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DOES COPYRIGHT ENFORCEMENT ENCOURAGE PIRACY?*

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When copyright enforcement is targeted at high-value buyers such as corporate and government users, the copyright holder charges super-monopoly prices, thereby encouraging low-value buyers to switch to inferior pirated copies. We show that enlarging the copyright holder's captive market through more extensive copyright enforcement reduces prices toward the monopoly level, increases sales of legitimate copies and can increase consumer surplus. Therefore, in contrast with the case of more intensive copyright enforcement, more extensive copyright enforcement over some range can increase the incentive to generate intellectual property while also reducing the loss to consumers from monopoly power.

I. INTRODUCTION

ECONOMIC THEORIES OF COPYRIGHT ENFORCEMENT HAVE FOCUSED on enforcement that is broad-based in that it raises the cost of piracy to all consumers.[1] For instance, pirated copies are made more costly by taxing new reproduction technologies, by intercepting and destroying illegal copies, or by prosecuting and penalizing distributors of pirated goods. However, the decentralized nature of the internet has made such methods more difficult, so enforcement is often aimed directly at end-users,[2] and in particular at those who are likely to be at the higher end of the demand curve. For instance, software copyright enforcement is aimed primarily at corporate and

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[1] Notable examples include Johnson [1985], Besen and Kirby [1989], Chen and Png [1999], and Yoon [2002]. For a survey see Peitz and Waelbroeck [2006].

[2] In response to the difficulty of shutting down distribution channels for internet piracy, the U.S. No Electronic Theft (NET) Act of 1997 criminalized even non-commercial piracy, and the U.S. Digital Theft Deterrence and Copyright Damages Improvement Act of 1999 increased penalties for end-users.

institutional users rather than individual users,[3] and copyright enforcement is typically stronger in richer countries than in poorer countries.[4]

We analyze how such targeted enforcement differs from broad-based enforcement in the standard piracy model of Besen and Kirby [1989] where a copyright holder competes with sellers of inferior pirated copies. By increasing the cost of buying or using pirated copies for all consumers, Chen and Png [1999] show that broad-based enforcement reduces piracy and allows the copyright holder to raise the price of a legitimate copy up toward the monopoly price. In contrast, enforcement targeted against high-value buyers gives the copyright holder monopoly power over them, but does not affect piracy costs for low-value buyers, so it encourages the copyright holder to raise prices to super-monopoly levels that only high-value buyers can afford. Since lower-value buyers face higher prices for legitimate copies, but do not face higher piracy costs under the targeted policy, they are induced to switch to inferior pirated copies, so targeted enforcement can increase rather than decrease piracy.

Because of super-monopoly pricing, enforcement that is targeted narrowly on high-value buyers increases copyright holder profits at very substantial cost to consumer surplus. However, as enforcement is extended further down the demand curve, more extensive enforcement benefits inframarginal consumers because the copyright holder lowers the price toward the monopoly level to gain new customers. We find that there is always some range within which this gain to inframarginal consumers exceeds the losses to marginal consumers who must buy the expensive legitimate copy instead of the pirated copy. Therefore both copyright holder profits and consumer surplus can increase due to more extensive enforcement, implying that the classic tradeoff between the *ex ante* incentive to generate intellectual property and the *ex post* inefficiency of monopoly power is avoided.[5]

That more enforcement can sometimes help consumers contrasts with the case of broad-based enforcement. This difference implies that Digital Rights

[3] The software industry's primary organization to combat piracy, the Business Software Alliance, has stated that its 'anti-piracy activities focus on corporate rather than home users . . .' ('Software Piracy in the European Union,' BSA [1999]). The BSA has also successfully lobbied to ensure legal software usage within the U.S. government and for the use of U.S. trade pressure to encourage similar policies in other countries.

[4] Estimated piracy rates across countries are an indirect measure of enforcement. For software, Varian [2005] shows that there is a strong negative correlation between piracy rates and per capita national income based on data from the Business Software Alliance. For music, the same pattern is apparent in piracy estimates based on data from the Institute for Policy Innovation (IPI: Policy Report #188 [2005]).

[5] Arrow [1962] emphasized this tradeoff. Landes and Posner [1989] analyze how the tradeoff can occur on dimensions including the length of copyright protection, the extension of copyright to derivative works, and the determination of how much material can be incorporated into new works without violating the copyright.

Management technologies that strengthen the monitoring and enforcement capabilities of the copyright holder have very different implications depending on how enforcement is modeled.[6] For instance, automated online authorization for use of software can be modeled as imposing an additional cost of piracy on all users that raises the price toward the monopoly level, or as enlarging the copyright holder's captive market and thereby reducing the price down to the monopoly level.

If copyright is enforced primarily against high-value buyers, the copyright holder may also have the opportunity to price discriminate between buyers. For instance, if businesses and consumers are treated separately for copyright enforcement, it may also be possible to charge them different prices. Or if piracy is restricted in richer countries, but not in poorer countries, it may be possible to price discriminate across countries. Such price discrimination allows the copyright holder to charge a super-monopoly price to the captive market and charge a discounted price to the non-captive market. If enforcement is made more extensive when price discrimination is possible,[7] inframarginal consumers continue to benefit from an expansion of enforcement, marginal consumers are hurt more by having to switch from the lower-priced version to the higher-priced version for the captive market, and extramarginal consumers now benefit because the price of the lower-priced version for the non-captive market falls as marginal consumers are switched to the captive market. This last effect, which is not present without price discrimination, ensures that more extensive enforcement continues to raise total consumer surplus despite the extra losses to marginal consumers.

The idea that consumer and copyright holder interests need not be in conflict has been argued from the alternative perspective that both sides can benefit from lax enforcement due to network effects (Conner and Rumelt [1991]; Takeyama [1994]; Shy and Thisse [1999], Slive and Bernhardt [1998]). In network models, wider distribution of the good increases its value to all users, implying that buyers of legitimate copies benefit from piracy. Since the copyright holder can then charge users a higher price, both sides benefit from lax enforcement.[8] In our model, more extensive enforcement within a reasonable range lowers the price and increases sales of the legitimate copy, but does not reduce total consumption of the good. Therefore, unlike the

[6] Much of the controversy surrounding the U.S. Digital Millennium Copyright Act of 1998 and the E.U. Intellectual Property Rights Enforcement Directive of 2004 relates to the role of these technologies. Potential effects include improved price discrimination (Meurer [1997]) and more efficient contracting (Dam [1999]).

[7] For instance, enforcement could be extended to small businesses, forcing them to pay for business rather than home versions.

[8] Alternatively, Takeyama [1997] shows in a durable monopoly model that allowing bootleggers to satisfy demand from low-value buyers allows the copyright holder to credibly commit to maintaining high prices, thereby helping the copyright holder.

case of broad-based enforcement, increased enforcement need not interfere with the efficiency gains from network effects.

II. THE MODEL

The Besen and Kirby [1989] standard model of piracy differentiates between the case in which buyers are willing to pay up to their own valuation for the legitimate copy (direct appropriability) and the case in which buyers will pay above their own valuation because they can benefit from sharing or selling copies of the work (indirect appropriability). While the latter case suggests a number of interesting pricing strategies (Liebowitz [1985]; Bakos, Brynjolfsson and Lichtman [1999]; Varian [2000]), Besen and Kirby note that a consumer has little incentive to pay above her own valuation when markets for pirated copies are competitive. Since internet piracy has driven the cost of pirated copies effectively to zero, we therefore analyze the case of direct appropriability.

Following their model, we assume buyers can purchase a legitimate copy of a copyrighted good from the copyright holder, purchase an inferior pirated copy from a bootlegger,[9] or not buy a copy at all.[10] There is a continuum of potential buyers with measure normalized to 1 and indexed by $q \in [0,1]$. Buyer values (or willingness to pay) for the legitimate and pirated copies are represented by the respective functions $V(q)$ and $v(q)$ which are bounded, continuous, and twice differentiable over $q \in [0,1]$.[11] We assume that $V(q) > v(q) > 0$ for $q \in [0,1)$ and $V(1) > v(1) = 0$ so that buyers with higher valuations of the legitimate copy also have higher valuations of the pirated copy, and that $V'(q) < v'(q) < 0$ for $q \in [0,1]$ so that the gap in valuations is decreasing in q.[12] The marginal cost of production is zero.[13]

[9] The assumption that the pirated copy is inferior is standard in the literature. For instance, pirated software may suffer from corrupted files or viruses, and help services and access to online content may also be restricted to licensed users. Similarly, pirated music or videos might be of substandard quality, and acquiring them might require visiting websites with viruses or other malware.

[10] Our analysis is limited to a single product so we do not consider the internet's role in expanding opportunities to bundle multiple information goods as analyzed by Bakos and Brynjolfsson [1998].

[11] Working with these inverse demand functions rather than with demand functions simplifies the presentation and facilitates our analysis of enforcement that is targeted at a range of q. Note that if $F(V)$ and $G(v)$ are the cumulative distribution functions for the values V and v, and $F^{-1}(q)$ and $G^{-1}(q)$ are the respective quantile distribution functions, then $V(q) = F^{-1}(1-q)$ and $v(q) = G^{-1}(1-q)$.

[12] The stronger assumption that $v(q)$ and $V(q)$ are proportional is widely used in the literature (e.g., Besen and Kirby [1989]; Chen and Png [1999]; Banerjee [2003]; Bae and Choi [2006]).

[13] The incentive to invest in the copyrighted product is also affected by fixed costs as discussed later when we consider the efficiency of copyright enforcement.

If the firm had monopoly power without the possibility of piracy it would just set quantity to maximize revenues,

$$(1) \qquad q^m = \arg\max_q \{V(q)q\}.$$

Our main restriction on demand is that we assume that the marginal revenue curve for legitimate copies is not only falling, which ensures uniqueness of q^m given zero marginal costs, but also steeper than the demand curve, $\partial^2 V(q)q/(\partial q)^2 < V'(q)$or $V''(q)q + V'(q) < 0$.

If piracy is possible, the copyright holder will have to compete with bootleggers. First consider the case without any copyright enforcement at all. Since the marginal cost of producing and distributing pirated copies is zero, the equilibrium price of such copies is zero. Let q^c represent the profit-maximizing output when the copyright holder competes with a competitive fringe of bootleggers charging zero,

$$(2) \qquad q^c = \arg\max_q \{(V(q) - v(q))q\}.$$

Similar to the monopoly case, we assume that marginal revenue in this case is also steeper than the demand curve, $(V''(q) - v''(q))q + V'(q) - v'(q) < 0$.

Notice that, because the legitimate copy has higher value, the presence of bootleggers does not drive the copyright holder's profits to zero. By choosing quantity q^c and corresponding price $V(q^c) - v(q^c)$, profits are lower than without bootleggers since $V(q)q > (V(q) - v(q))q$ for all q, but the copyright holder can still use its higher quality to successfully compete. We are interested in how copyright enforcement gives the copyright holder monopoly power over some consumers that creates a choice of whether to behave like a monopoly over them or instead compete with bootleggers.

Copyright enforcement is typically modeled as broad-based enforcement that raises the costs of copying to everyone (e.g., Besen and Kirby [1989]; Chen and Png [1999, 2003]; Yoon [2002]).[14] However, in practice enforcement is often targeted at high-value buyers. We believe this represents the current status of enforcement for software piracy where enforcement is concentrated on corporate and institutional buyers. It may also be a good approximation for music and software piracy where enforcement is stronger in richer countries where consumers have higher valuations and weaker in poorer countries where consumers have lower valuations.

To model such situations we assume that enforcement extends down the demand curve to type $q = q^e$, meaning all buyers $q \leq q^e$ can only purchase

[14] An exception is Bae and Choi [2006] which allows enforcement to widen the gap between $V(q)$ and $v(q)$ proportionately.

from the copyright holder but buyers $q > q^e$ can purchase from bootleggers.[15] Therefore the copyright holder faces a demand curve with separate segments. For quantities less than q^e, demand is given by buyer valuations $V(q)$ independent of the bootleg market so the firm has a monopoly position. For quantities greater than q^e the copyright holder must compete in the bootleg market so the copyright holder can charge no more than $V(q) - v(q)$. The (inverse) demand function for the copyright holder is therefore

$$(3) \qquad p(q, q^e) = \begin{cases} V(q) & \text{for } q \leq q^e \\ V(q) - v(q) & \text{for } q > q^e \end{cases}.$$

Ideally, the copyright holder would like to sell the monopoly output q^m at the monopoly price, but if $q^e < q^m$ then the seller must choose whether to sell at a super-monopoly price to the captive market of buyers $q \leq q^e$ or to compete with bootleggers and sell the competitive output q^c at a lower price. Clearly the competitive strategy generates more profits when q^e is so low that there are very few buyers to squeeze with a higher price. And as q^e approaches q^c the super-monopoly pricing strategy generates more profits since $V(q) > V(q) - v(q)$. We are interested in the exact enforcement level such that the copyright holder is indifferent between the two strategies. Note that, ignoring any fixed costs, copyright holder profits without competition are a strictly concave function of sales, are zero for zero sales and increasing at that point, reach a maximum at q^m, and are zero for sufficiently large sales. Again ignoring any fixed costs, profits in competition with bootleggers are $(V(q^c) - v(q^c))q^c$ which is strictly positive and strictly less than $V(q^m)q^m$ so there are exactly two quantities at which $V(q)q = (V(q^c) - v(q^c))q^c$. Let $\tilde{q} < q^m$ be the minimum of these,

$$(4) \qquad \tilde{q} = \min\{q | V(q)q = (V(q^c) - v(q^c))q^c\},$$

so that for $q^e < \tilde{q}$ the firm prefers to compete with bootleggers, at $q^e = \tilde{q}$ the copyright holder is indifferent between charging a super-monopoly price and competing with bootleggers, for $q^e \in (\tilde{q}, q^m)$ the firm charges the super-monopoly price, and for $q^e \geq q^m$ the copyright holder charges a monopoly price.

The left panel of Figure 1 shows the copyright holder's demand function when the value of legitimate copies is $V(q) = 1 - q$, the value of pirated copies is $v(q) = V(q)/3$, and $q^e = 3/10$ so copyright is strictly enforced for $q \leq 3/10$ and not enforced for $q > 3/10$. In this example with linear demand and zero marginal costs, the monopoly output is $q^m = \frac{1}{2}$ so the copyright holder would like to charge the monopoly price to a larger group than is

[15] We assume enforcement is sufficiently intense for buyers $q < q^e$ to prevent them from buying the pirated good, i.e., the cost of piracy is at least $V(q) - v(q)$ for buyers $q \leq q^e$ and zero for all other buyers.

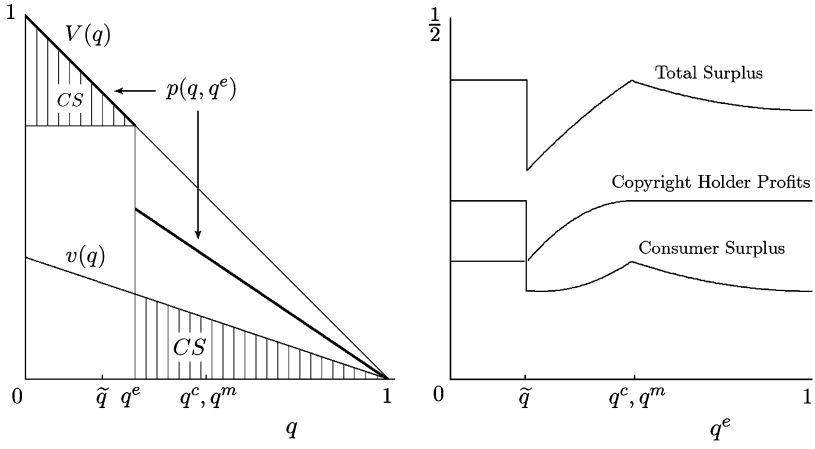

Figure 1
Targeted Copyright Enforcement

possible given the extent of enforcement. The copyright holder can choose to charge a super-monopoly price at $q = 3/10$ or to operate more competitively along the lower section of the demand curve. Since $\tilde{q} \doteq 0.21$ in this example, enforcement is sufficiently extensive for the super-monopoly pricing strategy to generate more profits.[16]

The impact on copyright holder profits and consumer surplus of different enforcement extents q^e is shown in the right panel of Figure 1. When q^e is small, the firm is better off sticking to its competitive strategy of selling q^c units at a low price, so profits are initially unaffected by increases in q^e. When enforcement reaches $q^e = \tilde{q}$, the firm switches to the strategy of selling only q^e units at a super-monopoly price, so profits begin to rise. Further increases in enforcement allow the copyright holder to sell to a larger number of captive consumers until enforcement reaches $q^e = q^m$, after which the firm continues to sell only q^m units. Regarding consumer surplus, it drops sharply once the monopolist switches from selling q^c units to selling only q^e units since high-value buyers pay a super-monopoly price and since many buyers react to the higher price by switching to the inferior pirated copy. As enforcement is extended further and the price falls toward the monopoly level, consumer surplus starts to rise until $q^e = q^m$, after which any further enforcement only hurts consumers who are prohibited from purchasing

[16] Under this strategy the price is 7/10 and profits are therefore 21/100. Following the competitive strategy the copyright holder would choose to operate at $q^c = 1/2$ and charge price $p = 1/3$, giving profits of 1/6.

pirated copies but will never purchase legitimate copies at the monopoly price.[17]

This example shows that targeted enforcement can raise the price to super-monopoly levels, thereby decreasing consumer surplus and encouraging some consumers to start buying inferior pirated copies. As the following Proposition shows, this result holds quite generally.[18]

Proposition 1. Enforcement targeted at high-value buyers (*i*) raises the legitimate copy price and decreases consumer surplus, and (*ii*) increases piracy for $q^e \in [\tilde{q}, \min\{q^c, q^m\}]$.

Enforcement which is just sufficient to induce the copyright holder to adopt the super-monopoly pricing strategy has a large negative impact on consumer surplus and comparatively little impact on copyright holder profits. But this pessimistic conclusion only applies to a comparison of some enforcement and no enforcement. Given that some enforcement is pursued, more extensive enforcement can lower the legitimate copy price and thereby increase sales and also benefit consumers. In the example of Figure 1, there is no conflict between copyright holder profits and consumer surplus in the range $q^e \in [\frac{1}{4}, \frac{1}{2}]$. Although consumers on the margin of enforcement lose, inframarginal consumers benefit from the lower price. The following proposition shows that consumers always benefit if pirated copies are sufficiently poor substitutes, implying there is little loss to marginal consumers from not being able to buy pirated copies, or if enforcement is sufficiently close to q^m, implying that there is a large number of inframarginal buyers who benefit from a lower price. The copyright holder always gains from more extensive enforcement, so both sides benefit over some range.

Proposition 2. More extensive enforcement in $q^e \in [q, q^m)$ (*i*) lowers the legitimate copy price and reduces piracy generally and (*ii*) increases consumer surplus if (*a*) pirated copies are sufficiently poor substitutes for legitimate copies or (*b*) q^e is sufficiently close to q^m.

This analysis takes the concentration of enforcement on high-value users as given, e.g., it is simply more practical to pursue enforcement against corporate users or against users in rich countries. Alternatively, one can consider how a copyright holder will choose to pursue enforcement when it is costly and the copyright holder must bear the enforcement costs. A key

[17] In this example $v(q)$ and $V(q)$ are proportional so, since $\arg\max_q\{V(q)q\} = \arg\max_q\{(1-\alpha)V(q)q\}$ for $\alpha \in (0, 1)$, it must be that $q^c = q^m$. Therefore the copyright holder will produce the same amount (at lower prices) with enforcement less than $q^e \leq \tilde{q}$ as it will with enforcement $q^e \geq q^m$, implying the total surplus is the same with no enforcement or with enforcement $q^e = q^m$. In general the total surplus may be higher or lower.

[18] In the example $q^c = q^m$, implying by the second part of the proposition that piracy increases over the whole range $[\tilde{q}, q^m]$.

concern in this case is that the copyright holder will not consider the impact of enforcement on consumer surplus, so the copyright holder's choice of enforcement might be inefficient.[19] For this reason, Chen and Png [1999, 2003] find that the copyright holder chooses inefficiently intense enforcement under broad-based enforcement in which more intense enforcement hurts consumers.

In our model of targeted enforcement the same concern arises that the copyright holder will not internalize the effects of enforcement on consumer surplus, but the result can be too little rather than too much enforcement. We know that enforcement which is too low ($0 < q^e < \tilde{q}$) is superfluous since it has no effect, and enforcement which is too high ($q^e > q^m$) is gratuitous since it hurts consumers without benefiting the copyright holder, but within these extremes both the copyright holder and consumers benefit from more extensive enforcement over some range. Therefore, if only the copyright holder is responsible for paying for more extensive enforcement, the result can be insufficiently extensive enforcement.[20] For instance, if it becomes increasingly costly to extend enforcement down the demand curve, then extending enforcement all the way until $q^e = q^m$ might not be worth the cost to the copyright holder even though consumers benefit.[21]

II(i). *Price Discrimination*

If there is differential enforcement across the demand curve there might also be the opportunity for differential pricing, i.e., for price discrimination. For instance, if the copyright holder can force business users to buy the legitimate software copy, it might also be able to force them to buy a business version rather than a nearly identical but cheaper home version.[22] Similarly, if copyright enforcement is strong in rich countries but weak in poor countries, the copyright holder may be able to exclude consumers in rich countries from purchasing low-price versions available in poor countries.

[19] In a model of broad-based enforcement, Banerjee, Banerjee, and Raychaudhuri [2008] consider strategic interactions between a copyright holder and a government when they share responsibility for copyright enforcement.

[20] This possibility has parallels in the literature on informative advertising. Esteban, Gil, and Hernandez [2001] find that a monopolist might inefficiently target high-value demanders and charge a high price rather than advertise more broadly and charge a lower price. The general question of how a firm benefits from changing its demand curve is analyzed by Johnson and Myatt [2006].

[21] However, this result is sensitive to different specifications of enforcement costs. For instance, rather than enforcement being easiest against high-value buyers, if enforcement is equally costly and effective against all buyers, then enforcement might be targeted at more intermediate value buyers who gain less from the legitimate version and are therefore more tempted to buy pirated copies.

[22] Notice that we are considering third-degree price discrimination. Without enforcement, the copyright holder might instead pursue second-degree price discrimination and let businesses and consumers choose different quality versions.

The combination of targeted enforcement and price discrimination allows the copyright holder to sell to the captive market at a super-monopoly price and set a discounted price to compete with bootleggers in the remaining non-captive market. Since the non-captive market is comprised of lower-value buyers, the price is lower and there is less rather than more piracy as in Proposition 2. As is standard with third-degree price discrimination, the impact on copyright holder profits of allowing for price discrimination is positive. Therefore, instead of switching between low and high prices based on the enforcement extent q^e, the copyright holder always prefers to offer the captive market the high-priced version and the non-captive market the low-priced version.

Regarding the impact of more extensive enforcement, marginal consumers who are switched from the non-captive to captive market are hurt more than without price discrimination because they can no longer buy the legitimate copy at a reduced price in the non-captive market.[23] Counteracting this loss is the gain to extramarginal consumers in the non-captive market. Without price discrimination they are unaffected by changes in enforcement but with price discrimination, they face a more favorable price when the captive market expands. Since the non-captive market loses its higher value members to the captive market, the copyright holder responds by lowering its discounted price. In the parameterized example used in Figure 2, the net result is that consumer surplus is rising in the range $q^e \in [\frac{1}{3}, \frac{1}{2}]$, a smaller range than without price discrimination. In general, more extensive enforcement continues to raise rather than lower consumer surplus for q^e sufficiently close to q^m as shown in the following Proposition.

Proposition 3. If price discrimination between captive and non-captive markets is possible, more extensive enforcement in $q^e \in [0, q^m)$ (*i*) lowers the captive market price and the non-captive market discounted price and reduces piracy generally and (*ii*) increases consumer surplus if q^e is sufficiently close to q^m.

II(ii). *Comparison with Broad-Based Copyright Enforcement*

For comparison, now consider enforcement that raises the cost of pirated copies to all consumers either by evenly targeting end users or by disrupting distribution channels or limiting access to copying technologies. For instance, until recently, most developed countries had successfully excluded

[23] We are assuming that as enforcement extent changes, the range over which price discrimination is possible changes with it. For instance, if enforcement is extended from large corporations to small businesses, requirements for buying business versions of software could also be extended to small businesses. Similarly, if enforcement is extended from richer countries to middle-income countries, low-priced versions could be withdrawn from sale in middle-income countries and restricted to low-income countries.

open markets for pirated copies of books, music and software, thereby forcing consumers to incur the time costs of arranging for and making private copies.[24] And a number of European countries have collected levies on blank recording machinery and media to compensate copyright holders for likely piracy (Besen and Raskind [1991]). The rise of the internet has altered this situation, but as a reference point we now consider the impact of copyright enforcement against all consumers. In practice, such enforcement will affect different buyers to different degrees, but to make a clear comparison with enforcement targeted solely at high-value buyers, we assume that enforcement raises costs uniformly.

The Besen and Kirby model only considers enforcement policies that either allow or do not allow copying, but it is readily reinterpreted to accommodate differing degrees of enforcement. In particular, they assume that piracy incurs higher copying costs than legitimate production. Since the internet has largely eliminated copying costs, any costs to consumers from acquiring illegal copies can be interpreted as a measure of the intensity of broad-based copyright enforcement.[25] Similar models of broad-based enforcement also follow this approach of modeling copyright enforcement as affecting the net value of a pirated copy.

Enforcement imposes a piracy cost c which can be viewed as either paid by the bootleggers or by the consumers of pirated copies. In either case, consumer q receives surplus $v(q) - c$ from acquiring a pirated copy in the competitive bootlegger market. Let q^b represent the marginal consumer whose valuation of a pirated copy equals the cost c of potentially being caught,

$$(5) \qquad q^b(c) = \begin{cases} \{q|v(q) = c\} & \text{for } c < v(0) \\ 0 & \text{for } c \geq v(0) \end{cases},$$

which exists and is unique by the restrictions on $v(q)$. Given that the value of a legitimate copy is $V(q)$, the copyright holder can charge no more than $V(q) - (v(q) - c)$ to consumers $q < q^b$, but can charge as much as $V(q)$ to consumers $q \geq q^b$. The (inverse) demand function facing the copyright holder therefore has two sections,

$$(6) \qquad p(q, c) = \begin{cases} V(q) - (v(q) - c) & \text{for } q < q^b \\ V(q) & \text{for } q \geq q^b \end{cases}.$$

[24] The United States Trade Representative complained to Congress in 1996 that 'compilation CD's' with $10,000 of software could be purchased openly for $5 in Hong Kong (Testimony before the Senate Finance Committee by U.S. Trade Representative Charlene Barshefsky on June 6, 1996), but such access to pirated goods was rare in the United States until the rise of the internet.

[25] Besen and Kirby consider royalty payments payable to the copyright holder that increase the cost of copies, such as occur through the Copyright Clearance Center in the U.S., but this is a separate issue from uncompensated piracy.

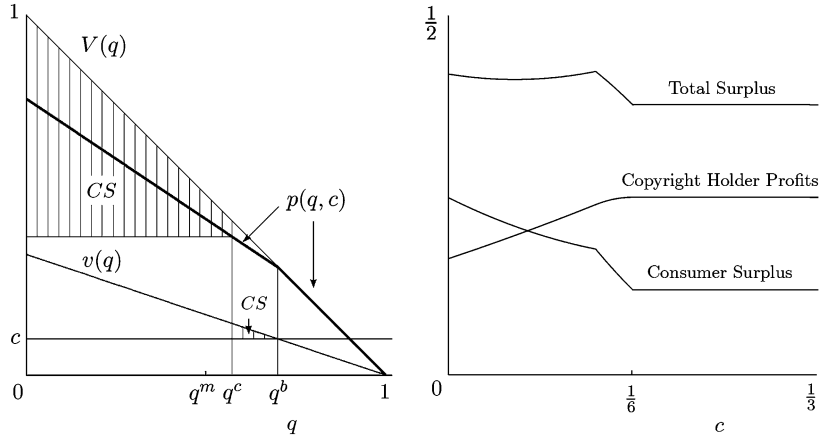

Figure 2
Broad-Based Copyright Enforcement

The copyright holder will act like a regular monopoly and produce q^m if c is sufficiently high that $q^b \leq q^m$. If not, the copyright holder will have to compete with bootleggers and will produce either at the kink q^b or at the competitive quantity

$$(7) \qquad q^c(c) = \arg\max_q \{(V(q) - (v(q) - c))q\},$$

which differs from the targeted enforcement case in that it is a function of the piracy cost c.

As the piracy cost c increases the first section of the demand curve in (6) rises and the kink q^b in the demand curve occurs at lower quantities, implying the demand function becomes closer and closer to that of a monopoly. Higher c makes the option of acquiring the pirated copy less attractive, so the copyright holder can squeeze out a higher price for the legitimate copy, thereby increasing profits and reducing consumer surplus. Although enforcement is broad-based, its effect is borne most obviously by low-value buyers. Since they are unwilling to pay the price of a legitimate copy and cannot continue to purchase the pirated copy due to the higher costs, they leave the market. The result is less piracy, but at the cost of less consumption.

The left panel of Figure 2 shows the copyright holder's demand function for the same case as Figure 1 except broad-based enforcement imposes a cost $c = 1/10$ on consumption of pirated copies. Since the bootleg market is competitive, a consumer can receive surplus $v(q) - c$ by purchasing a pirated copy, implying all consumers $q < q^b$ are potentially in the market for pirated copies. In the range $q \geq q^b$ the copyright holder can act as a monopolist.

In this example $q^m = \frac{1}{2}$, $q^c = 23/40$, and $q^b = 7/10$. Since $q^b > q^m$, the choice is between q^c and q^b, with the former generating the most profits. The right panel of Figure 2 shows the impact on profits and consumer surplus as c increases from 0. Since q^b is decreasing in c and q^c is increasing in c, at the point where $q^b = q^c$ the copyright holder produces at the kink q^b.[26] Consumer surplus then drops rapidly until $q^b = q^m$ at which point the copyright holder sticks to the monopoly strategy of $q = q^m$. At this point $c = v(q^m) = \frac{1}{6}$ so c is so high that piracy is never worthwhile even when the legitimate copy is provided at the monopoly price.

The following proposition shows that the results from the above example hold quite generally.

Proposition 4. More intensive broad-based enforcement raises the legitimate copy price, decreases consumer surplus, and reduces piracy.

This final proposition, parts of which also appear in Chen and Png [1999], Yoon [2002], and Bae and Choi [2006] as steps toward other results, highlights how differently copyright enforcement affects firm and consumer behavior depending on whether it is broad-based or targeted.[27] From Figure 2, marginal increases in the intensity of enforcement steadily reduce consumer surplus as the price rises toward the monopoly level and as low value consumers stop consuming at all. In contrast, from Figure 1, an increase in the extent of enforcement leads first to a discontinuous drop in consumer surplus as the firm switches to a super-monopoly price and low value consumers switch to inferior pirated copies, and then to a steady rise in consumer surplus as the price falls to the monopoly level and more consumers switch to the superior legitimate copy.

III. CONCLUSION

This paper shows that broad-based and targeted copyright enforcement have very different implications for firm pricing strategies, piracy and social welfare. We have focused on copyright enforcement, but targeted enforcement may also be relevant for patent and trademark enforcement. Unlike copyright piracy, patent infringement is often limited to a small number of companies who must make substantial investments in production capacity and are easily monitored. But in countries with a large number of producers the targeted enforcement model may be applicable. For instance,

[26] In the region immediately below this point, total surplus is increasing, a feature emphasized by Yoon [2002].

[27] Bae and Choi [2006] consider anti-piracy measures that lower the valuations of the pirated copies proportionately, i.e., that reduce $v(q)$ more for higher value buyers, or equivalently that make piracy more costly for higher value buyers. Similar to our result, they find that stronger anti-piracy measures can lead to more piracy.

the pharmaceutical industries in India and China are highly competitive with hundreds of producers. A targeted enforcement policy requiring the most reputable and most profitable producers to pay licensing fees to patent holders would have similar effects as discussed in this paper.[28] From an international perspective, if patent infringement is prevented in richer countries but not in poorer countries, then the model also applies. Regarding trademark infringement, enforcement is typically targeted at distribution channels and retailers, thereby raising costs to all consumers and making the broad-based enforcement model more appropriate. The targeted enforcement model applies if enforcement is primarily directed at prestigious retail outlets servicing high-value buyers, or if trademark enforcement is stronger in richer countries than poorer countries.

APPENDIX

Proof of Proposition 1: (*i*) Without enforcement, output is q^c so the price is $V(q^c) - v(q^c)$, profits are $(V(q^c) - v(q^c))q^c$, and consumer surplus is

$$\int_0^{q^c} (V(q) - (V(q^c) - v(q^c))dq + \int_{q^c}^1 v(q)dq. \tag{8}$$

For $q^e \in [0, \tilde{q})$ the copyright holder still chooses output q^c and price $V(q^c) - v(q^c)$ so enforcement has no effect and the results hold weakly. For $q^e \in [\tilde{q}, q^m]$ the firm chooses output q^e with super-monopoly price $V(q^e)$. Comparing this price with the competitive price $V(q^c) - v(q^c)$, since $V' < 0$ and $q^e \leq q^m$ a sufficient condition for $V(q^e)$ to be higher is $V(q^m) > V(q^c) - v(q^c)$. For the case $q^m \leq q^c$ this holds since $V' < 0$ and $v > 0$. Consider the case $q^m > q^c$. From (2) we know that q^c satisfies $(V'(q^c) - v'(q^c))q^c + V(q^c) - v(q^c) = 0$ and from (1) we know that q^m satisfies $V'(q^m)\ q^m + V(q^m)$, so $V(q^m) > V(q^c) - v(q^c)$ if $(V'(q^c) - v'(q^c))q^c > V'(q^m)q^m$. Since $v' < 0$ a sufficient condition is $V'(q^c)q^c > V'(q^m)q^m$. Since $q^m > q^c$ this holds if $V'(q)q$ is decreasing in q, which is equivalent to the assumption that $\partial^2 V(q)q/(\partial q)^2 < V'(q)$. Therefore the price always rises with the introduction of enforcement.

Now considering consumer surplus, with enforcement q^e it equals

$$\int_0^{q^e} (V(q) - V(q^e))dq + \int_{q^e}^1 v(q)dq. \tag{9}$$

For the case $q^e \leq q^c$ consumer surplus clearly falls with the introduction of enforcement since the price rises and quantity falls. For the case $q^e > q^c$ the difference (8)–(9) can be written as

$$\int_0^{q^c} V(q^e) - (V(q^c) - v(q^c))dq + \int_{q^c}^{q^e} V(q^e) - (V(q) - v(q))dq > 0, \tag{10}$$

[28] However, Lanjouw and Lerner [1998] show that smaller firms can be at a legal disadvantage in patent disputes and might therefore be more attractive enforcement targets.

where the inequality follows since $V(q^e) > V(q^c) - v(q^c)$ as established above and since $V(q) - v(q)$ is decreasing in q by assumption.

Finally, for $q^e \in (q^m, 1]$ the firm chooses the monopoly output q^m and the monopoly price $V(q^m) > V(q^c) - v(q^c)$, again implying lower consumer surplus by the above arguments.

(ii) Without any enforcement, the copyright holder chooses output q^c, implying the piracy range is $(q^c, 1]$. For enforcement levels $q^e \in [\tilde{q}, q^m]$ the copyright holder chooses output q^e, implying the piracy range is $(q^e, 1]$. If $q^c < q^m$ then piracy increases for $q^e \in [\tilde{q}, q^c]$, while if $q^m < q^c$ then piracy increases for $q^e \in [\tilde{q}, q^m]$. ■

Proof of Proposition 2: (*i*) The price of the legitimate copy in this range is $V(q^e)$ which is decreasing in q^e. For $q^e \in [\tilde{q}, q^m]$ the piracy range is $(q^e, 1]$ which is decreasing in q^e.

(*ii-a*) Differentiating consumer surplus (CS) from (9) and canceling terms,

$$\frac{dCS}{dq^e} = -V'(q^e)q^e - v(q^e). \tag{11}$$

Since $-V'(q^e)q^e > 0$, therefore $dCS/dq^e > 0$ for $v(q^e)$ sufficiently small.

(*ii-b*) From the first order condition for profit maximization, $V'(q^m)q^m + V(q^m) = 0$ so, substituting into (11),

$$\frac{dCS}{dq^e}\Big|_{q^e=q^m} = V(q^m) - v(q^m) > 0, \tag{12}$$

implying by continuity of $V(q)$ and $v(q)$ that $dCS/dq^e > 0$ for q^e sufficiently close to q^m. ■

Proof of Proposition 3: (*i*) The captive market price is still $V(q^e)$ which is decreasing in q^e. Let the quantity sold by the copyright holder in the non-captive market be q^d where

$$q^d = \arg\max_q \{(V(q^e + q) - v(q^e + q))q\}. \tag{13}$$

From total differentiation of the first order condition,

$$\begin{aligned}\frac{dq^d}{dq^e} &= -\frac{(V''(q^e + q^d) - v''(q^e + q^d))q^d + V'(q^e + q^d) - v'(q^e + q^d)}{(V''(q^e + q^d) - v''(q^e + q^d))q^d + 2(V'(q^e + q^d) - v'(q^e + q^d))} \\ &> -1,\end{aligned} \tag{14}$$

where the inequality follows since $(V'' - v'')q + V' - v' < 0$ and $V' < v'$ by assumption. Therefore $q^e + q^d$ rises as q^e rises, implying that the price in the non-captive market, $V(q^e + q^d) - v(q^e + q^d)$, is decreasing in q^e since $V' < v'$. The piracy range is $(q^e + q^d, 1]$ for $q^e \in [0, q^m]$ so piracy falls.

(*ii*) Consumer surplus (CS) is now

$$\begin{aligned}&\int_0^{q^e} V(q) - V(q^e)dq + \int_{q^e}^{q^e+q^d} V(q) - (V(q^e + q^d) - v(q^e + q^d))dq \\ &+ \int_{q^e+q^d}^{1} v(q)dq,\end{aligned} \tag{15}$$

so, differentiating and canceling terms,

$$\frac{dCS}{dq^e} = -V'(q^e)q^e - V(q^e) + V(q^e+q^d) - v(q^e+q^d) - (V'(q^e+q^d) - v'(q^e+q^d))q^d\left(1+\frac{dq^d}{dq^e}\right). \tag{16}$$

Recall that $V'(q^m)q^m + V(q^m) = 0$ so $-V'(q^e)q^e - V(q^e)$ goes to zero as q^e approaches q^m. Therefore, since $V(q) > v(q)$ and $V'(q) < v'(q)$, for q^e sufficiently close to q^m, $dCS/dq^e > 0$ if $dq^d/dq^e > -1$, as established in (i). ■

Proof of Proposition 4: If $q^b \leq q^m$ the firm will produce at q^m and more intensive enforcement has no additional impact, implying all the relations hold weakly. So we restrict attention to $q^m < q^b$, which has two cases, q^c, $q^m < q^b$ and $q^m < q^b \leq q^c$.

Regarding the price, for the case q^c, $q^m < q^b$ changes in c affect the price directly by shifting the demand curve and also indirectly via q^c, the profit maximizing choice of q. Totally differentiating the first order condition for profit maximization gives $dq^c/dc = -1/(\partial^2(p(q,c)q)/(\partial q)^2) = -1/(V''(q^c) - v''(q^c) + 2(V'(q^c) - v'(q^c)))$ so

$$\frac{dp(q^c,\,c)}{dc} = \frac{\partial p(q^c,\,c)}{\partial c} + \frac{\partial p(q^c,\,c)}{\partial q}\frac{dq^c}{dc} = 1 - \frac{V'(q^c) - v'(q^c)}{(V''(q^c) - v''(q^c))q^c + 2(V'(q^c) - v'(q^c))} > 0, \tag{17}$$

where the inequality follows from the assumption $(V''(q) - v''(q))q + V'(q) - v'(q) < 0$. For the case $q^m < q^b \leq q^c$ the firm chooses to produce at the kink in the demand function at q^b. Totally differentiating the identity $v(q^b) = c$, $dq^b/dc = 1/v'(q) < 0$ so an increase in c leads to a movement up the $V(q)$ curve, implying a higher price.

Regarding consumer surplus, an increase in c raises the price in both cases while increasing the supply of the legitimate quantity for q^c, $q^m < q^b$ and decreasing it for $q^m < q^b \leq q^c$. Therefore consumer surplus clearly falls in the second case. For the first case consumer surplus (CS) is

$$\int_0^{q^c} V(q) - (V(q^c) - (v(q^c) - c))dq + \int_{q^c}^{q^b} (v(q) - c)dq, \tag{18}$$

so, differentiating and simplifying,

$$\frac{dCS}{dc} = (v(q^c) - c)\frac{dq^c}{dc} - \frac{dp(q^c,c)}{dc}q^c - (v(q^c) - c)\frac{dq^c}{dc} - (q^b - q^c) = -\frac{dp(q^c,c)}{dc}q^c - (q^b - q^c) < 0, \tag{19}$$

implying consumer surplus falls in this case as well.

Regarding piracy, it only occurs for $q^b > q^c$, q^m. As noted $dq^c/dc = -1/(\partial^2(p(q,\,c)q)/(\partial q)^2) > 0$ and $dq^b/dc < 0$ so the piracy range $(q^c,\ q^b]$ shrinks. ■

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