The Intertemporal Enforcement Strategies of Copyright Protection :
An Analysis of Information Goods in the Presence of File-Sharing Networks

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Abstract

The paper analyzes a copyright owning firm's incentive to enforce its copyright in the presence of file-sharing networks. I devise a two-period model where a copyright owner sells two different versions of a creator's information good, and show that the firm's overall profits are enhanced by a strategy of differential inter-temporal enforcement of the copyright protection, compared to strategies of no enforcement or full enforcement in both periods. If the firm enforces no copyright protection in the first period, the low-valuation consumers may make and consume copies that are imperfect substitutes for the original information good. If there is a significant increase in the willingness-to-pay of some low-valuation consumers after they experience the information good, the firm can extract the increased consumer surplus by enforcing a positive level of copyright protection in the second period. Social welfare, however, is maximized in the case of no enforcement.

Keywords : Information Goods, Copyright Protection, File-sharing Network, Intertemporal Enforcement

Advances in technology have produced radical shifts in the ability to reproduce, distribute, control, and publish information goods. Recent technology progress allows Internet users to access and trade digital music files, DVD files, game files, computer software and electronic books through peer-to-peer (P2P) networks without paying those who have produced the goods. MP3 and other data compression technologies are turning the traded information goods into public goods, since no one can be prevented from enjoying an inexhaustible supply of digital copies.

After the explosive increase in the number of users of file-sharing programs, the Recording Industry Association of America (RIAA) sued Napster, which claimed to have 38 million registered users, for copyright infringement. The RIAA asserts that the sales of music CDs decreased by almost 40% due to copyright infringement through the Internet in MP3 file format, and that copyright protection enforcement should be strongly implemented "to promote the progress of science and useful arts by securing to authors the exclusive right to their respective writings."[1] However, others, such as Gallaway and Kinnear [2001], argue that music file sharing through the Internet does not hurt sales of pre-recorded CDs and may ac-

tually enhance sales by whetting consumers' appetites for new music.

The court finally decided that Napster, a file-sharing network, encouraged and assisted the infringement of recording companies' copyrights,[2] and Napster closed its Internet site in 2000. The RIAA filed several lawsuits against some Internet sites for similar reasons, and has threatened to file lawsuits against every copyright-infringing individual who shares MP3 files through P2P networks. Other entertainment industries, such as film, publishing, and game industries, also face a similar situation as the music industry.

The problem of copyright enforcement has only become more severe since the Napter lawsuit. The RIAA has been unsuccessful in inventing copy protection technologies. Also, "super-peer" networks now exist. Theses programs allow users to trade files without the use of a central server, thus making it very costly to stop trade from occurring over these networks. Therefore, copyright owning firms or their associations may want to strategically choose the level of copyright protection enforcement.

In fact, a copyright owner may not want to enforce copyright protection at all. In this case, consumers making copies may cause a large increase in demand or a large increase in the valuation for the good ("demand expansion effect"). Another option for copyright owners is

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1) Stronger intellectual property protection could encourage increased levels of creative output, resulting in morerapid progress and additional information products. But protecting intellectual property also entails costs. The costs are incurred in both directly related (e.g., enforcement) and indirectly related (e.g., decreased ability to build on work of others, increase in resources spent to legally reproduce a product) activities.

2) "Napster is enjoined from copying or assisting or enabling or contributing to the copy or duplication of all copyrighted songs and musical compositions of which the plaintiffs hold rights" (U.S. District Judge Marilyn Hall Patel's ruling).

to gradually increase the level of copyright protection enforcement over time.

There are many papers that study the effect of the existence of illegal copies on the sellers of originals. Among others, Johnson [1985] shows the models by which a case can be made for restricting copying even in the short run if copying induces a large reduction in demand for originals relative to its effect on total consumption.

Takeyama [1994] shows that unauthorized reproduction can not only induce greater firm profits relative to the case where there is no copying, it can also lead to a Pareto improvement in social welfare. Takeyama [1997] also shows that profits may be higher with copying than without copying and that the commitment value of copies may offer a strategic explanation for free giveaways of abridged versions of intellectual property.

Studies on shared goods (libraries, families, and rental markets) by Varian [2000], Besen and Kirby [1989], and Bakos, Brynjolfsson, and Lichtman [1999] have shown that the impact of sharing on producer profits depends critically on the assumption made about the formation of groups and the ability of the monopolist to appropriate the additional surplus that the secondary, shared uses add to the 'single-use' good.

1. The Basic Model

1.1 Assumptions

There are several assumptions for modeling the situation where consumers can easily make copies of information goods through P2P net-

works and the copyright holder can choose the degree of copyright protection enforcement. Specifically :

(1) A firm has the copyright for two different versions of information goods created by a producer, such as two different CD albums of a singer, and is trying to maximize its overall profit from selling the two versions : album 1 in the first period, and album 2 in the second period.[3] The firm can reproduce/distribute the information goods at constant marginal costs, c. The discount factor is β.

(2) Some consumers don't know their true valuations for the information goods before they experience an original or a copy. If they want to obtain a copy, they can join a P2P network through which they can download digital copies for free.

(3) Downloaded digital copies are imperfect substitutes for the original information goods that can be bought from the monopolistic distributor. The parameter for substitutability is α, where $0 < \alpha < 1$.

(4) Initially, there are two groups of consumers : the high- and the low-valuation group (sized N^H and N^L), each of whose willingness-to-pay for the first version of the information goods is V^H and V^L, respectively. V^H and V^L are sufficiently high so that each consumer's surplus from making a copy is positive when the copyright owner does not make any protection efforts.

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3) The purpose of assuming different albums in each period is to avoid the Coase problem, which is the conjecture that durable good consumers would come to anticipate price reductions and delay purchasing until prices fall.

(5) Digital copies are available to consumers through file-sharing networks without any fee. However, they may get caught for copyright infringement if the copyright-owning firm enforces copyright protection. A consumer compares the surplus from buying an original and from making a copy, and chooses the action that maximizes his surplus. A consumer needs to spend d to obtain a digital copy, in the case of no enforcement of copyright protection.

(6) If the firm makes efforts to prevent copyright infringement, its marginal cost of reproduction/distribution increases from c to $(1+\gamma)$ c, where γ is the parameter representing the degree of copyright protection enforcement.[4] The firm's efforts make consumers' marginal cost of copying increase from d to $(1+a\gamma)d$, where a is the parameter for the degree of effect of the firm's enforcement on consumers' copying costs.

In addition, I assume that the period of legal copyright protection is sufficiently long and its scope of protection is sufficiently wide so that copyright owners or their associations can choose the level of copyright protection enforcement.[5] This means that a copyright owner can choose no enforcement, full enforcement, or an in-between level of enforcement for its benefits.[6]

1.2 The Basic Model without File Sharing Networks

For a benchmark, I first consider the case without file-sharing networks. In this case, consumers must buy an original CD in order to listen to the songs or an original DVD to see the movie. The firm may choose one of the two prices for profit maximization, depending on the relative sizes and valuations of the consumer groups.

If the firm wants to sell the information goods only to the high-valuation consumers, the price should be such that $V^H - P \geq 0$ and $V^L - P < 0$. For the maximum profit, the firm needs to set the price at V^H and extracts all the surplus of the high-valuation consumers. The firm has the same situation in period 2. So, the firm's overall profit is :

$$\pi^H = (1 + \beta) N^H (V^H - c). \tag{1}$$

On the other hand, if the firm wants to sell CDs to both the high and the low valuation consumers, the price should be such that $V^L - P \geq 0$. The firm's optimal price is $P = V^L$, and the firm's overall profit is :

$$\pi^L = (1 + \beta)(N^H + N^L)(V^L - c). \tag{2}$$

4) For example, a copyright owning firm may need to pay a greater amount of per unit royalty for the security program that has an increased level of protection. In addition, c is likely to be larger than d because c includes distribution costs such as retailers' profits.

5) I am assuming the government can't enforce copyright protection fully, or its enforcement depends on copyright owners' strategies. In addition, when copyright holders decide not to implement copyright protection, consumers' making copies or downloading digital files is not illegal.

6) In fact, in cyberspace, the RIAA's team of Internet Specialists, with the assistance of a 24-hour automated webcrawler, helps to stop Internet sites that make illegal recordings available.

The firm's pricing strategies and resulting profits depend on the relative size and valuations of each consumer group. It is easily seen that the firm will find it optimal to supply only the high valuation group consumers $(\pi^H \geq \pi^L)$ if and only if the following condition is satisfied :

$$V^H \geq \left(1 + \frac{N^L}{N^H}\right)(N^L - c) + c. \qquad (3)$$

2. Demand Reshaping through P2P Networks

When a new singer's album releases, consumers usually don't know their true valuations for the songs in the album until they listen to them. Similarly, when a new game is introduced in the market, lots of gamers come to know their true valuation for the game only after they play it.

Therefore, I assume that some low-valuation consumers get to know their true valuations for the information goods after they buy or copy and experience the first version in period 1. Therefore, there can be an increase in the valuation of the fraction p of the low-valuation consumers who consume the good in period 1 from V^L to $(1 + \delta) V^L$ in period 2.

2.1 Full Enforcement of Copyright Protection

If the copyright owning firm makes every effort to prevent copyright infringements, such as using a new copy-protecting technology and filing lawsuits against every infringing individual, its marginal cost of reproduction/distribution increases by $\bar{\gamma} c$, where $\bar{\gamma}$ is the effort

level for not allowing any copyright infringements. At this effort level of copyright protection, consumers are not able to share files through P2P networks with a nonnegative surplus.

The firm's effort level for full enforcement $(\bar{\gamma})$ should be such that the increase in the high-valuation consumers' costs for copying makes the possible surplus from copying (or, from sharing files) zero or negative : $\alpha V^H - (1 + \alpha \bar{\gamma}) d \leq 0.$[7] Therefore, $\bar{\gamma} = \frac{\alpha V^H - d}{\alpha d}$. For a given valuation, if copies are poor substitutes for the originals, if consumers' marginal costs of copying are large, or if the degree of enforcement has a large effect on copying costs, the effort level $(\bar{\gamma})$ of full copyright protection enforcement doesn't need to be high.

The firm's overall profits in the two cases are :

$$\pi^H = (1 + \beta) V^H \left[V^H - c - \frac{c}{\alpha d}(\alpha V^H - d) \right], \qquad (4)$$

and

$$\pi^L = (1 + \beta)(V^H + N^L) \qquad (5)$$
$$\left[V^L - c - \frac{c}{\alpha d}(\alpha V^H - d) \right].$$

The firm's optimal strategy is to supply only the high-valuation consumers, if and only if

$$V^H \geq \frac{N^H + N^L}{N^H} V^L - \qquad (6)$$
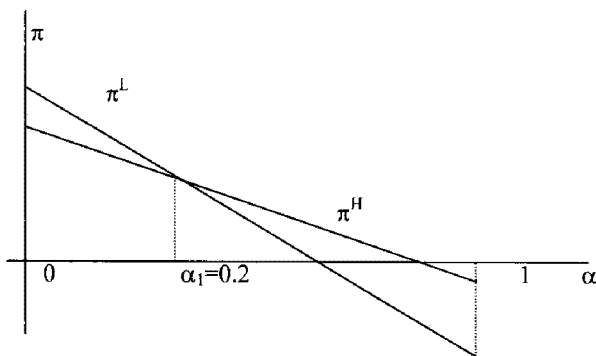$$\frac{N^L}{N^H}\left(c + \frac{c}{\alpha d}(\alpha V^H - d)\right)$$

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7) When the copyright law stipulates financial penalties to be imposed upon copyright infringers, consumers making copies must consider the additional expected cost of the penalty multiplied by the probability of being caught.

Note that Equation (6) depends on the value of α for given values of costs and valuations. For example, if I consider $N^H = N^L = 1000$, $V^H = 30$, $V^L = 20$, $c = 5$, $d = 2$, and $a = 2$, there is a range where the firm's best strategy is serving only the high-valuation consumers only if $\alpha \geq 0.2$. However, if $\alpha < 0.2$, as shown in Figure 1, serving both types of consumers is the firm's best strategy because the firm's efforts for preventing illegal copying is less costly due to the lower substitutability. This leads to Proposition 1.

Proposition 1 : *The copyright owning firm cannot have a positive profit from full enforcement of copyright protection if copies are close substitutes for the originals in the case that the enforcement efforts are costly.*

Looking at Equation (4), the firm cannot earn a positive profit if $\alpha > \dfrac{d}{c} \dfrac{c + a(V^H - c)}{V^H}$. Since $\alpha \leq 1$, there exists a range of α that makes the firm's profit negative if $\alpha \leq \dfrac{(c/d) V^H - c}{V^H - c}$. In that case, the firm cannot earn a positive profit

from full enforcement of copyright protection. This is shown in <Figure 1>.

Note that a, the parameter for the degree of the effect of the firm's enforcement on consumers' copying costs, is important for the firm when it decides prices and the targeted consumer group. If a is small, the firm needs to spend a relatively large amount of money for full enforcement of copyright protection. On the contrary, if a is large, the firm needs to spend a relatively small amount of money for full enforcement because in this case the firm's small expenditure for enforcement can increase consumers' copying costs by a large amount. Therefore, the firm's profit can be larger with a large a, as is shown in <Figure 2>. In addition, $\alpha_2 \geq \alpha_1$ in <Figures 1> and 2, meaning that the firm's best strategy is serving both consumer groups in a wider range of substitutability when the degree of enforcement effect is larger.

Note also that a change in the degree of substitutability has less effect on profits in when a is large. This can be seen when the partial derivative of Equation (4) with respect to the degree of substitutability is taken : $\dfrac{\partial \pi}{\partial \alpha} = -(1 + \beta)$ $\dfrac{c}{ad} N^H V^H$.

<Figure 1> Substitutability and the Best Strategy with a Small *a*
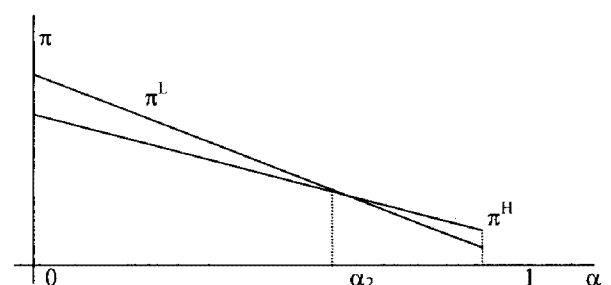
<Figure 2> Substitutability and the Best Strategy with a Large *a*

For the remainder of this article, I assume that a is greater than one. This seems reasonable, seeing that after the RIAA increased its online monitoring efforts and filed lawsuits against users who frequently traded music files, the number of people using file-sharing programs dropped significantly.

2.2 No Enforcement of Copyright Protection

Consider now the case of the firm making no efforts for copyright protection and allowing free copying. Consumers choose whether to buy originals or to obtain copies without the fear of getting caught, by comparing their net surplus from an original and from a copy. If the surplus from copying is greater, consumers can immediately obtain the files from a file-sharing network. In this case, a fraction p of the low-valuation consumers increases their valuation by δV^L in period 2, after using copies in period 1. The valuation of the remaining $1-p$ low valuation consumers does not change.

If the firm wants to sell the original goods only to the high-valuation group of consumers, its profit in period 1 is :

$$\pi_1^H = N^H[(1-\alpha)V^H + d - c],\qquad(7)$$

since a high-valuation consumer's surplus from buying an original should be greater than, or equal to, that from making a copy : $V^H - P_1 \geq \alpha V^H - d$, so the optimal price $P_1 = (1+\alpha)V^H + d$. If copies are perfect substitutes for originals, then optimal price $P_1 = d$. In this case ($\alpha = 1$), if $c > d$, no consumers buy originals.

Similarly, if the firm wants to sell originals to the high and the low-valuation consumers, its profit in period 1 is :

$$\pi_1^H = (N^H + N^L)[(1-\alpha)V^L + d - c],\qquad(8)$$

where the optimal price is found the same way as in Equation (7) with the low-valuation consumers : $P_1 = (1-\alpha)V^L + d$.

Proposition 2 draws from the above analysis :

Proposition 2 : *When the copyright-owning firm does not or cannot enforce copyright protection, the firm's optimal price is (i) the valuation of the lowest targeted consumers, in the case of no substitutability, or (ii) consumers' marginal copying cost, in the case of perfect substitutability.*

When there is no substitutability, the firm's optimal price seems to be $P = d + V$. However, consumer surplus at this price is negative. The highest price the firm can charge is therefore the valuation of the lowest targeted consumer group. On the other hand, when originals and copies are perfect substitutes, the firm's optimal price is just consumers' marginal copying cost. No consumers buy originals at any higher price.

Finally, the firm will sell only to the high-valuation consumers, if and only if :

$$V^H \geq \frac{N^H + N^L}{N^H}\left(V^L + \frac{d-c}{a-\alpha}\right) + \left(\frac{c-d}{1-\alpha}\right).\qquad(9)$$

In the second period, three groups of consumers exist : the low, the (new) medium, and

the high-valuation group. The firm's optimal pricing strategy in the second period depends on the fraction of the low-valuation consumers who increase their willingness-to-pay and the magnitude of the change in their willingness-to-pay. The size of the (new) medium valuation group in the second period can be denoted by $N^{LM} = pN^L$, and the new size of the low-valuation group is $N^{LL} = (1-p)N^L$.

If there is a sufficient increase in the valuation of the low-valuation consumers such that

$$\frac{N^H}{N^H + N^{LM}} = \left(V^H + \frac{d-c}{1-\alpha} \right) + \frac{c-d}{1-\alpha} \leq \quad (10)$$

$$(1+\delta) V^L \leq \frac{N^H + N^{LM}}{N^{LM}}$$

$$\left(V^H + \frac{d-c}{1-\alpha} \right) + \frac{c-d}{1-\alpha},$$

then serving the high and the medium-valuation consumers is the best strategy for the firm.[8] In this case, the fraction p of the low-valuation consumers in period 1 is now the medium-valuation consumers in period 2. Equation (10) says that the medium valuation should be close to the high valuation such that the firm maximizes profits from selling the goods to the high and the medium-valuation consumers. This is the situation that, after listening to the first album songs in MP3 files, some of initially low-valuation consumers have come to like the singer's songs, and increase their willingness-

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8) Equation (10) comes from the condition that the firm's period 2 profit from serving the medium and the high-valuation consumers is greater than from serving all consumers and smaller than serving only the (new) high-valuation consumers.

to-pay for the information goods.

Since a medium-valuation consumer's surplus from buying an original should be greater than, or equal to, the surplus from making a copy : $(1+\delta) V^L - P_2 \geq \alpha(1+\delta) V^L - d$, the optimal price in period 2 is $P_2 = (1-\alpha)(1+\delta) V^L + d$, and the firm's profit in period 2 is :

$$\pi_2^M = (N^H + N^{LM}) [(1-\alpha)(1+\delta) V^L + \quad (11)$$

$$d-c].$$

Note that, for given sizes and initial valuations of consumer groups, as the substitutability (α) decreases, as the firm's relative production efficiency $(d-c)$ increases, and as the increase in valuation (δ) becomes larger, the firm's overall profit increases.

2.3 Comparison between Full and No Enforcements

I now compare the firm's profit under full (π^{FE}) and no (π^{NE}) enforcement to determine the firm's optimal behavior. Proposition 3 addresses this question.

Proposition 3 : *If there is a sufficient increase in the willingness-to-pay of the low-valuation consumers who make copies initially, the copyright-owning firm earn a greater profit from no enforcement of copyright protection than from full enforcement when substitutability is sufficiently low.*

Equations (12) and (13) state the firm's profit under full and no enforcement with a significant

increase in the valuation of the low-valuation consumers :

$$\pi^{FE} = (1+\beta)N^H \left[V^H - c - \frac{c}{ad}(\alpha V^H - d) \right], \quad (12)$$

and

$$\pi^{NE} = N^H[(1-\alpha)V^H + d - c] + \quad (13)$$

$$\beta(N^H + N^{LM})\left[(1-\alpha)(1+\delta)V^L + d - c\right]$$

Comparing two these equations reveals that in the case of low substitutability such that

$$\alpha \leq \frac{A\{(1+\delta)V^L - V^H + 2d - 2c/a\} + (1-A)\{1+\delta\}V^L + d - c}{A\{(2c/ad - 1)V^H - (1+\delta)V^L\} - (1-A)(1+\delta)V^L}, \quad (14)$$

where $A = \dfrac{N^H}{N^H + N^{LM}}$, the firm's profit from no enforcement of copyright protection is greater than from full enforcement, with no discounting. This is because when substitutability is low, the firm can easily induce consumers to buy original goods at a relatively high price, leading to a greater profit for the firm.

Note that Equations (1) and (13) state that the firm's profit from allowing free copying (π^{NE}) can be greater than that without file-sharing networks (π^{NC}) if substitutability is sufficiently low such that

$$\alpha \leq \frac{A\left[(1+\delta)V^L - V^H + 2d) + (1-A)[(1+\delta)V^L + d - c]\right]}{A\left[V^H + (1+\delta)V^L\right] + (1+\delta)(1-A)V^L},$$

where $A = \dfrac{N^H}{N^H + N^{LM}}$. In addition, two restrictions on the value of substitutability already exist : (a) $\alpha \geq \dfrac{d}{V^L}$ from assumption (4), and (b) there should exist such α that satisfies Equation (10). Therefore, there is an area of

(α, δ) where no enforcement of copyright protection is more profitable. <Figure 3> shows an example where $N^H = N^{LM}$, $V^H = 30$, $V^L = 10$, $d = 2$, and $c = 5$.
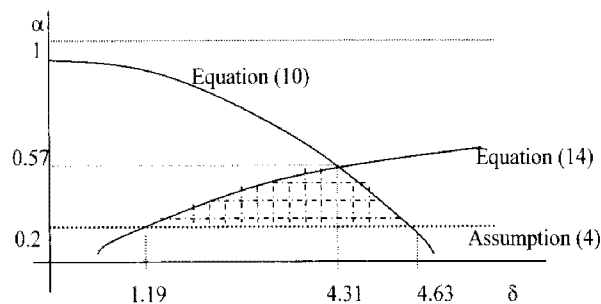
<Figure 3> No Enforcement and Substitutability

3. Intertemporal Enforcement Discrimination

3.1 Intertemporal Discrimination of Copyright Protection Enforcement

So far, I have considered that the firm implements the same level of copyright enforcement through two periods. However, it may be optimal for the firm to use different levels of copyright protection enforcement intertemporally. A low level of initial enforcement allows consumers to make copies, increasing some consumers' willingness to pay for the originals, and therefore increasing the firm's profit through a high level of enforcement in the second period. I consider the case where the firm enforces no copyright protection in period 1 and some positive level of copyright protection in period 2.[9]

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9) The case where the firm enforces copyright protection strongly in period 1 and weakly in period 2 is clearly suboptimal because in that case there is no valuation-increasing effect in the second period.

If the firm does not make any efforts to protect its copyright in period 1, consumers can make copies by spending only their marginal copying cost d. Assuming the valuations of the high-valuation consumers are sufficiently high, the firm's profit in period 1 is the same as Equation (7).

The firm's profit in period 2 is different from that with no enforcement or full enforcement because fraction p of the low-valuation consumers increases their willingness-to-pay in period 2 after their use of copies in period 1. Therefore, the firm's overall profit may increase through a positive level of copyright protection enforcement in period 2.

If there is a sufficient increase in the low-valuation group's willingness-to-pay so that Equation (10) is satisfied, serving the high and the medium-valuation consumers can maximize the firm's profits. The firm needs to make the medium consumers' surplus nonpositive in order not to allow make copies : $\alpha(1+\delta) V^L - (1+a\gamma)d \leq 0$. Therefore, the firm's optimal level of enforcement is $\gamma^* = \dfrac{\alpha(1+\delta) V^L - d}{ad}$. The optimal price level becomes :

$$P = (1-\alpha)(1+\delta) V^L + (1+a\gamma^*)d \qquad (15)$$
$$= (1+\delta) V^L$$

which implies that the optimal price in the second period is equal to the medium consumer group's valuation under the enforcement level of γ^*. Then, the corresponding profit in the second period is :

$$\pi_2 = (N^H + N^{LM}) \qquad (16)$$
$$\left((1+\delta)(1-\frac{\alpha c}{ad}) V^L - \frac{a-1}{a} c \right)$$

Therefore, the firm's overall profit from the differential enforcement through the two periods is :

$$\pi^{DE} = N^H[(1-\alpha) V^H + d - c] \qquad (17)$$
$$+ \beta(N^H + N^{LM})\left((1+\delta)(1-\frac{\alpha c}{ad}) V^L - \frac{a-1}{a} c \right)$$

3.2 Comparison between Differential Enforcement and Other Cases

The firm's second period profit from no enforcement needs to be compared to the optimal level of enforcement in order to determine the firm's intertemporal best strategy that maximizes profits.

Proposition 4 : *If free copying in the first period causes a sufficient increase in some low-valuation consumers' willingness-to-pay in the second period, the firm earns a greater profit from an intertemporal differential level of copyright protection enforcement than from no enforcement.*

When comparing π_2^{DE} and π_2^{NE}, $\pi_2^{DE} \geq \pi_2^{DE}$ if and only if $\alpha(1+\delta) V^L \geq d$. This implies the initially low valuation consumers' surplus from making a copy should be nonnegative in the case of no enforcement of copyright protection. This condition should hold because the surplus from making a copy should be nonnegative for

the low-valuation consumers to make copies in the first period, which is one of the assumptions. Therefore, if there is a sufficient increase in some low-valuation consumers' willingness-to-pay in the second period, the firm earns a greater profit from an intertemporal differential level of copyright protection enforcement than from no enforcement.

I now compare the firm's profit from differential enforcement with its profit without file sharing networks :

Proposition 5 : *The copyright-owning firm earns a larger profit with an intertemporal differential level of copyright protection enforcement than without file sharing network, only if copies have poor substitutability for originals and the degree of the enforcement effect is sufficiently large.*

Considering Equations (1) and (17), $\pi^{DE} \geq \pi^{NC}$ only if

$$\alpha \leq \frac{a(1+\delta)\,V^L - aA(\,V^H - c - d) - (a - a)c}{aAL^H + (c/d)(1+\delta)\,V^L},$$

where $A = \dfrac{N^H}{N^H + N^{LM}}$. In order for α to have a range where it satisfies this condition, the numerator should be positive. Therefore, a should be greater than $\dfrac{c}{A(\,V^H - d - c) - (1+\delta)\,V^L + c}$. This means that the firm can earn a greater profit from differential enforcement only if the substitutability is sufficiently low, for given group sizes, valuations, and parameters. In other words, if α increases, the firm needs to decrease the period 1 price, and enforce a higher

level of protection. This makes differential enforcement less profitable. Therefore, the degree of the enforcement effect should be higher for differential enforcement to be preferred. On the other hand, for larger values of a and N^{LM}, there can be a wider range of α that satisfies Proposition 5. <Figure 4> displays the regions of profitability when $N^H = N^{LM}$, $V^H = 30$, $V^L = 10$, $c = 5$, $d = 2$, and $\beta = 1$.
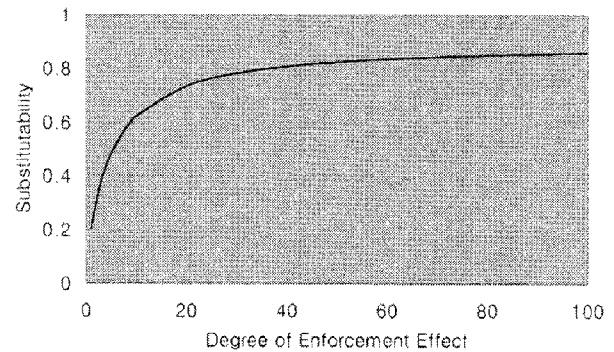

<Figure 4> Differential Enforcement vs. No File Sharing Networks

4. Numerical Examples

I now consider numerical examples that support the previously stated propositions. Group sizes are equal at $N^H = N^{LM} = N^{LL} = 1000$, and their valuations in period 1 are $V^H = 40$, and $V^L = 10$. One half of the initial low-valuation consumers increase their willingness to pay in period 2, and their new valuation is $V^{LM} = 30$. In addition, I suppose that the firm's marginal reproduction/distribution cost is $c = 4$ and consumers' marginal copying cost is $d = 3$. The discount factor is 1.

I compare the firm's profits across the four cases when there is a small degree of enforce-

ment effect $(a = 2)$ first. As seen in <Figure 5>, the firm's profit without file-sharing networks is always largest, and its profit from differential enforcement is always larger than that from no enforcement. <Figure 5> also shows that differential enforcement is best for the firm when the substitutability is intermediate $(0.3 \leq \alpha \leq 0.86)$, while full enforcement is best when the substitutability is high $(0.86 < \alpha \leq 1)$. Therefore, the firm's best strategy for copyright protection enforcement depends on the copies' level of substitutability for the originals for a given degree of enforcement effect.
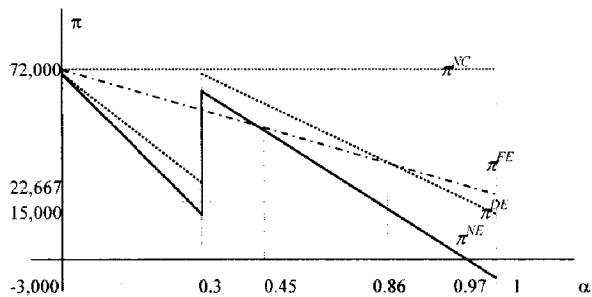
<Figure 5> Substitutability and Optimal Strategy When a Is Small

However, if the degree of enforcement effect on copying costs is large, the firm can receive a greater profit from differential and full en-
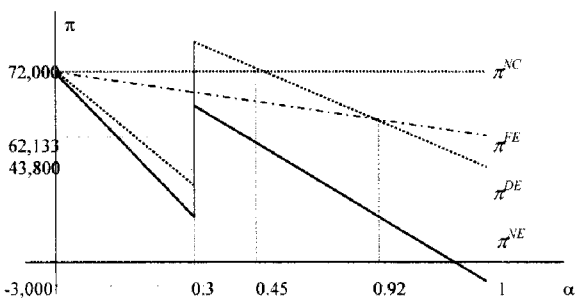
<Figure 6> Substitutability and Optimal Strategy When a Is Large

forcements. <Figure 6> displays the firm's profits in each case when $a = 10$. As in Figure 5, differential or full enforcement is best, depending on the level of substitutability.

5. Welfare Implications of Copyright Protection Enforcements

In the case of an intertemporal differential level of enforcement, the firm's optimal price in period 1 is $P_1 = (1 - \alpha) V^H + d$. Its optimal price in period 2 is $P_2 = (1 + \delta) V^L$, which is the new willingness-to-pay of the valuation-increasing consumers. The firm enforces the optimal level of copyright protection that makes the targeted consumers' surplus from copying non-positive in the second period.

In the cases of no enforcement and differential enforcement, the first period prices are the same. However, the firm's optimal price in the second period is higher in the intertemporal differential level of enforcement. This implies that the consumer surplus is smaller in the case of differential enforcement. As shown in <Figure 7> and <Figure 8>, consumer surplus with an intertemporal differential enforcement is :

$$CS^{DE} = N^H(\alpha V^H - d) + N^L(\alpha V^L - d) + \quad (18)$$
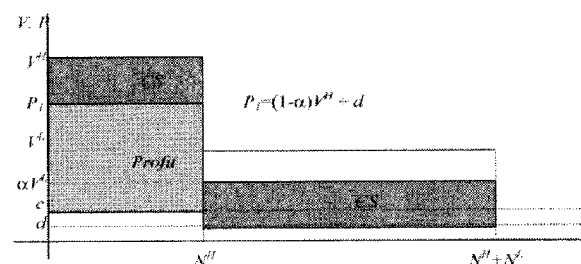
<Figure 7> Social Surplus under Differential Enforcement in Period 1

$$\beta N^{H}\{ V^{H} - (1 + \delta) V^{L}\}$$

This is clearly smaller than CS^{NE} because the high-valuation consumers need to pay more to buy originals, and the low-valuation consumers who do not change their willingness-to-pay do not make copies due to the firm's optimal level of enforcement in period 2.
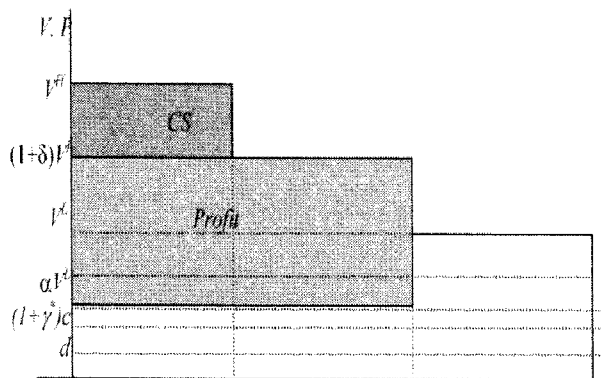
From Equations (17) and (18), social surplus under the firm's intertemporal differential level of protection enforcement is :

$$SS^{DE} = (1 + \beta)\{ N^{H}(V^{H} - c) + \qquad (19)$$
$$N^{L}(\alpha V^{L} - d)\} +$$
$$\beta\{ -\gamma^{*}cN^{H} + N^{LM}((1 - \alpha + \delta) V^{L} -$$
$$(1 + \gamma^{*})c + d) - N^{LL}(\alpha V^{L} - d)\}$$

where $\gamma^{*} = \dfrac{\alpha(1 + \delta) V^{L} - d}{ad}$. Comparing surplus equations leads to the following relationship between SS^{NE} and SS^{DE} :

$$SS^{DE} = SS^{NE} - \beta\{\gamma^{*}c(N^{H} + N^{LM}) + \qquad (20)$$
$$N^{LL}(\alpha V^{L} - d)\}.$$

Therefore, social surplus from differential

⟨Figure 8⟩ Social Surplus under Differential Enforcement in Period 2

enforcement is smaller than no enforcement, while the firm's profit from differential enforcement can be greater. The first term in the bracket is the decrease in social surplus due to the firm's higher production/distribution cost, and the second term is the decrease resulting from no consumption of the low-valuation consumers in the second period. Note that when the firm's enforcement is very efficient, or $a \to \infty$, the first term converges to zero. From the above analysis, the following proposition about the welfare implications is obtained :

Proposition 6 : *Taking as given the existence of the good, consumer surplus and social welfare are highest when the firm does not enforce copyright protection.*

⟨Table 1⟩ summarizes the analysis so far. The firm's profit is maximized with an intertemporal differential enforcement of copyright protection, while consumer surplus is maximized with no enforcement. Finally, social welfare is maximized when the firm enforces no copyright protection.

6. Summary and Conclusion

⟨Table 1⟩ Welfare Comparisons

Change in Strategy (or Situation)	$\Delta \Pi$	ΔCS	ΔSS
No File Sharing N/W → Enforcement	–	No Δ	–
Full Enforcement → No Enforcement	+	+	+
No Enforcement → Differential Enforcement	+	–	–

This research has shown that a monopolist who owns the copyright of intellectual property can earn a maximum profit, if it allows consumers to make copies initially, increasing the valuation of the good for some consumers, and then enforces the optimal level of copyright protection to induce the demand-increased consumers to buy original information goods.

This model especially fits for the case of a new singer who is not well known to music lovers. Allowed to make free copies initially, a significant size of consumers may come to know their true valuations for the songs, and increase their willingness-to-pay. Then the copyright owner can raise the price and the level of copyright protection at the same time, and earn the maximum profit. This research has also shown that social welfare is maximized when the copyright owning firm enforces no copyright protection in the presence of file-sharing networks. Since the firm doesn't need to spend money for the enforcement efforts, and the initial copying consumers spend lower costs, social surplus can be greater than the cases of no file-sharing networks, no enforcement, and full enforcement of copyright protection.

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