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Endogenous IPR Protection, Commercial Piracy, and Welfare Implications for Anti-Piracy Laws*

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Abstract: In the presence of commercial digital piracy, should the government provide costly protection for intellectual property rights (IPR)? Under what conditions will government protection and private protection be substitutes or complements? We show that a product's original developer has an incentive to bear R&D costs for private protection when the quality of a pirated copy is moderate. We consider that the welfare-maximizing government determines its costly IPR protection and commits a fraction of the pirate's monetary fines to the developer for compensation while striking a balance in the enforcement budget. In this case, the government will not launch costly IPR enforcement unless the pirated copy's quality is sufficiently high. Otherwise, government IPR protection is socially undesirable. These results suggest that government protection and private protection are substitutes.

Keywords*:* digital piracy, intellectual property rights, government protection, private protection
JEL codes*:* D23, D43, L13, L86

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1. Introduction

Voluminous studies have contributed to our understanding of commercial piracy and its impact on profits accrued to products' original developers and the quality of digital products in the market.[1] Recognizing the existing studies' contributions in the literature, we observe two fundamental questions continuously challenging product innovators and anti-piracy policymakers in markets with extensive commercial piracy. What are the conditions under which the government should provide costly protection for intellectual property rights (IPR) to achieve social welfare maximization? Will IPR protection and product developers' private protection be substitutes or complements? In this paper, we attempt to provide preliminary answers to the questions.

Our study complements the contribution of Lu and Poddar (2011). The authors examine economic incentives an original product developer has for undertaking R&D investments to deter a commercial pirate in a given regime of IPR protection. The authors consider that the commercial pirate and the product developer engage in Bertrand competition under a partial cover market. In this study, we introduce the endogenous decisions of IPR protection (enforcement and punishment) by the government into a full cover market to see how it affects a product developer's incentive to undertake private protection.

We consider a three-stage game. At stage one, the government launches an IPR enforcement and imposes monetary fines on commercial pirating to maximize social welfare.

[1] Piracy of products in a digital format involves low or zero costs, creating a strong incentive to pirate digital goods. For contributions that analyze general issues on commercial piracy, see, e.g., Banerjee (2003, 2011), Andres (2006), Kiema (2008), Jaisingh (2009), Martínez-Sánchez (2010), and Lu and Poddar (2011). For studies on digital and software piracy effects on market outcomes see, e.g., Conner and Rumelt (1991), Slive and Bernhardt (1998), Shy and Thisse (1999), Yao (2005), Bae and Choi (2006), Peitz and Waelbroeck (2006), Belleflamme and Picard (2007), Cremer and Pestieau (2009), and Chang and Walter (2015). For issues on copyright laws, protection and enforcement, see, e.g., Koboldt (1995), Landes and Posner (1989), Stolpe (2000), Chen and Png (2003), Andres (2006), and Kim (2007).

The government commits a fraction of the pirate's monetary fines to compensate the product developer's financial damage by commercial piracy while striking a balance in the enforcement budget.[2] At stage two, the product developer takes the government's decisions (IPR protection and compensation) as given and undertakes an optimal R&D investment to increase piracy costs. At stage three, the developer and the pirate engage in price competition. The key findings are as follows. (i) The original developer has an incentive to increase piracy costs by undertaking R&D investments only when the pirated copy's quality is moderate. (ii) The government will not launch costly IPR enforcement unless the pirated copy's quality is sufficiently high. Otherwise, government IPR protection is socially undesirable. These results imply that government protection and private protection are substitutes.

2. The Model

Consider a product developer (as a monopoly) who has invented a new digital good to serve a continuum of consumers. A pirate has the technology to copy the original product with little or no cost but at a lower quality. Consumers may use the pirated copy but enjoy a *lower* valuation of the product, denoted as q, where $0 < q < 1$. To combat commercial piracy – by increasing its costs,[3] the product developer undertakes R&D investments (denoted as x), which is taken to be a quadratic function: $c_o(x) = \frac{1}{2}x^2$. As piracy hurts the product developer, the developer requests compensation from the pirate.[4] We consider that the government commits a fraction (denoted by α) of the monetary fines to be allotted to the product developer for

[2] We borrow this balanced budget consideration from Banerjee (2003).
[3] This is consistent with the notion of cost-raising strategies as discussed in Salop and Scheffman (1987).
[4] We owe this valuable point to an anonymous referee who suggests that we discuss the more realistic case in which the product developer requests financial compensation from the pirate. This suggestion leads to interesting results with policy implications.

compensation, where $0 < \alpha < 1$.

Consumers with different valuations for a product (either the original or the pirated one) are indexed uniformly over a unit line, i.e., $X \in [0,1]$.[5] Consumer heterogeneity in tastes for product quality is captured by the following preference function:

$$U = \begin{cases} X - p_0 & \text{if buys the original version;} \\ qX - p_p & \text{If buys the pirated copy,} \end{cases} \tag{1}$$

where p_0 is the price of the original product, and p_p is the price of the pirated copy.

The marginal consumer, denoted as X^*, is indifferent between the original product and the pirated copy such that $X^* - p_o = qX^* - p_p$. This implies that

$$X^* = \frac{p_o - p_p}{(1-q)}.$$

Market demand for the original product is:

$$D_o = \int_{X^*}^{1} dx = (1 - X^*) = \frac{(1-q) - (p_o - p_p)}{(1-q)}, \tag{2}$$

and that for the pirated good is:

$$D_p = \int_{0}^{X^*} dx = \frac{p_o - p_p}{(1-q)}. \tag{3}$$

Denoting $c(>0)$ as the per-unit penalty cost that the government imposes on the pirate, the total monetary fine is then given as cD_p.

Using backward induction to solve the subgame perfect Nash equilibrium in a three-stage game, we begin with the third stage at which the developer and the pirate engage in Bertrand

[5] We consider the case of a fully covered market. This consideration is consistent with the literature that uses a vertical product differentiation framework (see, e.g., Crampes and Hollander 1995; Wauthy 1996; Chang and Raza 2018) to examine various issues on product quality.

competition. The pirate's profit function is:

$$\pi_p = (p_p - c - x)D_p = (p_p - c - x)\left[\frac{p_o - p_p}{(1-q)}\right]$$

and its first-order condition (FOC) is:

$$\frac{\partial \pi_p}{\partial p_p} = \frac{(p_o - p_p) + (c + x - p_p)}{(1-q)} = 0. \tag{4}$$

The original developer's profit function is:

$$\pi_o = \ p_o D_o + \alpha c D_p - \frac{1}{2}x^2 = p_o\left[\frac{(1-q)-(p_o - p_p)}{(1-q)}\right] + \alpha c\left[\frac{p_o - p_p}{(1-q)}\right] - \frac{1}{2}x^2,$$

and its FOC is:

$$\frac{\partial \pi_o}{\partial p_o} = \frac{(1-q)-(p_o - p_p) + p_o + c\alpha}{1-q} = 0. \tag{5}$$

The FOCs in (4) and (5) imply the Bertrand prices:

$$p_o = \frac{c + x + 2(1-q) + 2\alpha c}{3} \text{ and } p_p = \frac{2(c+x)+(1-q)+\alpha c}{3}. \tag{6}$$

Substituting the prices from (6) back into the demands in (3) and (4) yields:

$$D_o = \frac{c + x + 2(1-q) - \alpha c}{3(1-q)} \text{ and } D_p = \frac{(1-q)-(c+x)+\alpha c}{3(1-q)}. \tag{7}$$

We move to the second stage, at which the product developer undertakes an optimal R&D investment to increase piracy costs by solving the following problem:

$$\begin{aligned}\underset{\{x\}}{\text{Max}}\ \pi_o &= p_o D_o + \alpha c D_p - \frac{x^2}{2} \\ &= \left[\frac{c + x + 2(1-q) + 2c\alpha}{3}\right]\left[\frac{c + x + 2(1-q) - \alpha c}{3(1-q)}\right] - \alpha c\left[\frac{1 - q - (c+x) + \alpha c}{3(1-q)}\right] - \frac{x^2}{2}.\end{aligned} \tag{8}$$

The developer's FOC is:

$$\frac{\partial \pi_o}{\partial x} = -\frac{\left(2c - 4q - 7x - 2c\alpha + 9qx + 4\right)}{9(1-q)} = 0$$

which implies that the optimal R&D investment is:

$$x^* = \frac{2(1-\alpha)c + 4(1-q)}{7-9q}. \tag{9}$$

It follows from (9) that [6]

$$x^* > 0 \text{ iff } 0 < q < \frac{7}{9} \approx 0.7778. \tag{10}$$

We, therefore, have:

PROPOSITION 1. *In the presence of commercial piracy, a product's original developer has an incentive to undertake R&D for increasing piracy costs when the quality of the pirated copy is moderate* $(0 < q < 0.7778)$. *If, instead, the pirated copy's quality is sufficiently high* $(q > 0.7778)$, *the developer finds it unprofitable to undertake R&D for deterring piracy.*

We proceed to the first stage, at which the welfare-maximizing government determines its IPR protection and enforcement by imposing an optimal fine (*c*) on commercial pirating. Before solving the monetary penalty, we calculate market prices, demands, and firm profits in terms of *c*. Substituting $x^*(>0)$ from (9) back into (4)-(7) yields:

$$p_o = \frac{3(1-q)[c+2(1-q)] + 2c\alpha(2-3q)}{7-9q}, \quad p_p = \frac{(1-q)(6c+5-3q) + c\alpha(1-3q)}{7-9q},$$

$$D_o^* = \frac{3[(1-\alpha)c + 2(1-q)]}{7-9q}, \quad D_p^* = \frac{(1-3q) - 3c(1-\alpha)}{7-9q},$$

$$\pi_o = \frac{[c+2(1-q)]^2 + \alpha c[(3-5q) - c(2-\alpha)]}{7-9q}, \quad \pi_p^* = \frac{(1-q)[3c(1-\alpha) + (3q-1)]^2}{(7-9q)^2}. \tag{11}$$

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[6] The second-order condition (SOC) is satisfied when the inequality condition in (10) holds since $\partial^2 \pi_o / \partial x^2 = -(7-9q)/[9(1-q)] < 0.$

The government's effort in enforcing anti-piracy laws by imposing monetary fines is costly. It is plausible to assume that this enforcement cost (*EC*) is a non-decreasing function of fines. As in the literature, social welfare (*SW*) is the sum of consumer surplus (from consuming both the original product and the pirated copy), the product developer's profit, the pirate's profit, and the government's net revenue, which is the total monetary fine collected from the pirate minus (i) that portion of the fine allotted to the product developer as compensation and (ii) the cost of enforcing the anti-piracy laws. That is,

$$SW = \int_{X^*}^{1}(X - p_o^*)dx + \int_0^{X^*}(qX - p_p^*)dx + \pi_o + \pi_p + [cD_p - \alpha cD_p - EC(c)].$$

Taking into account the government's balanced budget condition for enforcement effort that $cD_p = \alpha cD_p + EC(c),$ we have:

$$SW = \left[\frac{X^2}{2} - p_o X\right]_{X^*}^{1} + \left[\frac{qX^2}{2} - p_p X\right]_0^{X^*} + \pi_o + \pi_p, \tag{12}$$

where product prices and demands, and firm profits are given in (11). The government's FOC is:

$$\frac{\partial SW}{\partial c} = \frac{(\alpha - 1)[c(1-\alpha)(45q - 41) + 2(q-1)(9q-1)]}{(9q-7)^2} = 0,$$

which implies that the socially optimal fine is:

$$c^* = \frac{2(1-q)(9q-1)}{(1-\alpha)(45q-41)}. \tag{13}$$

It follows from c^* in (13) that[7]

$$c^* > 0 \text{ when } q > 0.91111. \tag{14}$$

We thus have:

PROPOSITION 2. *In the presence of commercial piracy, a welfare-maximizing government that*

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[7] The SOC for welfare maximization is: $\frac{\partial^2 SW}{\partial c^2} = -\frac{(1-\alpha)^2(45q-41)}{(9q-7)^2} < 0$ when $0.91111 < q < 1$.

commits a fraction of the pirate's monetary fines to the developer for compensation while striking a balance in the enforcement budget will not launch costly IPR enforcement unless the pirated copy's quality is sufficiently high $(q > 0.91111)$. *Otherwise, government IPR protection is socially undesirable.*

Propositions 1 and 2 imply that government protection and private protection are substitutes. Under the circumstances that a product's original developer requests compensation and the government considers a balanced budget when maximizing social welfare, the latter finds it beneficial to enforce costly IPR only when the pirated product's quality is critically high. In this case, the original developer's financial damage is considerably large, and the government's revenue from charging fines on commercial piracy may be sufficient to defray the costs of enforcement and compensation.[8]

Substituting c^* in (13) back into (11), we calculate profits for the original developer and the pirate:

$$\pi_o^* = \frac{4(1-q)[9q(72q+2\alpha+45q\alpha-128)+504-391\alpha]}{2(1-\alpha)(45q-41)^2},$$

$$\pi_p^* = \frac{(1-q)[3c(1-\alpha)+(3q-1)]^2}{(9q-7)^2}. \quad (15)$$

The economic implications of the results in (15) are as follows:

PROPOSITION 3. *Whether a product's original developer finds it profitable to stay in business or not depends on the values of* α and q. *However, commercial piracy is always profitable for* $0 < q < 1$ and $0 < \alpha < 1$.

[8] However, If the pirated product's quality is low, the government does not have any incentive to enforce IPR because the financial damage to the original firm is small. In this case, the government's revenue collected from penalizing commercial piracy may not be sufficient to cover the enforcement effort, and the financial compensation to the product developer.

Proposition 3 implies that an original developer's profit may be less than zero when the pirated copy’s quality is extremely high, and the share of the financial compensation is critically low. Consequently, the original developer quits its business.

3. Concluding Remarks

In this paper, we examine two issues of policy importance. One is to identify the conditions under which the government should provide costly IPR protection to achieve social welfare maximization in the presence of commercial digital piracy. The other is to see whether government IPR protection and private protection are substitutes or complements. We show that the original developer has an incentive to increase piracy costs by undertaking R&D investments only when the pirated copy's quality is moderate. Nevertheless, endogenous IPR enforcement and punishment are socially desirable only when the pirated copy's quality is sufficiently high. Otherwise, government IPR protection is socially undesirable. These results suggest that endogenous IPR protection and private protection are substitutes. Furthermore, if the pirated good’s quality is extremely high, and the share of the financial compensation to an original developer is critically low, the developer finds it unprofitable to stay in business.

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