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ENFORCEMENT SHARING AND COMMERCIAL PIRACY

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Abstract. This paper uses a strategic entry-deterrence framework to analyze the effects of enforcement sharing between the government and the monopolist in dealing with commercial copyright piracy. The monopolist is the incumbent firm and is responsible for monitoring the illegal operations of a commercial pirate, the possible entrant, who illegally reproduces and sells unauthorized copies of the monopolist's product. The monopolist bears the monitoring cost and the government is responsible for setting a penalty. We show that even when enforcement is shared the socially optimal penalty may result in no piracy in equilibrium only if the government is sensitive to piracy.

1. Introduction

Copyright piracy has emerged, in recent years, as one of the leading global challenges. This issue assumes importance because of the high magnitude of the loss in retail sale, loss in tax revenues that can be used for meaningful public programs, and job losses due to piracy.[1] According to Wikipedia, the free encyclopedia, copyright infringement is "the unauthorized use of copyrighted material in a manner that violates one of the copyright owner's exclusive rights,.... This may occur through organized black market reproduction and distribution channels, sometimes with blatantly open commercial sale, or through purely private copying or downloading to avoid paying a purchase price."[2]

The existing literature on copyright infringement focuses on end-user piracy, which is private copying or downloading for personal use, and anti-piracy efforts to restrict it.[3] Banerjee (2003, 2006) explores the impact of government action on commercial piracy where the government is the sole party responsible for identifying and punishing sellers of illegal copies of legitimate products. However, in many countries, copyright holders initiate private litigation against commercial pirates by identifying their illegal activities and the government is responsible for penalizing

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[1]See the Eighth Annual BSA Global Software Piracy Study (2003), published by International Planning and Research Corporation for figures on retail, tax, and job losses due to piracy.

[2]See http://en.wikipedia.org/wiki/Copyright_infringement.

[3]Chen and Png (1999) show that pricing rather than monitoring is a better strategy for a firm in dealing with piracy by *end-users*. Cheng, Sims, and Teegen (1997) and Noyelle (1990) mention that the high price of software products is the dominant reason for piracy. Harbough and Khemka (2000) compares targeted enforcement to extensive enforcement and show that the latter is better than the former. Oz and Thisse (1999) show that in the presence of network externalities non-protection against piracy is an equilibrium. Takeyama (1994), Conner and Rumelt (1991), and Nascimento and Vanhonacker (1988) also discuss the role of network externalities on the marketing of software.

them.[4] In this paper we extend the literature on commercial piracy and study the impact of sharing of anti-piracy enforcement efforts between a producer and a government on piracy using a strategic entry-deterrence framework. This is an issue, which to the best of our knowledge, is yet to be addressed in the literature on copyright infringement.

We consider a market in which the legitimate producer, hereafter referred to as the monopolist, is the incumbent firm and acts as a leader. There is a possible entrant, hereafter referred to as the pirate, who does counterfeiting and offer unauthorized reproductions of licensed products commercially to compete with the legitimate one.[5] The government sets a penalty for copyright violations and the monopolist after observing the penalty chooses a monitoring and a pricing strategy. We assume that monitoring is costly and the monopolist bears this cost fully.

The monopolist's pricing strategy either allows (*accommodating strategy*) or deters (*aggressive strategy*) the pirate's entry. The accommodating pricing strategy does not eliminate the pirate's entry, which in this case, only depends on the monitoring rate. The aggressive strategy is a limit price such that it is not profitable for the pirate to enter the market. The pirate makes a choice among selling unauthorized reproductions of licensed products and risking enforcement, and not selling his product. If piracy is detected then the pirate pays a penalty to the monopolist as specified by the government. We make this assumption to avoid any other issues regarding the redistribution of the penalty.[6] The users are not prosecuted for buying pirated products.

The government's social welfare maximizing penalty determines the subgame perfect equilibrium monitoring and pricing strategy.[7] We show that even when the anti-piracy tools are shared between the government and the monopolist, the prevention of piracy solely depends on the government's attitude or sensitivity towards piracy. Sensitivity towards piracy is reflected by a weight that the government attaches to the monopolist's profit in the social welfare function.[8] Higher magnitudes of this weight indicate greater sensitivity towards piracy and a stronger anti-theft policy.

We show that if the government has a strong anti-theft policy and therefore, is sensitive towards piracy then only the socially optimal penalty may result in

[4]A recent report by Associated Press says, "Investigators from the Australian recording industry raided the Sydney offices of Internet file-swapping network Kazaa...in search of evidence to support allegations of copyright infringements... The Federal Court gave major Australian record labels permission to raid 12 premises in three states to collect evidence against Kazaa... The group (Music Industry Piracy Investigations) is owned by Universal, Festival Mushroom Records, EMI Music, Sony, Warner Music Australia and BMG Australia." See http://www.wired.com/news/, 9/02/2004. Similar type of arrangements also exists in the software industry where a firm may initiate and pursue investigations towards piracy on the directives of the court.

[5]The evidence presented in footnote 2 suggests that there are usually one or two organizations that produces bootlegged copies of licensed software and sell it through different retail channels. Indian Music Industry (IMI) in its web site www.indianmi.org lists three or four shops in each major cities of India that have been raided and their owners arrested for the sale of pirated music CDs. This highlights the importance that IMI attaches to commercial copyright infringement and provides a justification for considering a locally oligopolistic market structure in our paper.

[6]This transfer of penalty to the monopolist can also be viewed as compensation to cover the monitoring cost and the treble damages due to piracy.

[7]Social welfare is defined as the sum of the surpluses of every agent in the model.

[8]The sensitivity parameter can also be interpreted as a measure of special interest lobbying by the monopolist.

the aggressive strategy as the subgame perfect equilibrium. Consequently, there is monitoring and no piracy in equilibrium. The equilibrium limit price is less than the monopoly price and the monopoly outcome is never restored. If the sensitivity parameter is zero or "sufficiently" small then the socially optimal penalty structure is too low to induce any monitoring and therefore, the accommodating strategy with no monitoring is the subgame perfect equilibrium. Consequently, there is piracy in equilibrium. These results show that sensitivity towards piracy is a necessary but not a sufficient condition to prevent piracy even when enforcement is shared and the monopolist bears the full cost of monitoring. This is the main contribution of this paper.

The findings of this paper differ from those in Banerjee (2003, 2006) where the government, who is solely responsible for monitoring and penalizing the pirate, maximizes social welfare subject to a balanced budget constraint.[9] This implies that the government's only choice variable is the monitoring rate and the penalty is determined by the balanced budget rule. Banerjee (2006) considers an entry-deterrence framework and show that lobbying by a monopolist may result in monitoring as the socially optimal outcome which may not necessarily deter commercial software piracy. Only in the extreme case the monopoly outcome is restored. Banerjee (2003) do not consider a strategic entry-deterrence framework and show that if not monitoring is the socially optimal policy, then following the balanced budget rule there is no penalty in equilibrium. If monitoring is the socially optimal policy then piracy is prevented and the monopoly result is restored.

Let us now discuss the relevance of addressing the issue of commercial piracy. Harbough and Khemka (2000) in the context of targeted enforcement versus extensive enforcement show that enforcement targeted towards high value users encourage piracy among low value users because it raises the price and profit of the original product. This is due to the difficulty in raising the costs to home-users by disrupting easy access to bootlegged copies because home-users usually have lower valuations of most copyrighted products (e.g. software), which implies smaller gains from forcing the use of legitimate products. They also discuss the technical difficulties in implementing extensive enforcement even though it may be superior to the targeted policy. Given the difficulty in restricting end-user piracy, the anti-piracy policies may be directed towards commercial piracy. Consumers' who find it relatively expensive to make copies or download (in terms of lack of required expertise to make copies, lack of time to make copies or search for the necessary sites etc.), may be inclined to purchase pirated products, if available, for a relatively low price. Therefore, it is important to address commercial piracy separately from end-user piracy. This may not eliminate overall piracy but at least restrict it.[10]

This paper proceeds as follows. In section 2 we discuss the model. In section 3 we analyze the equilibrium accommodating and aggressive strategies. In section 4 we discuss the government's optimal social welfare policy and the corresponding

[9]The government's cost of monitoring equals its expected revenue from the penalty.

[10]On June 6 1996, in a testimony before the US Senate Finance Commitee, the US Trade representative complained that "compilation CD's" with 10,000 US dollar worth of software can be purchased for 5 US dollars in Hong Kong. A press release by Software and Information Industry Association, April 12, 2000, mentions prices as low as 13 US dollars for software retailing at 609 US dollars. This evidence highlights the significance of commercial piracy and the need to address this issue separately from end-user piracy.

subgame perfect equilibrium pricing and monitoring strategies. Sections 5 and 6 contain the discussions and the concluding remarks.

2. The Model

We consider a market for a copyrighted product and begin our analysis by describing the monopoly situation in the absence of piracy.[11] There is a continuum of consumers indexed by θ, $\theta \in [0,1]$. θ is assumed to follow a uniform distribution. We assume there is no resale market for used copyrighted products. Each consumer is assumed to purchase only one unit of the product. The utility of a type θ consumer from purchasing a unit of the software is:

$$U(\theta) = \begin{cases} \theta - p_m & \text{if the consumer buys the product} \\ 0 & \text{if the consumer does not buy} \end{cases} \tag{1}$$

θ is the valuation of the consumer and p_m is the price of one unit of the software charged by the monopolist. Thus, in the model, consumers differ from one another on the basis of their valuation of the software. The heterogeneity of the consumers, represented by the different magnitudes of θ, can be interpreted as a function of factors like product usage frequency, degree of utilization, user proficiency, and so on. Higher magnitudes of each of these factors are indexed by higher values of θ.

θ_m is the marginal consumer who is indifferent between buying and not buying.

$$U(\theta_m) = \theta_m - p_m = 0 \Rightarrow \theta_m = p_m \tag{2}$$

The monopolist faces the demand function,

$$D_m(p_m) = \int_{\theta_m}^{1} d\theta = 1 - p_m. \tag{3}$$

For simplicity we assume the cost of replicating the product is zero, and we model an installed monopolist, which allows us to avoid incorporating the fixed cost of developing the original product.[12] Hence, the profit of the monopolist is its total revenue, which is $\pi_m = p_m D_m$. The equilibrium monopoly results are,

$$p_m^* = \frac{1}{2}, \quad \theta_m^* = \frac{1}{2}, \quad \pi_m^* = \frac{1}{4}. \tag{4}$$

Let us introduce the commercial pirate in our model. The game played between the government, the monopolist, the pirate, and the consumers is specified in an extensive form as follows.

(1) **Stage 1**: The government chooses a penalty, G.
(2) **Stage 2**: The monopolist chooses a price, p_m, and a monitoring rate, α.
(3) **Stage 3**: The pirate observes the government's policy and the monopolist's strategy, and decides to enter or not. If it enters then it choses a price p_c.
(4) **Stage 4**: The consumers decide either to buy the original software or the pirated one or nothing.

We now discuss the behavior of each of the agents in the model. The monopolist is responsible for monitoring the pirate. Let α be the monitoring rate. If the illegal operations of the pirate are discovered, he pays a penalty G, $G_{\max} \geq G \geq 0$, to the monopolist, which is set by the government. We make this assumption to avoid

[11] The model in this paper was originally designed to consider a software market, but it applies just as well to other copyrightable products like music and movies.

[12] We discuss some of the issues regarding the effect of piracy on innovation in Section 6.

issues of redistribution of the penalty. This transfer of the penalty from the pirate to the monopolist can be viewed as compensation to the monopolist for incurring the monitoring cost and for the treble damages due to piracy.[13]

Let $c(\alpha)$ denote the cost of monitoring with the following properties; $c'(\alpha) > 0,\ c''(\alpha) > 0,\ c'(0) > 0$.[14] For algebraic tractability we assume the monitoring cost function has the form, $c(\alpha) = \frac{\alpha}{1-\alpha}$. The rationale behind using this cost function is that it is convex and that the cost of detecting the pirate with certainty goes to infinity.[15]

There is a qualitative difference between the original and the pirated product. This may be due to the support-benefits that are included with the purchase of the original product but does not come with the purchase of the pirated one. It may also be due to the risk that the pirated product is defective because they usually do not have a warranty. On the other hand, the original product receives full warranty. Let q be the quality of the pirated product and it is assumed to be common knowledge. We assume that $q \in [0, 1]$ and the quality of the original product is normalized to one which means that the pirate's product is an imperfect substitute of the original one.[16]

The purchasing options of a type-θ consumer are as follows. Option 1, he only buys the original product. Option 2, he buys the pirated product if it is available which occurs with probability $(1 - \alpha)$, otherwise he buys the original product. Option 3, he only buys the pirated product subject to its availability. Option 4, he buys nothing. So the utility of a type-θ consumer is,

$$U(\theta) = \begin{cases} \theta - p_m \text{ in option 1} \\ \alpha(\theta - p_m) + (1-\alpha)(q\theta - p_c) \text{ in option 2} \\ (1-\alpha)(q\theta - p_c) \text{ in option 3} \\ 0 \text{ in option 4.} \end{cases} \tag{5}$$

$q\theta$ is the consumer's effective valuation of the pirated software.

There are three marginal consumers; $\theta_1,\ \theta_2$ and θ_3. θ_1 is the marginal consumer who is indifferent between buying the original product only and buying the original one only if the pirated version is not available. θ_2 is the marginal consumer who is indifferent between buying the original product if the pirated one is not available and only buying the pirated version subject to its availability. θ_3 is the marginal consumer who is indifferent between buying the pirated version subject to its availability and not buying anything. These three marginal consumers are,

$$\begin{array}{l} \theta_1 - p_m = \alpha(\theta - p_m) + (1-\alpha)(q\theta - p_c) \ \Rightarrow\ \theta_1 = \frac{p_m - p_c}{1-q} \\ \alpha(\theta - p_m) + (1-\alpha)(q\theta - p_c) = (1-\alpha)(q\theta - p_c) \ \Rightarrow\ \theta_2 = p_m \\ (1-\alpha)(q\theta - p_c) = 0 \ \Rightarrow\ \theta_3 = \frac{p_c}{q} \end{array} \tag{6}$$

[13] We discuss this assumption in detail in Section 5.

[14] The assumption $c'(0) > 0$ is explained later in this paper.

[15] It is possible that the firm monitors but cannot detect the seller of the pirated software. This means that the firm knows that illegal software is sold in the market but cannot catch the seller. One explanation is that pirates conduct their operations through makeshift arrangements, eg., by continually changing their location. Or, it may be that a pirate gets some prior information about a possible raid and decides not to sell on that day or at that location. As Becker and Stigler (1974) mention that detection with certainty is difficult because malfeasant agents try to prevent detection and it is too costly to guarantee detection with certainty.

[16] Banerjee (2003, 2006), Besen and Kirby (1989), Takeyama (1994) also assumes that copies and originals are imperfect substitutes.

We assume that $1 > \theta_1 > \theta_2 > \theta_3$. A type-$\theta$ consumer strongly prefers the original product to the pirated one if $\theta \in [\theta_1, 1]$. The condition, $1 > \theta_1$, which means that some consumers buy the original product, implies $p_m < p_c + (1-q)$. A type-θ consumer weakly prefers the original product to the pirated one if $\theta \in [\theta_2, 1]$ and strongly prefers the pirated product to the original one if $\theta \in [\theta_3, \theta_2]$. A type-$\theta$ consumer does not buy anything if $\theta \in [0, \theta_3]$. The conditions $\theta_1 > \theta_2$ and $\theta_2 > \theta_3$, which imply that $p_c < qp_m$, means that some consumers buy the pirated good. If $\theta_1 > \theta_2$ then $\theta_1 > \theta_3$ also holds.[17]

The demand for the monopolist's product consists of buyers who strongly and weakly prefer the original product to the pirated one. The latter group consists of consumers who buy the original product if the pirated one is not available which occurs with probability, α. If the pirate does not enter then both groups buy the original product. There is a demand for the pirated product only if the pirate enters the market and his illegal operations are not detected, which occurs with probability $(1-\alpha)$. Therefore, the demand for the original and the pirated product are,

$$D_m(p_m, p_c, \alpha) = \begin{cases} (1-\theta_1) + \alpha(\theta_1 - \theta_2) = 1 - \frac{p_m - p_c}{1-q} + \alpha \frac{qp_m - p_c}{1-q} & \text{if pirate enters} \\ 1 - \theta_2 = 1 - p_m & \text{if pirate does not enter} \end{cases}$$
$$D_c(p_m, p_c, \alpha) = \begin{cases} (1-\alpha)(\theta_1 - \theta_2) = \frac{(1-\alpha)(qp_m - p_c)}{q(1-q)} & \text{if pirate enters} \\ 0 & \text{if pirate does not enter} \end{cases} \tag{7}$$

We assume that the market for product is quite large and is not fully covered, i.e., $D_m(p_m, p_c, \alpha) + D_c(p_m, p_c, \alpha) < 1$.

The consumer surplus is,

$$CS = \begin{cases} \int_{\theta_1}^{1} (\theta - p_m) d\theta + \alpha \int_{\theta_2}^{\theta_1} (\theta - p_m) d\theta + (1-\alpha) \int_{\theta_3}^{\theta_2} (q\theta - p_c) d\theta & \text{if pirate enters} \\ \int_{\theta_2}^{1} (\theta - p_m) d\theta & \text{if pirate does not enter} \end{cases} \tag{8}$$

If the pirate enters then the consumer surplus is the sum of the surplus to consumers who only purchase the original product, the surplus to the consumers who purchase the original product only if the pirated one is not available which occurs with probability α, and the surplus to the consumers who purchase the pirated product subject to its availability, the probability of which is $1 - \alpha$. If the pirate does not enter then the consumer surplus is the surplus of the consumers who strongly and weakly prefer the original product to the pirated one.

Let us now discuss the profits of the firms. We assume that a firm remains in the market only if it is making nonzero profit. Using the demand functions in equation (7) we get the monopolist's and the pirate's profits, denoted by π_m and π_c, as

[17]The condition $p_c < qp_m$ can be rewritten as $\frac{p_c}{q} < p_m$. Note that $\frac{p_c}{q}$ is the effective price of the pirated good. So $p_c < qp_m$ means that the price of the original product exceeds the effective price of the pirated one.

follows.

$$\pi_m(p_m,p_c,\alpha,G)=\begin{cases} p_m-\frac{p_m^2-p_mp_c}{1-q}+\frac{\alpha(qp_m^2-p_mp_c)}{1-q}+\alpha G-\frac{\alpha}{1-\alpha} & \text{if pirate enters}\\ p_m(1-p_m)-\frac{\alpha}{1-\alpha} & \text{if pirate does not enter}\end{cases}$$
$$\pi_c(p_m,p_c,\alpha,G)=\begin{cases}\frac{(1-\alpha)(qp_mp_c-p_c^2)}{q(1-q)}-\alpha G & \text{if pirate enters}\\ 0 & \text{if pirate does not enter}\end{cases} \tag{9}$$

The revenue to the monopolist is the product of its price and the demand for its product. If the pirate enters and the monopolist detects him, which occurs with probability α, then the monopolist receives the penalty G. So αG appears as a positive and a negative term in the monopolist's and the pirate's profit functions if the latter enters the market. If the pirate does not enter then the monopolist only incurs the monitoring cost.

The monopolist's objective is to choose a price and a monitoring rate that maximizes its profit. The monopolist chooses either an *accommodating* pricing strategy (ac) or an *aggressive* pricing strategy (ag). In case of the *ac-strategy*, the monopolist chooses a price and a monitoring rate that maximizes its profit by taking into consideration that the pirate enters the market. In this case, the pirate enters only if the optimal monitoring rate is such that the pirate's equilibrium profit is non-negative. On the contrary, the *ag-strategy* is a limit price such that it is not profitable for the pirate to enter the market. In this case the monopolist chooses a monitoring rate that maximizes its profit subject to the entry-deterrence condition.

The government chooses a penalty that maximizes social welfare. The social welfare (SW), is the sum of the profits of the monopolist and the pirate, and the consumer surplus.

$$SW=\begin{cases} p_mD_m+(1-\alpha)p_cD_c+CS-c(\alpha) & \text{if pirate enters}\\ p_mD_m+CS-c(\alpha) & \text{if pirate does not enter}\end{cases}. \tag{10}$$

3. Equilibrium Accommodating And Aggressive Strategies

We solve for the equilibrium by using the method of backward induction. In view of equation (9), the reaction function of the pirate is, $p_c=\frac{qp_m}{2}$. Therefore, in equilibrium the marginal condition $\theta_1>\theta_2>\theta_3$ is satisfied.

3.1. **The Accommodating Strategy.** Substituting the pirate's reaction function into the monopolist's profit function, and equating its first derivative with respect to p_m and α to zero, yields

$$\frac{\partial\pi_m^{ac}}{\partial p_m}=0\ \Rightarrow\ p_m=\frac{1-q}{2-q-\alpha q} \tag{11}$$

$$\frac{\partial\pi_m^{ac}}{\partial\alpha}=0\ \Rightarrow\ \frac{qp_m^2}{2(1-q)}+G=\frac{1}{(1-\alpha)^2}. \tag{12}$$

The RHS of equation (12) is the marginal revenue from monitoring and the LHS is the marginal cost of monitoring.[18] Substituting equation (11) in equation (12)

[18]The general form of equation (12) is $\frac{\partial\pi_m^{ac}}{\partial\alpha}=0\Rightarrow\frac{qp_m^2}{2(1-q)}+G=c'(\alpha)$. If $c'(\alpha)=0$, then $G_{\min}$ becomes negative. This means that the monopolist has to pay for not monitoring which is unrealistic. This justifies the assumption that $c'(0)>0$.

we get,

$$\frac{2}{q(1-q)}\left(\left(\frac{2-q-\alpha q}{1-\alpha}\right)^2-(2-q-\alpha q)^2G\right)=1 \tag{13}$$

Let α^{ac*} be the solution to equation (13), which is the equilibrium monitoring rate. Substituting this in equation (11) gives us the equilibrium *ac-strategy*, $p_m^{ac*}=\frac{1-q}{2-q-\alpha^{ac*}}$. The equilibrium profits of the monopolist and the pirate are $\pi_m^{ac*}(G)=\frac{1-q}{2(2-q-q\alpha^{ac*})}+\alpha^{ac*}G-\frac{\alpha^{ac*}}{(1-\alpha^{ac*})}$, and $\pi_c^{ac*}(G)=\frac{q(1-\alpha^{ac*})(1-q)}{4(2-q-q\alpha^{ac*})^2}-\alpha^{ac*}G$.

Proposition 1 summarizes some of the comparative static analyses with respect to G.[19]

Proposition 1. *i) There is no monitoring in equilibrium if the penalty is below the critical level $G_{\min}$, that is, $\alpha^{ac*}=0$ if G satisfies, $0\le G\le G_{\min}$, where $G_{\min}=1-\frac{q(1-q)}{2(2-q)^2}$. Also, $G_{\min}$ satisfies $0<G_{\min}<1$. (ii) The monopolist's equilibrium price, monitoring rate, and profit are strictly increasing in the penalty G, for $G\ge G_{\min}$.*

Proposition 1 shows that there is monitoring in equilibrium only when the penalty is above $G_{\min}$. Intuitively, the higher is the penalty the greater is the monopolist's incentive to monitor. Hence, the monitoring rate is strictly increasing in the penalty beyond the critical level $G_{\min}$. However, the increase in the monitoring rate due to an increase in the penalty raises the cost of monitoring. Consequently, the monopolist raises its price to generate higher revenues that compensates for the higher monitoring cost. Alternatively, we can also say that the monopolist can sustain a high price for its product by increasing the monitoring rate.

The possibility of detecting the pirate increases with an increase in the penalty beyond the critical level. There is a level of the penalty, say $\overline{G}$ at which $\pi_c^{ac*}(\overline{G})=\frac{q(1-\alpha^{ac*})(1-q)}{4(2-q-q\alpha^{ac*})^2}-\alpha^{ac*}\overline{G}=0$ hence, the pirate cannot enter. So for any penalty in the interval $G\ge\overline{G}$, there is no piracy and the monopolist's profit is $\pi_m^{ac*}(G)=p_m^{ac*}(1-p_m^{ac*})-\frac{\alpha^{ac*}}{1-\alpha^{ac*}}$.

In view of equations (8) and (10) the consumer surplus and the social welfare functions for the equilibrium *ac-strategy* are,

$$\begin{aligned} CS^{ac}(G)&=\tfrac{1}{2}-p_m^{ac*}+\tfrac{(4-3q-q\alpha^{ac*})p_m^{ac*}}{8(1-q)},\\ SW^{ac}(G)&=\tfrac{1}{2}-\tfrac{p_m^{ac*}}{8}-\tfrac{p_m^{ac*2}}{4}-\tfrac{\alpha^{ac*}}{1-\alpha^{ac*}}. \end{aligned} \tag{14}$$

3.2. **The Aggressive Strategy.** Substituting the pirate's reaction function in its profit function, we get, $\pi_c(p_m,\alpha,G)=\frac{(1-\alpha)qp_m^2}{4(1-q)}-\alpha G$. The pirate's entry is deterred if $\pi_c(p_m,\alpha)=\frac{(1-\alpha)qp_m^2}{4(1-q)}-\alpha G\le 0$ which can be written as, $p_m^2\le\frac{4\alpha G(1-q)}{(1-\alpha)q}$.

Suppose the entry deterrence condition holds with strict inequality, that is, $p_m^2<\frac{4\alpha G(1-q)}{(1-\alpha)q}$. In this case the monopolist can increase the price without changing the monitoring rate such that the inequality still holds. This also maximizes the monopolist's profit because the monitoring cost decreases. We continue this until

[19]The proofs of all the propositions in this paper are available on request from the author.

the entry-deterrence condition holds with equality. So the monopolist's profit-maximization problem is,

$$\begin{aligned} &\max_{\alpha} \ \pi_m(p_m, \alpha) = (1 - p_m)p_m - \tfrac{\alpha}{1-\alpha} \\ &\text{subject to} \quad p_m = \sqrt{\tfrac{4\alpha G(1-q)}{q(1-\alpha)}} \end{aligned} \tag{15}$$

Let p_m^{ag*} and α^{ag*} be the solution to this aggressive entry-deterrence strategy. The results are summarized in Proposition 2.

Proposition 2. *(i) The equilibrium ag-strategy is the limit price* $p_m^{ag*} = \frac{2(1-q)G}{4(1-q)G+q}$. *The equilibrium monitoring rate is* $\alpha^{ag*} = \frac{q(1-q)G}{q(1-q)G+(4(1-q)G+q)^2}$. *(ii) The monopolist's equilibrium profit* $\pi_m^{ag*} = \frac{(1-q)G}{4(1-q)G+q}$, *is strictly increasing in* G.

In the absence of a penalty the market is contestable, that is, the equilibrium limit price is zero, which is the perfectly competitive price since the marginal cost of production is assumed to be zero. Correspondingly, the equilibrium profit is also zero. $p_m^{ag*} < p_m^*$ and $\pi_m^{ag*} < \pi_m^*$ because $0 \leq G \leq G_{\max}$ by assumption. Therefore, the outcomes for the equilibrium aggressive strategy are less than that in the monopoly case. This is because the monopolist bears the monitoring cost which is always there because of the pirate's threat of entry which in turn generates some form of competition which causes the limit price to be always less than the monopoly price.[20]

The consumer surplus and the social welfare functions for the equilibrium *ag-strategy* are,

$$\begin{aligned} &CS^{ag}(G) = \tfrac{4((1-q)G)^2+4q(1-q)G+q^2}{2(4(1-q)G+q)^2} \\ &SW^{ag}(G) = \pi_m^{ag}(G)^* + CS^{ag}(G)^* = \tfrac{12((1-q)G)^2+6q(1-q)G+q^2}{2(4(1-q)G+q)^2} \end{aligned} \tag{16}$$

4. Social Welfare And Optimal Strategies

In this section we discuss the social welfare issues and the government's choice of optimal penalty. The government's social welfare maximizing penalty determines the subgame perfect equilibrium pricing and monitoring strategy. Let G^* be the socially optimal penalty. The results for the social welfare-maximizing penalty and the corresponding subgame perfect equilibrium strategies of the monopolist are summarized in Proposition 3.[21]

Proposition 3. *Any penalty* G *that satisfies* $0 \leq G < \frac{1}{2}$ *is socially optimal, that is,* $G^* \in [0, \frac{1}{2})$. *The ac-strategy* $p_m^{ac*} = \frac{1-q}{2-q}$ *and* $\alpha^{ac*} = 0$ *is the subgame perfect equilibrium.*

[20]Increases in G affect the monopolist's profit by affecting the equilibrium entry-deterring limit price and the equilibrium monitoring rate. $p_m^{ag*\prime} = \frac{2q(1-q)}{(4(1-q)G+q)^2} > 0$ which implies that the equilibrium limit price is strictly increasing in G. However, $\alpha^{ag*\prime} = \frac{q(1-q)(4(1-q)G+q)(q-2(1-q)G)}{(q(1-q)G+(4(1-q)G+q)^2)^2}$ is positive, negative, or zero, if $q > 2(1-q)G$, $q < 2(1-q)G$or $q = 2(1-q)G$. So starting from zero as G increases initially the equilibrium monitoring rate increases and then it decreases. The initial increase in the monitoring rate that increases the monitoring cost is outweighed by the increase in the revenue due to an increase in the equilibrium limit price. For further increases in G the monitoring cost decreases because the equilibrium monitoring rate decreases and the revenue increases because the limit price increases. Hence, the monopolist's profit is strictly increasing in G.

[21]We assume that if $\pi_m^{ag*}(G) = \pi_m^{ac*}(G)$, for any G, the monopolist chooses the *ag-strategy*.

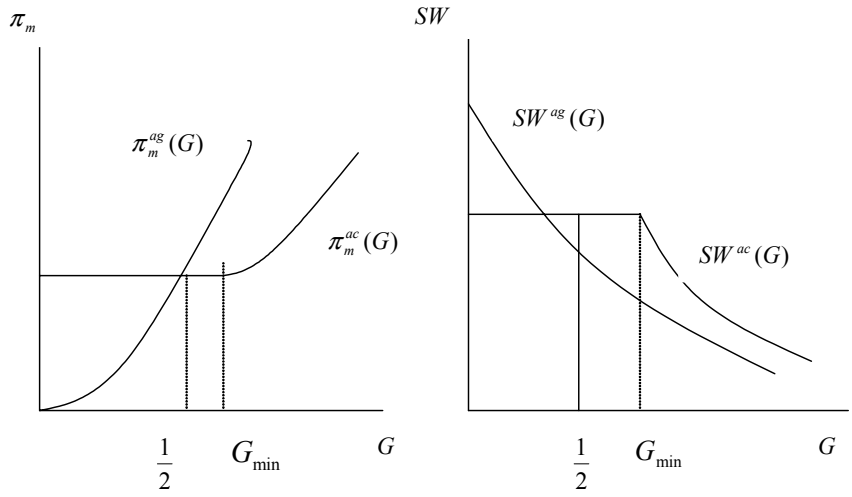

FIGURE 1. A diagramatic representation of proposition 3.

The two panels in Figure 1 provide a diagrammatic explanation of Proposition 3. From the right hand panel we see that zero penalty maximizes $SW^{ag}(G)$ and any penalty in the interval $[0, G_{\min}]$ maximizes $SW^{ac}(G)$. From the left hand panel we observe that in the interval $G \in [0, \frac{1}{2}]$ the accommodating strategy is weakly dominant because $\pi_m^{ac*} > \pi_m^{ag*}$. So any penalty in the interval $G \in [0, \frac{1}{2}]$ is social welfare maximizing. This is because if the government chooses a G such that $G > \frac{1}{2}$ then the monopolist will choose the aggressive strategy since it is the dominant strategy in the interval $G > \frac{1}{2}$. However, this penalty is not welfare maximizing since zero penalty maximizes the social welfare associated with the equilibrium aggressive strategy.

Proposition 3 shows that even when anti-piracy policies are shared between the government and the monopolist, and the latter bears the cost of monitoring, the government's social welfare maximizing penalty, which may be positive, do not result in monitoring and therefore, there is piracy in equilibrium.

Let us discuss the conditions under which it is possible to prevent piracy. Suppose the government is sensitive towards piracy. This means that the government cares about the loss to the monopolist due to piracy and therefore, attaches a weight $1+\beta$ to the monopolist's profit in the social welfare function. The parameter $\beta > 0$ measures the extent of the government's sensitivity to piracy. Higher magnitudes of β imply greater sensitivity to piracy. In this case the social welfare function becomes,

$$SW_s^i(G) = (1+\beta)\pi_m^{i*} + \pi_c^{i*} + CS^i = SW^i(G) + \beta\pi_m^{i*},\ i \in \{ac, ag\}. \tag{17}$$

The subscript, 's', represents the social welfare function with the inclusion of the sensitivity parameter.

The inclusion of the sensitivity parameter may change the property of the social welfare functions with respect to the penalty. From equation (17) we get $SW_s^{ag\prime}(G) = SW^{ag\prime}(G) + \beta\pi_m^{ag*\prime}(G)$. The sign of $SW_s^{ag\prime}(G)$ is ambiguous because

$SW^{ag\prime}(G) < 0$ and $\beta\pi_m^{ag*\prime}(G) > 0$. Since π_m^{ac*} is independent of G in the interval $G \in [0, G_{\min}]$, hence, SW^{ac} is also independent of G in this interval. For $G > G_{\min}$, the sign of $SW_s^{ac\prime}(G) = SW^{ac\prime}(G) + \beta\pi_m^{ac*\prime}(G)$ is ambiguous because $SW^{ac\prime}(G) < 0$ and $\beta\pi_m^{ac*\prime}(G) > 0$.

Let G_s^{ac*} and G_s^{ag*} be the penalties that maximize $SW_s^{ac}(G)$ and SW_s^{ag}. We assume that the sensitivity parameter is such that G_s^{ac*} and G_s^{ag*} are interior solutions, that is, $0 < G_s^{i*} < \overline{G}$, $i \in \{ac, ag\}$. Let G_s^* be the socially optimal penalty. The result for the optimal penalty with the inclusion of the sensitivity parameter is discussed in Proposition 4.

Proposition 4. *Piracy is prevented only if the sensitivity parameter is such that either, (i)* $G_s^{ag*} \geq \frac{1}{2}$ *and* $SW_s^{ag}(G_s^{ag*}) > SW_s^{ac}(G_s^{ac*})$*, or (ii)* $G_s^{i*} \in \left[\frac{1}{2}, \overline{G}\right)$ *is satisfied,* $i \in \{ac, ag\}$*. The socially optimal penalty is* $G_s^* = G_s^{ag*}$ *and the aggressive strategy is the subgame perfect equilibrium.*

Proposition 4 shows that government's sensitivity towards piracy is a necessary but not a sufficient condition to prevent piracy. If the conditions specified in Proposition 4 are not satisfied then either the accommodating strategy is the subgame perfect equilibrium in which case piracy exists or equilibrium does not exist.[22] So the prevention of piracy solely depends on the government's stance towards piracy which is reflected by the magnitude of the parameter β.

Propositions 3 and 4 suggest that differences in the penalty structure across countries may explain the observed variation in piracy rates across countries.[23] In a market where the monopolist is competing with the pirate, the monopolist who may not be locally headquartered may even be perceived with some hostility and the government may only look at the short run benefits associated with piracy. Such a government may not consider piracy as a serious offence. In this situation the penalty structure may not be sufficient to prevent piracy. On the contrary, a government that considers piracy as a serious offence and have a consistent anti-theft policy may have a penalty structure that results in the deterrence of commercial piracy.

To understand the significance of attaching a weight to the monopolist's profit that may result in deterring piracy, we consider some alternate specifications. First, let us consider a social welfare function with a weight attached to the consumer's surplus. Consumer surplus is decreasing in the penalty for both the accommodating and aggressive strategies. This is because an increase in the penalty increases the price that results in a fall in the consumer surplus. So attaching a weight to the consumer surplus reinforces the inverse relationship between the social welfare functions and the penalty and the result summarized in Proposition 3 continues to hold.

Second, excluding the pirate's profit from the social welfare function only affects the social welfare function for the equilibrium accommodating strategy but not that for the equilibrium aggressive strategy since it does not contain the pirate's profit in the first place. So with no change in SW^{ag} it continues to be strictly decreasing in the penalty and therefore, a zero penalty maximizes SW^{ag}. Consequently, the

[22] This is discussed in the proof of Proposition 4 in the Appendix.

[23] See the Eighth Annual BSA Global Software Piracy Study (2003), published by International Planning and Research Corporation for figures on piracy rates, which is measured as the amount of software installed without a license, across countries. This measure includes both end-user and commercial piracy. For example, piracy rates in 1999 vary from 24% in the US to 95% in Vietnam.

aggressive strategy is never a subgame perfect equilibrium which means that piracy exists in equilibrium. The same result holds if we consider a social welfare function with no weights attached to the monopolist's profit and consumer surplus, and a weight $\beta < 1$ attached to the pirate's profit. In this case again SW^{ag} is unaffected for reasons mentioned above, hence a zero penalty maximizesSW^{ag}, therefore, the aggressive strategy is never a subgame perfect equilibrium and piracy exists in equilibrium.

Finally, let us consider a social welfare function where a reduced weight is attached to the consumer surplus, and the monopolist's and pirate's profit are treated neutrally. In this case the inverse relation between SW^{ag} and the penalty is weakened and G_s^{ag*} may be an interior solution. Then there may be no piracy in equilibrium if the conditions specified in Proposition 4 are satisfied. The same is true if a reduced weight is attached to both consumer surplus and the pirate's profit, and the monopolist's profit is treated neutrally.

The above discussions regarding alternative specifications of the social welfare function suggests that the result summarized in Proposition 4 continues to hold as long as the relative weight attached to the monopolist's profit exceeds that attached to the consumer surplus and the commercial pirate's profit.

5. Discussion

In this section we discuss some of the issues regarding the legal distinctions between civil versus criminal actions regarding copyright piracy. We cite the U.S. legal documents to provide support for the above and for assuming the redistribution of penalty to the monopolist as compensation for incurring the monitoring cost and other treble damages.

According to The Computer Crime and Intellectual Property Section (CCIPS) of the US Department of Justice, "the law of copyright provides federal legal protection for infringement of certain exclusive rights, such as reproduction and distribution, of certain "original works of authorship", including computer software, literary works, musical works, and motion pictures." (See 17 U.S.C. § 102(a)). "Intellectual property may be misappropriated in many ways. A copyrighted work may be illegally infringed by making and selling an unauthorized copy, as with pirated computer software... Although civil remedies that may provide compensation to wronged intellectual property rights holders are available, criminal sanctions are often warranted to ensure sufficient punishment and deterrence of wrongful activity. Indeed, because violations of intellectual property rights often involve no loss of tangible assets and, for infringement crimes, do not even require any direct contact with the rights holder, the rights holder often does not know it is a victim until a defendant's activities are specifically identified and investigated. (US) Congress has continually expanded and strengthened criminal laws for violations of intellectual property rights specifically to ensure that those violations are not merely a cost of doing business for defendants. Criminal infringement of copyrighted works is set out at 17 U.S.C. § 506(a) and 18 U.S.C. § 2319. Experience has proven that federal investigators and prosecutors can bring cases under these provisions that result in punishment for the wrongdoer, as well as deterrence for intellectual property crimes."[24]

[24]See the US Department of Justice, CCIPS's website www.cybercrime.gov/ipmanual/01ipma.htm.

According to Title 17, Chapter 5, § 504, "Remedies for infringement: Damages and profits" provided by the LII / Legal Information Institute of the Cornell Law School,

"(a) In General.– Except as otherwise provided by this title, an infringer of copyright is liable for either

(1) the copyright owner's actual damages and any additional profits of the infringer, as provided by subsection (b); or

(2) statutory damages, as provided by subsection (c).

(b) Actual Damages and Profits − The copyright owner is entitled to recover the actual damages suffered by him or her as a result of the infringement, and any profits of the infringer that are attributable to the infringement and are not taken into account in computing the actual damages. In establishing the infringer's profits, the copyright owner is required to present proof only of the infringer's gross revenue, and the infringer is required to prove his or her deductible expenses and the elements of profit attributable to factors other than the copyrighted work.

(c) Statutory Damages -

(1) Except as provided by clause (2) of this subsection, the copyright owner may elect, at any time before final judgment is rendered, to recover, instead of actual damages and profits, an award of statutory damages for all infringements involved in the action, with respect to any one work, for which any one infringer is liable individually, or for which any two or more infringers are liable jointly and severally, in a sum of not less than $750 or more than $30,000 as the court considers just. For the purposes of this subsection, all the parts of a compilation or derivative work constitute one work.

(2) In a case where the copyright owner sustains the burden of proving, and the court finds, that infringement was committed willfully, the court in its discretion may increase the award of statutory damages to a sum of not more than $150,000."[25]

6. Conclusion

The focus of the earlier literature on copyright piracy was on piracy by end-users and government's role in implementing enforcement policies to counter commercial piracy. In this paper, we used a strategic entry-deterrence framework to analyze the effects of enforcement sharing between the government and the monopolist on commercial piracy.

Specifically, we considered a situation where the government is responsible for penalizing the pirate and the monopolist is responsible for monitoring the illegal operations of the pirate, which is costly, and pricing its product. The monopolist either chose an accommodating or an entry-deterring aggressive pricing strategy. The government's social welfare maximizing penalty endogenously determined the monopolist's subgame perfect equilibrium pricing and monitoring strategy.

We found that the socially optimal penalty may result in monitoring and no piracy in equilibrium only if the government is sufficiently sensitive to piracy. In this case the aggressive strategy is the subgame perfect equilibrium. If the government is not sensitive or sensitivity is rather low then the socially optimal penalty may

[25]See www4.law.cornell.edu/uscode/html/uscode17.

be positive but the accommodating strategy with no monitoring is the subgame perfect equilibrium and consequently piracy prevails. So sensitivity to piracy is a necessary but not a sufficient condition to prevent piracy. This also supports Microsoft's continuous argument for higher penalties.[26]

Our findings suggest that even when anti-piracy efforts are shared between a government and a firm, the prevention of piracy solely depends on the government's attitude towards piracy which is reflected by the optimal penalty structure. The variation in the governments' attitude results in a variation in the penalty structure across countries. This in turn may explain the observed variation in the piracy rates across countries.

In this paper the extensive form representation begins with decisions that are post-innovation. Hence, the impact of piracy on innovation is ignored. A more general representation would account for innovation costs and the monopolist's decision of whether to innovate or not. In relation to this issue, Banerjee and Mukherjee (2006) analyses the relationship between copying cost, and a monopolist's profit and product quality in the presence of commercial piracy. They show that the monopolist's subgame perfect equilibrium investment in quality, and profit is either unaffected or positively affected by changes in the copying cost. Tariffs on copying devices may be an effective copyright protection instrument. Though an increase in tariff increases the monopolist's profit, product quality and therefore, the monopolist's incentive to invest, the welfare effects are ambiguous. Novos and Waldman (1984) show that increases in copyright protection increases the social welfare loss due to underproduction. A rise in copyright protection increases the number of consumers of the original product, which in turn increases the quality of the product. This in turn may result in switching of consumers from the original to the copied product. So the overall effect depends on the relative strengths of these two opposing forces and hence, an increase in copyright protection may increase the social welfare loss due to underproduction.

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