\theta}) + \sqrt{(\bar{\theta} - c - q\bar{\theta})^2 + q(\bar{\theta}^2 - c^2 - q\bar{\theta}^2)} = \frac{b}{1-\phi^*} > 0$, the market price of the pirated recordings is positive.

(a). When $a > a^* (\phi > \phi^*)$, i.e., $\pi_{m1}^{c} - \pi_{m1} > 0$, the recordings revenue of the record company with piracy in the market will increase.

(b). When $a = a^* (\phi = \phi^*)$, i.e., $\pi_{m1}^{c} - \pi_{m1} = 0$, the recordings revenue of the record company with piracy in the market will not change.

(c). When $a < a^* (\phi < \phi^*)$, i.e., $\pi_{m1}^{c} - \pi_{m1} < 0$, the recordings revenue of the record company with piracy in the market will decrease.

The second term in the brace on the right-hand side of (38) indicates that the concert revenue of the record company with piracy in the market will be increasing. The main reason is that recordings sales of the record company with piracy in the market increase, which will attract more consumers to go to the concert.

$$(\pi_{m21}^{c} - \pi_{m2}) = \frac{\alpha(\bar{\theta} - c)(a - qc)}{4(1-q)} > 0 . \quad (41)$$

The third term on the right-hand side of (38) indicates that the concert revenue of the record company with piracy in the market will increase. The concert revenue that comes from consumers who buy pirated recordings.

$$\pi_{m22}^{c} = \frac{z(\bar{\theta}-c)}{4(1-q)}\left[q\left[(1-q)\bar{\theta}+c\right]+(q-2)a\right] > 0\,. \qquad (42)$$

It follows from what has been said that if $a \geq a^{*}$, then $\pi_2 > \pi_1$, so the recordings and concert revenue of the record company with piracy in the market will increase. When $a < a^{*}$, then the recordings revenue of the record company with piracy in the market will decrease, but the concert revenue of the record company with piracy in the market will increase. Thus, we must compare π_1 and π_2. It can be further discussed as follows.

$$\pi_2 - \pi_1 = \frac{\left[(1-q)\bar{\theta}+(a-c)\right]^2}{4(1-q)} - \frac{(\bar{\theta}-c)^2}{4} + \frac{\alpha(\bar{\theta}-c)(a-qc)}{4(1-q)} + \frac{z(\bar{\theta}-c)}{4(1-q)}\left[q\left[(1-q)\bar{\theta}+c\right]+(q-2)a\right]$$

$$= \underbrace{\frac{1}{4(1-q)}\left[-q\bar{\theta}^2 + qc^2 + 2a(\bar{\theta}-c) + a^2 - 2q\bar{\theta}a + q^2\bar{\theta}^2\right]}_{-}$$

$$+ \underbrace{\frac{(\bar{\theta}-c)}{4(1-q)}\left[\alpha(a-qc) + zq\left[(1-q)\bar{\theta}+c\right] + z(q-2)a\right]}_{+}. \qquad (43)$$

Let a^{**} satisfy

$$\left[-q\bar{\theta}^2 + qc^2 + 2a(\bar{\theta}-c) + a^2 - 2q\bar{\theta}a + q^2\bar{\theta}^2\right]$$

$$+ (\bar{\theta}-c)\left[\alpha(a-qc) + zq\left[(1-q)\bar{\theta}+c\right] + z(q-2)a\right] = 0 \quad \text{i.e.,} \quad \pi_2 - \pi_1 = 0\,. \qquad (44)$$

We can obtain the expression of a^{**} as

$$a^{**} = \frac{1}{2}\left\{-\left[(2-2q+\alpha+zq-2z)\bar{\theta} - (2+\alpha+zq-2z)c\right] \pm \left[\left[(2-2q+\alpha+zq-2z)\bar{\theta} - (2+\alpha+zq-2z)c\right]^2\right.\right.$$

$$\left.\left. - 4\left[(z-1)q\bar{\theta}^2 + (1+\alpha-z)qc^2 + (1-z)q^2\bar{\theta}^2 + (zq-\alpha)q\bar{\theta}c\right]\right]^{1/2}\right\}. \qquad (45)$$

We take a^{**} that is positive.

$$a^{**} = \frac{1}{2}\left\{-\left[(2-2q+\alpha+zq-2z)\bar{\theta} - (2+\alpha+zq-2z)c\right] + \left[\left[(2-2q+\alpha+zq-2z)\bar{\theta} - (2+\alpha+zq-2z)c\right]^2\right.\right.$$

$$\left.\left. - 4\left[(z-1)q\bar{\theta}^2 + (1+\alpha-z)qc^2 + (1-z)q^2\bar{\theta}^2 + (zq-\alpha)q\bar{\theta}c\right]\right]^{1/2}\right\} = \frac{b}{1-\phi^{**}} \qquad (46)$$

We first explain the case of market price of the pirated recordings.

(a). When $a^{**} < a < a^{*}$ ($\phi^{**} < \phi < \phi^{*}$), i.e., $\pi_2 - \pi_1 > 0$, this indicates that the

recordings revenue of the record company with piracy in the market is a loss, but the loss can be overcompensated because the concert revenue increases for the record company with piracy in the market. The total revenue of the record company still increases.

(b). When $a = a^{**}$ ($\phi = \phi^{**}$), i.e., $\pi_2 - \pi_1 = 0$. This indicates that the recordings revenue of the record company with piracy in the market is a loss, but the loss is just overcompensated by the concert revenue of the record company with piracy in the market increase. The total revenue of the record company does not change.

(c). When $a < a^{**}$ ($\phi < \phi^{**}$), i.e., $\pi_2 - \pi_1 < 0$. This indicates that the recordings revenue of the record company with piracy in the market is a loss, but the loss can not be overcompensated by the concert revenue of the record company with piracy in the market increase. Thus, total revenue of the record company decreases. As mentioned above, we have:

***Proposition 4*: When the government enforcement level is lower than the upper bound that allows pirated recordings to exist in the market, a higher pirated price (stricter government enforcement) will increase profit of the record company**.

To sum up, the market price of the pirated recordings (government enforcement) will affect the total revenue of the record company. That is, total revenue of the record company will increase with the market price of the pirated recordings (a) (government enforcement (ϕ)).

Differential the quality of pirated recordings to the profit of the record company

Next we turn to the case of the quality of pirated recordings. We rearrange (43) as

$$\pi_2 - \pi_1 = \frac{1}{4(1-q)}\left[-\bar{\theta}^2 q + c^2 q + 2a(\bar{\theta}-c) + a^2 - 2a\bar{\theta}q + \bar{\theta}^2 q^2\right]$$
$$+\frac{(\bar{\theta}-c)}{4(1-q)}\left[\alpha(a-cq) + zq\left[(1-q)\bar{\theta}+c\right] + za(q-2)\right]. \qquad (43a)$$

Let q^* satisfy

$$\left[-\bar{\theta}^2 q + c^2 q + 2a(\bar{\theta}-c) + a^2 - 2a\bar{\theta}q + \bar{\theta}^2 q^2\right]$$
$$+(\bar{\theta}-c)\left[\alpha(a-cq) + zq\left[(1-q)\bar{\theta}+c\right] + za(q-2)\right] = 0, \text{ i.e., } \pi_2 - \pi_1 = 0. \qquad (47)$$

We can obtain the expression of q^* as

$$q^* = \left\{2\left[(1-z)\bar{\theta}^2 + zc\bar{\theta}\right]\right\}^{-1}\left\{-\left[(z-1)(\bar{\theta}^2 - c^2) - \alpha c(\bar{\theta}-c) + (z-2)a\bar{\theta} - zac\right]\right.$$
$$\left.\pm\left\{\left[(z-1)(\bar{\theta}^2 - c^2) - \alpha c(\bar{\theta}-c) + (z-2)a\bar{\theta} - zac\right]^2 - 4\left[(1-z)\bar{\theta}^2 + zc\bar{\theta}\right]\left[(2a+\alpha-2za)(\bar{\theta}-c) + a^2\right]\right\}^{1/2}\right\}$$

(48)

We take q^* that is positive ($0 < q < 1$).

$$q^* = \left\{2\left[(1-z)\bar{\theta}^2 + zc\bar{\theta}\right]\right\}^{-1}\left\{-\left[(z-1)(\bar{\theta}^2 - c^2) - \alpha c(\bar{\theta}-c) + (z-2)a\bar{\theta} - zac\right]\right.$$
$$\left.+\left\{\left[(z-1)(\bar{\theta}^2 - c^2) - \alpha c(\bar{\theta}-c) + (z-2)a\bar{\theta} - zac\right]^2 - 4\left[(1-z)\bar{\theta}^2 + zc\bar{\theta}\right]\left[(2a+\alpha-2za)(\bar{\theta}-c) + a^2\right]\right\}^{1/2}\right\}$$

(48a)

(a). When $q > q^*$, i.e., $\pi_2 - \pi_1 > 0$. This indicates that when the quality of pirated recordings is higher, then total revenue of the record company will increase.

(b). When $q = q^*$, i.e., $\pi_2 - \pi_1 = 0$. This indicates that when the quality of pirated recordings is equal to q^* then the total revenue of the record company does not change.

(c). When $q < q^*$, i.e., $\pi_2 - \pi_1 < 0$. This indicates that when the quality of pirated recordings is lower, then the total revenue of the record company will decrease.

From the above, we immediately have: a higher pirated quality will increase profits of the record company. As pirated quality is an endogenous variable, we can

find that $\frac{\partial q^e}{\partial c} > 0$, i.e. the original album packaging is more attractive or there are value-added goods in it. Thus the cost of original recording will increase, and this causes pirated manufacturers to upgrade the pirated quality.[3] We get:

***Proposition 5*: When the government enforcement level is lower the upper bound that allows pirated recordings to exist in the market, a higher pirated quality will increase profits of the record company**.

These results lead to the interesting conclusion that if the quality of the pirated recordings is higher, then it will increase the profit of original firm. This result contradicts intuition, since the negative effect of pirated recordings may be overcompensated by a positive effect due to peripheral commodity.

Figure 2 illustrates the relationships between the $(\pi_2 - \pi_1)$ and ϕ, q as described in ***Proposition*** 3, 4 and 5. In Figure 2 points $\mathrm{A}, \mathrm{B}, \mathrm{C}, \mathrm{A}', \mathrm{A}''$ occur when the government enforcement level is lower than the upper bound that allows pirated recordings to exist in the market, as $\phi < \bar{\phi}$. A indicates that $a = a^{**}(\phi = \phi^{**})$, i.e. $\pi_2 - \pi_1 = 0$. This states that the recordings revenue of the record company with piracy in the market is a loss, but the loss is overcompensated by the increased concert revenue of the record company with piracy in the market. Total revenue of the record company does not change. (Point A states that when the quality of pirated recordings equals q^*, then the total revenue of the record company does not change.) B indicates that $a^{**} < a < a^*(\phi^{**} < \phi < \phi^*)$, i.e., $\pi_2 - \pi_1 > 0$. This states that the recordings revenue of the record company with piracy in the market is a loss, but the loss can be overcompensated by the increased concert revenue of the record company with piracy in the market. The total revenue of the record company is increased. C indicates that $a < a^{**}(\phi < \phi^{**})$, i.e., $\pi_2 - \pi_1 < 0$. This states that the recordings

[3] The proof is given in Appendix B.

revenue of the record company with piracy in the market is a loss, but the loss can not be overcompensated by the increased concert revenue of the record company with piracy in the market. The total revenue of the record company decreases. A' indicates that $q > q^*$, i.e., $\pi_2 - \pi_1 > 0$. This states that when the quality of pirated recordings is higher, then the total revenue of the record company will increase. A'' indicates that $q < q^*$, i.e., $\pi_2 - \pi_1 < 0$. This states that when the quality of pirated recordings is lower, then the total revenue of the record company will decrease.

Points D, E, F occur when the government enforcement level is at the upper bound that allows pirated recordings to exist in the market, $\phi = \bar{\phi}$. D indicates that $q < \frac{2\alpha}{1+\alpha}$, i.e., $\pi_2\big|_{a=\bar{a}} - \pi_1 > 0$. This states that quality of pirated recordings is lower but the total revenue of the record company will increase. E indicates that $q = \frac{2\alpha}{1+\alpha}$, i.e., $\pi_2\big|_{a=\bar{a}} - \pi_1 = 0$. This states that when the quality of pirated recordings equals $\frac{2\alpha}{1+\alpha}$ then the total revenue of the record company does not change. F indicates that $q > \frac{2\alpha}{1+\alpha}$, i.e., $\pi_2\big|_{a=\bar{a}} - \pi_1 < 0$. This states that when the quality of pirated recordings is higher but the total revenue of the record company will decrease.

V. Conclusion

By constructing a piracy model with peripheral commodity market, this paper considers conditions when pirated recordings emerge, and how this will affect profits of the record company. Our main findings are as follows. First, a higher pirated price will increase both sales and profits of the original firm, and reduce the pirated recording sales. Second, if the price of pirated recordings is at the upper bound that allows pirated recordings to exist in the market, as $a = \bar{a}$ (i.e. when the government enforcement level is the upper bound that allows pirated recordings to exist in the

market, $\phi = \bar{\phi}$), then higher pirated quality will reduce the profit of original firm. Third, if the price of pirated recordings is lower the upper bound that allows pirated recordings to exist in the market, as $a < \bar{a}$ (i.e. when the government enforcement level is lower than the upper bound that allows pirated recordings to exist in the market, $\phi < \bar{\phi}$), then a higher pirated quality will increase profit of the record company. If the original firm knows that it can make the original album packaging more attractive or there are value-added goods in it, then the cost of original recording will increase and this will lead pirated manufacturers to upgrade the pirated quality, so the original firm can increase its profit.

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Appendix A: The Proof of Proposition 1

When piracy occurs in the market, the profit function for the pirated firm is

$$\pi_c = (a-b)D_c = (a-b)\frac{q[(1-q)\bar{\theta}+c]+(q-2)a}{2(1-q)q}.$$

Pirated firms choose pirated quality (q) to maximize $\pi_c = (a-b)D_c$, and the first order condition of profit-maximization for pirated firm is

$$\frac{\partial \pi_c}{\partial q} = \frac{(a-b)}{2}\left\{\frac{[(\bar{\theta}+c)-2q\bar{\theta}+a](q-q^2)-\left[q(1-q)\bar{\theta}+c\right]+(q-2)a\right](1-2q)}{(q-q^2)}\right\} = 0,$$

$$(a+c)q^2 - 4aq + 2a = 0.$$

We get

$$q^e = \frac{2a \pm \sqrt{2a^2-2ac}}{(a+c)}.$$

Root must be greater than zero

$$2a^2 > 2ac \qquad \therefore a > c.$$

$$\because\ 0 < q < 1 \ \text{ and } \ 2a > a + c.$$

So we take $2a - \sqrt{2a^2-2ac}$, then we get

$$q^e = \frac{2a - \sqrt{2a^2-2ac}}{(a+c)}.$$

Appendix B: As pirated quality is an endogenous variable

Suppose that pirated firm choose pirated quality (q^e) to maximize its profit. We find that q^e is a function of a and c, let us differentiate q^e with respect to c and obtain

$$\frac{\partial q^e}{\partial c} = \frac{6ac}{2(a+c)^2\sqrt{2a^2-2ac}} > 0.$$

It shows that the original album packaging is more attractive or there are value-added goods in it, then the cost of original recording will increase and this will lead pirated manufacturers to upgrade the pirated quality.

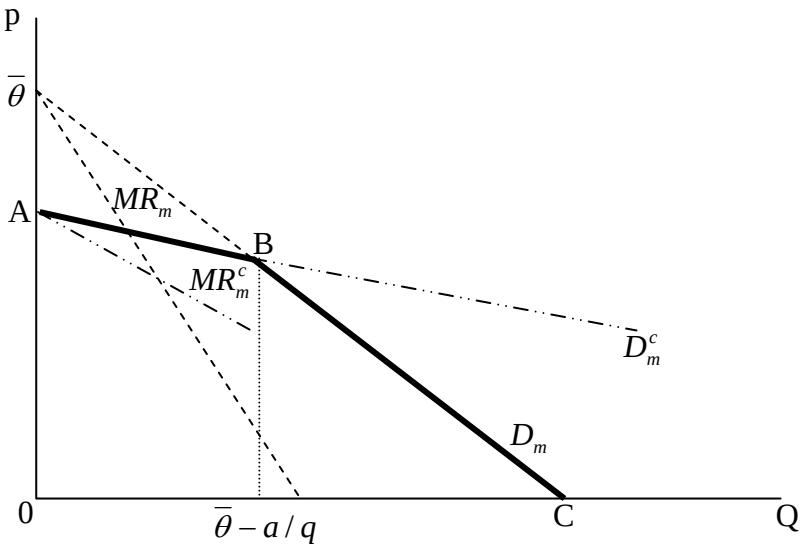

Figure 1. Demand for original product

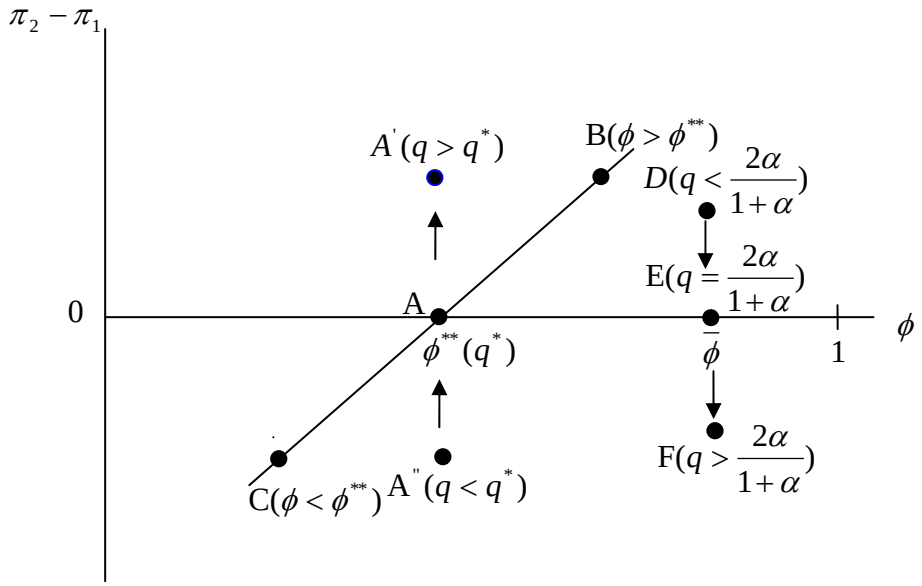

Figure 2. The relationships between $(\pi_2 - \pi_1)$ and $\phi,\ q$

Table 1

The evolution of CD sales in the world

Rank	Country	Yearly sales in millions USD			Proportion of P2P worldwide users (2003)
		2002	2003	2004	
1	USA	803.3	746	767	55.4%
2	Japan	228.9	205.8	201.3	0.7%
3	UK	N/A	167.2	174.6	5.4%
4	Germany	179.4	146.8	146.6	10.2%
5	France	130.4	117.9	106.4	7.8%
6	Mexico	51.1	53.5	53.2	0.3%
7	Canada	57.0	53.1	54.8	8.0%
8	Brazil	N/A	52.4	51.5	N/A
9	Spain	N/A	42.4	34	1.1%
10	Australia	N/A	41.6	39.5	0.91%
11	Italy	36.8	36.2	33.1	1.7%
12	* China	23.3	34.3	52	N/A
13	* Russia	18.2	30.3	58	N/A
14	Netherlands	27.9	24.6	23.2	1.0%
15	Sweden	N/A	19.1	16.6	0.7%
16	Switzerland	N/A	18.6	18.2	0.6%
17	South Korea	21.4	15.6	11.5	0.2%
18	* India	8.6	15.3	26.2	N/A
19	Taiwan	9.7	15.1	14.9	N/A
20	Belgium	N/A	13	15.6	0.8%

Source: Sandulli (2007)