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PROFITABLE PIRACY IN MUSIC INDUSTRIES

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Abstract. This paper considers how optimal copyright enforcement is affected by the development of those media industries promoting musicians. Accounting for situations in both developing and developed countries, we point out two cases, a strictly convex and a strictly concave profit function with respect to the level of copyright enforcement. In the first case a copyright holder prefers a minimal level of enforcement under immature media industries, and a maximal level of enforcement under mature ones. This means that optimal copyright enforcement switches from minimum to maximum along with the development of media industries. In the second case, optimal copyright enforcement gradually increases concomitant with the development of media industries. If there are various levels of singers, a conflict regarding optimal copyright enforcement among them is more sever in a convex case than in a concave one.

1. Introduction

In most developing countries, copyright infringement is problematic with almost no enforcement.[1] From the standpoint of developed countries, such a situation appears to damage copyright holders as well as consumers by resulting in less content. Policymakers in developed countries consider strict copyright enforcement to be beneficial for developing countries, as well as for themselves, by preventing their content being illegally supplied to developing countries.

Domon and Nakamura (2007)[2] did field work on this problem for three years in Vietnam, which joined the WTO in 2007. Domon and Nakamura conclude that, as far as domestic music copyright holders are concerned, copyright infringement did not damage but rather increased their profits. Although a few top singers complained of pirated CDs and DVDs, most singers felt that piracy brought people to their performances as a main source of their earnings, that is, piracy played a role as a form of promotion. Behind such a phenomenon, we must consider the situation of media industries in developing countries. Unlike developed countries with their

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[1]See Business Software Alliance (2007).

[2]See Domon and Nakamura (2007) concerning the situtation of piracy in Vietnam. They explain how piracy played a role in promotion and that P2P was unpopular.

many radio and TV programs, musicians in developing countries, like Vietnam, have very little mass media on which to broadcast their content. Even concerning the Internet, since the penetration rate is less than 10%, due to the relatively high cost of using the Internet or buying a personal computer, the number of consumers who could obtain information about musicians from the Internet is fairly small.[3]

Whether piracy plays a role in promotions or not depends on the number of media, including the Internet, that musicians and copyright holders have available to them. If there are numerous opportunities for them to be introduced through mass media or the Internet, pirated goods are then unnecessary. This suggests that in the process of development of media industries there is a critical point above which piracy does not play a role in promotion. This explains why most musicians in Vietnam need pirated CDs and DVDs, and why they support almost no enforcement, while those in developed countries tend to support strict enforcement.

This paper considers optimal copyright enforcement along with the development of media industries. We indicate two types of process: a switch and continuous increase. In the first case a copyright holder prefers a minimal level of enforcement under immature media industries, and a maximal level under mature ones. This means that optimal copyright enforcement switches from minimum to maximum along with the development of media industries. This is caused by convexity of the profit function with respect to copyright enforcement. In the second case, optimal copyright enforcement gradually increases concomitant with development of media industries. This is caused by concavity of the profit function with respect to enforcement. If there are various levels of singers, a conflict about optimal copyright enforcement among them is more serious in the first case than in the second one. We also obtain the necessary conditions for maximizing economic welfare.

Many authors have considered copyright infringement and piracy, especially, after digital content[4] was in the marketplace. Even before the digital era, whenever a new copy technologies, such as photocopies and VCRs, were invented, controversies about copyright infringement took place and researchers analyzed the effect of such phenomenon.[5] However, such considerations focused on the situation in developed countries. Few researchers considered copyright infringement in developing countries, perhaps because they thought that there was little difference in factors between developed and developing countries, or perhaps they neglected developing countries because they thought the impact on copyright holders was small. Therefore, our theoretical consideration is unique.

[3]For example, GDP per capita in Vietnam in 2007 was about $800 USD.
[4]See Domon and Yamazaki (2004), Domon (2006) and Liebowitz (2006) for considerations of the characteristics of digital information.
[5]See Gordon (1982), Novos and Waldman (1984), Johnson (1985), Liebowitz (1985), and Landes and Posner (2003) for papers concerning copying of analog information.

Our consideration proceeds as follows: In Section 2, we set up a model. In Section 3, we obtain a market equilibrium, and show the effect of copyright enforcement on the profit function. In Section 4, we obtain a private optimal copyright enforcement under convex and concave profit functions and show the differences in enforcement under those functions. In Section 5, we also consider a Vietnam-type situation. In Section 6, we consider a socially optimal copyright enforcement. In the final section, we extend our discussion and discuss remaining problems.

2. The Model

We consider a market in which a copyright holder (a singer)[6] competes with pirates. A singer has two profit sources, a stage performance and a CD sale. Profits from a stage performance and a CD sale positively affect each other, since people can learn about singers through stage performances and vice-versa.

The profit function of a singer is

$$\pi = \pi^1 + \pi^2 = \left[p^1(q^1, q^2, q^3, M)q^1 - C^1(q^1)\right] + \left[p^2(q^1, q^2, q^3, M)q^2 - C^2(q^2)\right] \quad (1)$$

where π^1 and π^2 are, respectively, profits from performance and from original CD sales. p^1, q^1 and C^1 are respectively a price, a quantity, and a cost function of the performance. p^2, q^2 and C^2 are respectively a price, a quantity, and a cost function of an original CD. q^3 and M, where $\underline{M} \leq M \leq \overline{M}$, are respectively the quantity of a pirated CD and the level of media industries. $\underline{M}$ is the level of media industries in developing countries, and $\overline{M}$ is that in developed countries. We need assumptions in order to consider the maximum of the profit function. π is assumed to be strictly concave in q^1 and in q^2. C^1 and C^2 are both assumed to be strictly convex. Concerning external effects, we assume

$$\frac{\partial p^1}{\partial q^2} > 0, \ \frac{\partial p^1}{\partial q^3} > 0, \ \frac{\partial p^1}{\partial M} > 0, \ \frac{\partial p^2}{\partial q^1} > 0, \text{ and } \frac{\partial p^2}{\partial M} > 0 \quad (2)$$

Finally, we assume that in the market for CDs, a singer competes with pirates, that is, $\frac{\partial p^2}{\partial q^3} < 0$.

A pirate's profit function is

$$\pi^3 = p^3(p^1, p^2, M)q^3 - C^3(q^3, E) \quad (3)$$

where p^3 and C^3 are respectively the price and the cost function of an illegal CD, and E (where $0 \leq E \leq \overline{E}$) is the level of copyright enforcement.[7] We assume that C^3 is strictly increasing and convex in q^3. We also assume that π^3 is strictly

[6]Unlike developed countries, most singers in Vietnam manage to release CDs by themselves. Copyright is held not by recording companies but by the singers themselves. A contract between a singer and a composer is done by a lump-sum payment before releasing a CD.

[7]More exactly, we do not need the maximal level of enforcement, $\overline{E}$, for our analysis. However it is convenient for our graphical analysis to use this notation.

concave with respect to q^3, that $\frac{\partial p^3}{\partial q^1} > 0$, $\frac{\partial p^3}{\partial q^2} < 0$, and that

$$\frac{\partial p^3}{\partial M} > 0,\ \frac{\partial C^3}{\partial E} > 0,\ \text{and}\ \frac{\partial^2 C^3}{\partial q^3 \partial E} > 0 \tag{4}$$

We assume that a singer is a monopolist in the markets for an original CD and in the performance market,[8] while a pirate faces perfect competition in the pirated CD market. To simplify notation, a pirate is a representative firm[9] whose level of production stands for the market supply of pirated CDs. Since a pirate must obtain an original CD to produce a pirated one, the timing of this game is as follows: a singer first determines q^1 and q^2, and then a pirate determines q^3.

3. Equilibrium

To solve this game, we first obtain the best-response of a pirate to the original producer's strategies. The first-order condition for maximizing π^3 given q^1 and q^2 is

$$p^3(q^1, q^2, M) = \frac{\partial C^3(q^3, E)}{\partial q^3} \tag{5}$$

We denote the best-response as $\widetilde{q}^3(q^1, q^2, E, M)$. From (4) it is apparent that $\frac{\partial \widetilde{q}^3}{\partial M} > 0$ and $\frac{\partial \widetilde{q}^3}{\partial E} < 0$.

Taking into account this response, a singer maximizes the following function

$$\widetilde{\pi} = \left[p^1(q^1, q^2, \widetilde{q}^3, M)q^1 - C^1(q^1)\right] + \left[p^2(q^1, q^2, \widetilde{q}^3, M)q^2 - C^2(q^2)\right] \tag{6}$$

where of course $\widetilde{q}^3$ is given by $\widetilde{q}^3(q^1, q^2, E, M)$. The first-order conditions are

$$\frac{\partial \widetilde{\pi}}{\partial q^1} = \left(\frac{\partial p^1}{\partial q^1} + \frac{\partial p^1}{\partial \widetilde{q}^3}\frac{\partial \widetilde{q}^3}{\partial q^1}\right) q^1 + p^1 + \left(\frac{\partial p^2}{\partial q^1} + \frac{\partial p^2}{\partial \widetilde{q}^3}\frac{\partial \widetilde{q}^3}{\partial q^1}\right) q^2 - \frac{dC^1}{dq^1} = 0 \tag{7}$$

$$\frac{\partial \widetilde{\pi}}{\partial q^2} = \left(\frac{\partial p^1}{\partial q^2} + \frac{\partial p^1}{\partial \widetilde{q}^3}\frac{\partial \widetilde{q}^3}{\partial q^2}\right) q^1 + p^2 + \left(\frac{\partial p^2}{\partial q^2} + \frac{\partial p^2}{\partial \widetilde{q}^3}\frac{\partial \widetilde{q}^3}{\partial q^2}\right) q^2 - \frac{dC^2}{dq^2} = 0 \tag{8}$$

A solution for this maximizing problem is denoted as $q^{1*}(E, M)$ and $q^{2*}(E, M)$, and $\widetilde{q}^3(q^1, q^2, E, M)$ becomes $q^{3*}(q^{1*}, q^{2*}, E, M)$. We denote a singer's profit at this equilibrium as $\pi^*(E, M)$.

Our objective is to check the impact of E on the equilibrium in order to consider the optimal copyright enforcement for a singer. From the total differential of (7) and (8) under $dM = 0$, we obtain

$$D\begin{bmatrix} dq^1 \\ dq^2 \end{bmatrix} = \begin{bmatrix} -\frac{\partial^2 \pi^*}{\partial q^1 \partial E} dE \\ -\frac{\partial^2 \pi^*}{\partial q^2 \partial E} dE \end{bmatrix} \quad \text{where} \quad D = \begin{bmatrix} \frac{\partial^2 \pi^*}{\partial (q^1)^2} & \frac{\partial^2 \pi^*}{\partial q^1 \partial q^2} \\ \frac{\partial^2 \pi^*}{\partial q^1 \partial q^2} & \frac{\partial^2 \pi^*}{\partial (q^2)^2} \end{bmatrix} \tag{9}$$

[8]Substitutability caused by a CD price change is smaller than that in other goods, for example, between coffee and tea. When people buy CDs of their favorite singers, they are not likely to buy a CD of another singer when the price of their favorite CD is high. Their decision is whether to buy or not.

[9]Even if we assume n firms to express perfect competition, the results derived are the same as under the assumption of a representative firm.

From the second order condition, we know that the determinant of D, denoted by $|D|$, is strictly positive. Therefore

$$\frac{dq^{1*}}{dE} = \frac{1}{|D|}\left[-\frac{\partial^2\pi^*}{\partial q^1 \partial E}\frac{\partial^2\pi^*}{\partial (q^2)^2} + \frac{\partial^2\pi^*}{\partial q^1 \partial q^2}\frac{\partial^2\pi^*}{\partial q^2 \partial E}\right] \tag{10}$$

$$\frac{dq^{2*}}{dE} = \frac{1}{|D|}\left[-\frac{\partial^2\pi^*}{\partial q^2 \partial E}\frac{\partial^2\pi^*}{\partial (q^1)^2} + \frac{\partial^2\pi^*}{\partial q^2 \partial q^1}\frac{\partial^2\pi^*}{\partial q^1 \partial E}\right] \tag{11}$$

Proposition 1. *Supposing* $\frac{\partial q^{2*}}{\partial E} > 0$ *and* $\frac{\partial q^{1*}}{\partial E} < 0$*, a singer's profit strictly increases (or decreases) with the level of copyright enforcement if and only if the marginal promotion effect of pirated CDs,* $\frac{\partial \pi^{1*}}{\partial q^{3*}}$*, is smaller (or greater) than the marginal competitive effect,* $-\frac{\partial \pi^{2*}}{\partial q^{3*}}$*.*

Proof. The effect of enforcement upon total profits of a singer is

$$\frac{\partial \pi^*}{\partial E} = \frac{\partial \pi^*}{\partial q^{1*}}\frac{\partial q^{1*}}{\partial E} + \frac{\partial \pi^*}{\partial q^{2*}}\frac{\partial q^{2*}}{\partial E} + \frac{\partial \pi^*}{\partial q^{3*}}\left(\frac{\partial q^{3*}}{\partial E} + \frac{\partial q^{3*}}{\partial q^{1*}}\frac{\partial q^{1*}}{\partial E} + \frac{\partial q^{3*}}{\partial q^{2*}}\frac{\partial q^{2*}}{\partial E}\right)$$

But, from (7) and (8) the first two terms of this are both equal to 0. Thus we have

$$\begin{aligned}\frac{\partial \pi^*}{\partial E} &= \frac{\partial \pi^*}{\partial q^{3*}}\left(\frac{\partial q^{3*}}{\partial E} + \frac{\partial q^{3*}}{\partial q^{1*}}\frac{\partial q^{1*}}{\partial E} + \frac{\partial q^{3*}}{\partial q^{2*}}\frac{\partial q^{2*}}{\partial E}\right) \\ &= \left(\frac{\partial \pi^{1*}}{\partial q^{3*}} + \frac{\partial \pi^{2*}}{\partial q^{3*}}\right)\left(\frac{\partial q^{3*}}{\partial E} + \frac{\partial q^{3*}}{\partial q^{1*}}\frac{\partial q^{1*}}{\partial E} + \frac{\partial q^{3*}}{\partial q^{2*}}\frac{\partial q^{2*}}{\partial E}\right)\end{aligned}$$

By assumption, we have $\frac{\partial q^{3*}}{\partial E} < 0$, $\frac{\partial q^{3*}}{\partial q^{1*}} > 0$, $\frac{\partial q^{1*}}{\partial E} < 0$, $\frac{\partial q^{3*}}{\partial q^{2*}} < 0$ and $\frac{\partial q^{2*}}{\partial E} > 0$. Thus, each of the terms in $\frac{\partial q^{3*}}{\partial E} + \frac{\partial q^{3*}}{\partial q^{1*}}\frac{\partial q^{1*}}{\partial E} + \frac{\partial q^{3*}}{\partial q^{2*}}\frac{\partial q^{2*}}{\partial E}$ is negative. This means that the sign of $\frac{\partial \pi^*}{\partial E}$ is the opposite of the sign of $\frac{\partial \pi^{1*}}{\partial q^{3*}} + \frac{\partial \pi^{2*}}{\partial q^{3*}}$. Therefore, $\frac{\partial \pi^*}{\partial E} \gtreqless 0$ as $\frac{\partial \pi^{1*}}{\partial q^{3*}} \lesseqgtr -\frac{\partial \pi^{2*}}{\partial q^{3*}}$. □

The assumptions, $\frac{\partial q^{1*}}{\partial E} < 0$ and $\frac{\partial q^{2*}}{\partial E} > 0$ are considered as natural ones. Detailed conditions leading to this situation can be obtained by (10) and (11). The first inequality suggests that the number of people visiting a stage performance decreases with enforcement, due to increased enforcement reducing the supply of pirate copies, and in turn this leading to a reduction of the promotional effects from pirated goods on stage performance profit. The second inequality suggests that sales of original CDs increase with copyright enforcement. This proposition indicates that pirated CDs are beneficial for a singer when a marginal promotion effect from them is relatively high. It notes that π^* depends on M as well as on E. We now consider the effect of M on the shape of the profit function.

4. Concavity/Convexity of the Profit Function

We want to consider a singer's incentive regarding copyright enforcement. We suppose that his or her profit function is either concave or convex with respect to

E.[10] Since M increases a singer's profits, a profit curve of $\pi^*(E, M)$, given E, shifts upward with M. This shift is crucial for a singer's optimal copyright enforcement.

Before obtaining a proposition, we need some further assumptions.

Assumption 1. $\frac{\partial^2 \pi^*}{\partial E \partial M} > 0$.

This assumption describes how π^* shifts. We use $\widehat{E}$ to denote the level of enforcement E under a local minimum or maximum of π^*, that is, a point which satisfies $\frac{\partial \pi^*}{\partial E} = 0$. To check how $\widehat{E}$ changes with M, we totally differentiate $\frac{\partial \pi^*}{\partial E} = 0$ and obtain

$$\frac{d\widehat{E}}{dM} = -\frac{\left(\frac{\partial^2 \pi^*}{\partial E \partial M}\right)}{\left(\frac{\partial^2 \pi^*}{\partial E^2}\right)} \tag{12}$$

Under Assumption 1, this condition indicates that $\frac{d\widehat{E}}{dM} < 0$ (resp. >0) if π^* is strictly convex (resp. concave) in E. These situations are depicted in Figure 1 (resp. Figure 2).

Considering situations in developing and developed countries, we also assume

Assumption 2. $\frac{\partial \pi^*}{\partial E} < 0$ at $E = 0$ and $M = \underline{M}$, and $\frac{\partial \pi^*}{\partial E} > 0$ at $E = \overline{E}$ and $M = \overline{M}$.

In a developing country like Vietnam, strict copyright enforcement decreases a singer's profits, while, in a developed country, it increases profits. Under Assumptions 1 and 2, the profit function, π^*, is depicted as in Figures 1 and 2.

We first consider the case of a convex function. In Figure 1, $\underline{M}$ represents the level of media industries in developing countries, and $\overline{M}$ ($> \underline{M}$) that in developed countries. In developing countries, pirated CDs play the role of a singer's promotion under immature media industries. In Figure 1, we describe this situation where the marginal promotion effect, $\frac{\partial \pi^{1*}}{\partial q^{3*}}$, is greater than a marginal competitive effect $-\frac{\partial \pi^{2*}}{\partial q^{3*}}$ (see Proposition 1). The optimal copyright enforcement for a singer is $E = 0$. When media industries become mature, he or she does not need to depend on pirated CDs for promotion yet these still damage original CD sales. In developed countries, most singers' profits decrease with lax copyright enforcement. This situation is described with a profit curve $\pi^*(E, \overline{M})$ like that in Figure 1. Due to convexity of a profit function, optimal copyright enforcement becomes a corner solution. We denote a critical level of media industries as $\widehat{M}$, below which optimal enforcement is $E = 0$, and above which it is $E = \overline{E}$. As media industries become mature with economic development, optimal copyright enforcement jumps from 0 to $\overline{E}$ at $\widehat{M}$.

The second case is a concave profit function. Assuming that privately optimal copyright enforcement is $E = 0$ in developing countries and $E = \overline{E}$ in developed

[10]It is difficult to determine whether the profit function is convex or concave, even though we obtain the condition mathematically.

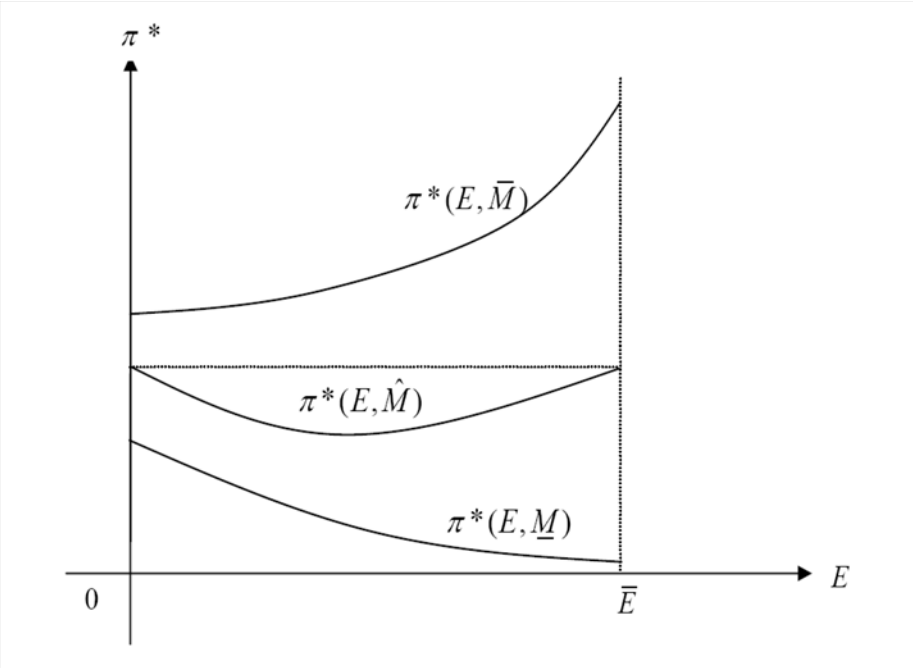

FIGURE 1. Convex profit function

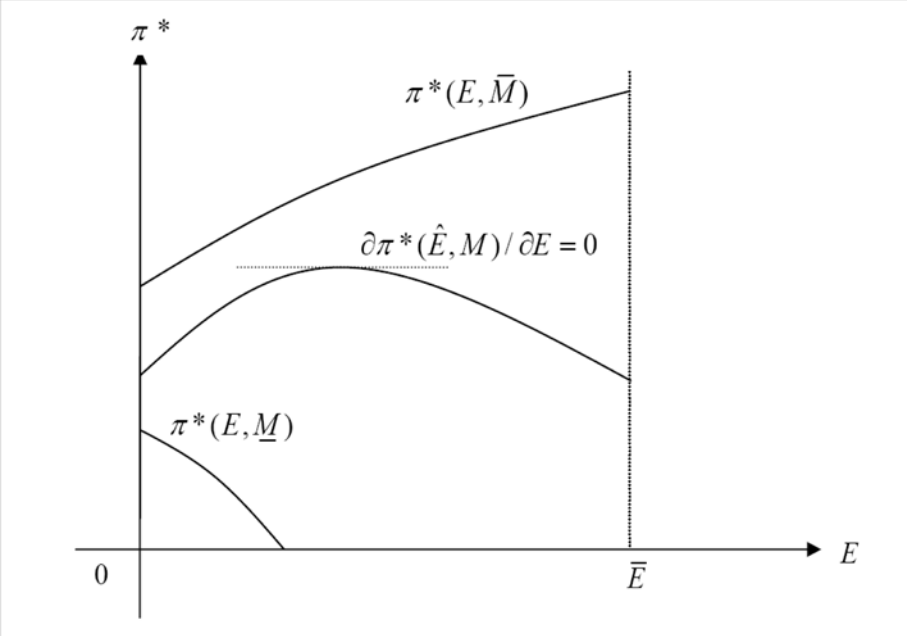

FIGURE 2. Concave profit function

countries, we can describe a profit curve like that in Figure 2. In such a case, the optimal copyright enforcement gradually increases with the level of media industries.

From the above considerations, we obtain the following proposition:

Proposition 2. *If π^* is strictly convex with respect to E, the privately optimal copyright enforcement is $E = 0$ when $M \leq \widehat{M}$, and it is $E = \overline{E}$ when $M > \widehat{M}$. If π^* is strictly concave with respect to E, the privately optimal copyright enforcement continuously increases from $E = 0$ to $E = \overline{E}$ with M.*

We can obtain criteria on whether π^* is strictly convex or concave. There are M under which π^* has a local minimum (or maximum) with respect to E. If π^* has a local minimum (resp. maximum) at $\widehat{E}$, then, from Proposition 1,

$$\frac{\partial \pi^{1*}}{\partial q^{3*}} > (\text{resp. } <) - \frac{\partial \pi^{2*}}{\partial q^{3*}} \text{ for } 0 \leq E < \widehat{E}, \text{ and} \tag{13}$$

$$\frac{\partial \pi^{1*}}{\partial q^{3*}} < (\text{resp. } >) - \frac{\partial \pi^{2*}}{\partial q^{3*}} \text{ for } \widehat{E} < E \leq \overline{E}. \tag{14}$$

In this case, under a relatively lax (resp. strict) copyright enforcement, the marginal promotion effect is greater (resp. smaller) than the marginal competitive effect. Whether a switch in optimal copyright enforcement takes place or not depends on the inequalities in (13) and (14).

In the concave case, three optimal points exist, two corner solutions and an inner solution. The first two solutions have the same characteristics as those in a convex case in terms of the inequality between the marginal promotion effect and the marginal competitive effect. At the inner solution, which emerges in the process of development of media industries, the marginal promotion effect is smaller than the marginal competitive effect under relatively lax enforcement, and vice verse under relatively strict one.

5. An Example: The Vietnamese Situation

We conducted research in Vietnam where more than 90% of content and software is illegal. Interviews that we conducted with three levels of singers: young singers who have never released a CD, unknown singers who have released CDs, and well-known singers with many released CDs, revealed that most singers – the top ones are the exception – needed pirated CDs for promotion. The reason for this situation is that singers do not have effective ways to let people know of their existence in Vietnam, since media industries are immature in contrast to those in developed countries. Even though people can make use of the Internet to gather information, the penetration rate is less than 10%.

By using our model, we can consider a situation like that of the Vietnamese music market. We first note that most singers cannot earn profits from a CD sale, although they can use sales as an effective promotion tool. They produce a minimal amount of CDs, for example, 3000 CDs,[11] which are then copied by pirates for pirated CD shops. This means that the cost for releasing a CD is a fixed cost for promotion. Taking into account this fact, we modify the model as follows:

$$\pi^3 = p^3(q^1, \overline{q}^2, M)q^3 - C^3(q^3, E) \tag{15}$$

$$\pi = \pi^1 + \pi^2 = \left[p^1(q^1, \overline{q}^2, q^3, M)q^1 - C^1(q^1)\right] + \left[p^2(q^1, \overline{q}^2, q^3, M)\overline{q}^2 - C^2(\overline{q}^2)\right] \tag{16}$$

where $\overline{q}^2$ is a minimal amount for releasing a CD and a given. We denote a solution for the maximand of (15) as $\widetilde{q}^3(q^1, E, M)$, and for the maximand of (16), taking into account $\widetilde{q}^3$, as $q^{1*}(E, M)$. Thus, in the end $\widetilde{q}^3$ becomes $q^{3*}(q^{1*}, E, M)$.

Since $\frac{\partial q^{1*}}{\partial E} = 0$, under $q^2 = \overline{q}^2$ the following result is obtained

$$\frac{\partial \pi^*}{\partial E} = \left(\frac{\partial \pi^{1*}}{\partial \widetilde{q}^3} + \frac{\partial \pi^{2*}}{\partial \widetilde{q}^3}\right)\frac{\partial q^{3*}}{\partial E} \tag{17}$$

That is, strict copyright enforcement damages a singer's profits, since it is apparent in Vietnam that $\frac{\partial \pi^{1*}}{\partial \widetilde{q}^3} + \frac{\partial \pi^{2*}}{\partial \widetilde{q}^3} > 0$.

6. Economic Welfare

Finally, we check the conditions for maximizing economic welfare. We define an economic welfare function as

$$W(E, M) = U(q^{1*}, q^{2*}, q^{3*}) - \sum_{i=1}^{3} C^i(q^{i*}) - C^E(E), \tag{18}$$

where U is a representative consumer's utility function, and we assume utility maximization, that is, $\frac{\partial U}{\partial q^{i*}} = p^{i*}$ for $i = 1, 2, 3$. Since M is assumed to be an exogeneous variable for policymakers, depending on economic development, the variable used to maximize the economic welfare is E. The cost function for enforcement is expressed as $C^E(E)$, which is assumed to be strictly convex with respect to E. Given that assumption, a necessary condition for maximization (an interior solution) is $\frac{\partial W}{\partial E} = 0$, where

[11] Top singers in Vietnam, with a population of about 80 million, can sell less than 100 thousand original CDs, even though a CD gets to the top of the hit charts.

$$\begin{aligned}\frac{\partial W}{\partial E} &= \sum_{i=1}^{3}\left(\frac{\partial U}{\partial q^{i*}}-\frac{dC^1}{dE}\right)\frac{\partial q^{i*}}{\partial E}-\frac{dC^E}{dE}\\ &= \sum_{i=1}^{3}\left(p^{i*}-\frac{dC^1}{dE}\right)\frac{\partial q^{i*}}{\partial E}-\frac{dC^E}{dE}\\ &= \left(p^{1*}-\frac{dC^1}{dE}\right)\frac{\partial q^{1*}}{\partial E}+\left(p^{2*}-\frac{dC^2}{dE}\right)\frac{\partial q^{2*}}{\partial E}-\frac{dC^E}{dE} \qquad (19)\end{aligned}$$

where we have used (5).

Because of a positive markup and no intervention, under copyright laws, in monopoly markets, policymakers will be able to find an E that satisfies this condition under $\frac{\partial q^{1*}}{\partial E}<0$ and $\frac{\partial q^{2*}}{\partial E}>0$.

The problem is whether this economic welfare function satisfies the sufficient condition for maximization. For example, even though π^* is strictly concave, it is not certain whether the representative consumer's surplus function, $U-\sum_{i=1}^{3}p^iq^i$, is concave. Whether it is concave or convex, it is highly possible that $E=0$ is best for a consumer due to the low price of pirated CDs.

7. Concluding Remarks

Our model assumed a singer who is a monopolist in an original CD market. It is easy to extend this model to an oligopoly case with symmetric players, although due to heterogeneity it is impossible to obtain characteristics in a symmetric oligopoly model. By using our model, however, we can obtain an interesting result derived from the heterogeneity of singers. Under a profit function which is convex with respect to the level of copyright enforcement, singers are divided into two groups: those supporting maximal copyright enforcement and those who are against any copyright enforcement. In such a situation, a severe conflict[12] takes place between these two groups. Compared to such a situation, the level of optimal copyright enforcement for singers, under a concave profit function, is distributed between $E=0$ and $E=\overline{E}$. Therefore, in this case, the conflict among heterogeneous singers is weaker than under a convex profit function.

Most developing countries, which have already joined or are willing to join the WTO, must obey international copyright laws, as well as domestic laws. However, even if they enact such laws, how to enforce these copyright laws is a different issue. One reason for lax enforcement is a lack of officers to enforce them. The other factor is that policymakers are not willing to strictly enforce because domestic copyright holders cannot otherwise obtain any benefits. This situation is totally different

[12]Interviews with three levels of singers suggested that the top singers were eager for strict copyright enforcement, while less popular singers insisted on the need for pirated CDs.

from that in developed countries in which piracy damages copyright holders. Policymakers in developed countries should take this situation into account when they make demands on developing countries to strictly enforce copyrights.

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