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Does copyright enforcement encourage piracy?*

Rick Harbaugh
Claremont McKenna College

Rahul Khemka
Georgetown University

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Abstract

More intensive copyright enforcement reduces piracy, raises prices, and lowers consumer surplus. We show that these results do not hold regarding the extent rather than intensity of enforcement. When enforcement is targeted at high-value buyers such as corporate and government users, the copyright holder has an incentive to charge super-monopoly prices, thereby encouraging piracy among low-value buyers. Extending enforcement down the demand curve broadens the copyright holder's captive market, leading to lower prices and higher sales that can increase both profits and consumer surplus. The standard tradeoff between incentives to generate intellectual property and costs of monopoly power is therefore avoided. Private enforcement by copyright holders may be insufficiently extensive since consumers can also benefit from more extensive enforcement. Similarly, new technologies which lead to stronger control over illicit use can paradoxically benefit consumers.

JEL Classification Categories: L12, L86, K11, K42.

Key words: intellectual property, copyright, piracy, monopoly pricing

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1 Introduction

Internet piracy threatens to reverse the success of many countries at controlling intellectual property theft. By driving reproduction and distribution costs toward zero, the internet has largely eliminated the cost advantages once held by legitimate producers. And by allowing decentralized distribution through email and other peer-to-peer technologies, the internet has greatly impeded anti-piracy efforts. The resulting proliferation of free software and other intellectual property led the U.S. to criminalize even non-commercial piracy under the No Electronic Theft (NET) Act of 1997. Nevertheless, piracy rates appear to be rising after a long period of decline.[1]

To evaluate copyright enforcement in this environment, we compare broad-based enforcement with targeted enforcement aimed at specific users. Broad-based enforcement raises the cost of piracy generally by, for instance, taxing new reproduction technologies (Johnson, 1985), intercepting and destroying illegal copies, or prosecuting and penalizing distributors of pirated goods. We argue that such strategies are of decreasing relevance due to the decentralized nature of the internet. Instead, successful copyright enforcement must directly punish violations by end-users. Such enforcement can be broad-based in that all consumers face the same risk of enforcement. But in practice enforcement is usually targeted at large businesses and institutions which are volume buyers and are more readily identified and monitored than individual consumers. Since large organizations are also likely to place a higher value on the copyrighted work than other buyers, enforcement is effectively targeted at the high end of the demand curve.

Broad-based enforcement reduces piracy by directly increasing the cost of buying or using

[1]The Business Software Alliance's "Global Software Piracy Report" for 2000 showed an increase in world piracy for the first time in the survey's history.

pirated copies, but we find that targeted enforcement can paradoxically increase piracy relative to no enforcement under the standard Besen and Kirby (1989) assumption that pirated goods are inferior substitutes for legitimate copies.[2] Targeted enforcement gives the copyright holder monopoly power over high-value buyers, encouraging the copyright holder to raise prices rather than compete with pirated copies for sales to lower-value buyers. 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. We find that enforcement sufficiently concentrated on high-value buyers leads to more piracy than no enforcement. And if pirated copies are valued by consumers proportionately to legitimate copies as assumed by Besen and Kirby, any reasonable enforcement level leads to more piracy than no enforcement.

Regarding the impact of enforcement policies on social welfare, the tradeoff between incentives to generate intellectual property investment and the costs of monopoly power has long been recognized as the central issue in intellectual property rights (Arrow, 1962).[3] We show that this tradeoff between copyright holder profits and consumer surplus depends on the assumption that copyright holders have a sufficiently large captive market that they follow a normal monopolistic strategy. If copyright holders are responsible for enforcement costs, we find conditions under which they will enforce a smaller captive market, implying that they will charge a super-monopoly price. More extensive enforcement benefits inframarginal consumers because the copyright holder lowers the price toward the monopoly level to gain new customers. We find that if pirated copies are sufficiently poor substitutes for legitimate copies, this gain exceeds the losses to consumers at the margin who must buy the expensive legitimate copy

[2]For instance, pirated software may suffer from viruses or corrupted files. Help services and access to online content may also be restricted to licensed users. In a world of zero copyright enforcement, reputable companies could provide copies and related services of the same quality as those of the copyright holder. In this paper we vary the degree of enforcement against end-users, but assume that there is always enough enforcement against producers and distributors to prevent legitimate businesses from entering the bootleg industry.

[3]The tradeoff occurs on a number of 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 (Landes and Posner, 1989).

instead of the pirated copy. Therefore both copyright holder profits and consumer surplus rise from more extensive enforcement. Even if pirated copies are arbitrarily close substitutes for legitimate copies, there will be some range over which more extensive enforcement increases both copyright holder profits and consumer surplus.

If copyright is enforced only 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. The copyright holder can then charge a super-monopoly price to business users and a discounted price for a non-business version that competes with pirated copies. Since it is directed at lower-value buyers, this discounted price will be lower than the competitive price without price discrimination, implying that piracy will fall rather than rise. As is standard in price discrimination models, the monopolist will benefit from price discrimination and consumers might or might not benefit. Regarding the marginal impact of more extensive copyright enforcement,[4] the basic results are unaffected by allowing for price discrimination. In particular, more extensive enforcement can continue to raise rather than lower consumer surplus.

The lack of conflict between consumer and copyright holder interests has implications for enforcement policy. In their model of broad-based enforcement Chen and Png (1999) allow firms to determine how much resources to devote to detecting piracy. They find that firms choose inefficiently intense monitoring because they do not internalize the losses to consumer welfare. In our model of targeted enforcement we reach the opposite conclusion regarding how extensive enforcement should be. Since both sides can benefit from more extensive enforcement, if the copyright holder alone is responsible for enforcement costs the result may be insufficient rather than excessive enforcement.[5] As a result, technologies that strengthen the monitoring

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

[5]This result has an interesting parallel in the literature on informative advertising. Even if informative advertising increases prices by raising demand, consumers may still benefit from the opportunity to purchase a

and enforcement capabilities of the copyright holder need not lead to a loss in consumer surplus.[6] For instance, automated online authorization for use of software can broaden the copyright holder's captive market, reducing the price down to the normal monopoly level.

The idea that consumer and copyright holder interests need not be in conflict has been argued from the opposite perspective that both sides can benefit from lax enforcement due to network effects (Takeyama, 1994; Shy and Thisse, 1999, Slive and Bernhardt, 1999). In network models broader distribution of the good increases its value to all users, implying buyers of legitimate copies benefit from piracy. Since the copyright holder can then charge users a higher price, both sides benefit from lax enforcement.[7] Our model indicates that super-monopoly pricing is a factor that can work in the opposite direction, encouraging both sides to favor more extensive enforcement within a reasonable range.

2 Copyright enforcement in practice

The changing roles of broad-based and targeted enforcement are illustrated by the case of software piracy. Before the rise of the internet, broad-based enforcement had stopped open markets for pirated copies from arising in most large economies. While the United States Trade Representative complained to Congress in 1996 that "compilation CDs" with $10,000 of software could be purchased openly for $5 in Hong Kong,[8] consumers in the United States did

product they would not otherwise have known about (Shapiro, 1980). 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 advertising and enforcement models differ in that more informative advertising has a direct positive impact on consumers that may or may not be offset by price effects, while greater copyright enforcement has a direct negative impact that may or may not be offset by price effects.

[6] Much of the controversy surrounding the Digital Millennium Copyright Act of 1998 relates to the role of these technologies. Other potential benefits are more efficient contracting (Dam, 1999) and improved price discrimination (Meurer, 1997).

[7] A different argument also supports the idea that weak enforcement helps the copyright holder. In a durable monopoly model, allowing bootleggers to satisfy demand from low-value buyers allows the copyright holder to credibly commit to maintaining high prices (Takeyama, 1997).

[8] Testimony before the Senate Finance Committee by US Trade Representative Charlene Barshefsky on June 6, 1996.

not have such easy and inexpensive access to pirated software. In a few years, the situation changed dramatically. Checks by the Business Software Alliance (BSA) in 1999 found over two million websites worldwide that offered, linked to, or discussed pirated software under the standard term "warez"[9] and more than 368,000 web pages that offered "crackz" to defeat copy protection measures.[10] Even before its official unveiling, Microsoft discovered over 100 websites offering free downloads of Windows 2000.[11] And a 2000 survey of internet auction sites in the United States found that 91% of software for sale was pirated.[12]

Although software companies are attempting to disrupt online distribution of pirated software just as they have successfully disrupted offline distribution in many countries, the futility of these attempts is widely recognized. As the BSA website acknowledges, "Bookmarking a 'Top 10 Warez Sitez' page is an easy way of finding all the illegal software you could ever want." Partly due to the problem of identifying the creators and operators of pirate websites, the first convictions under the 1997 No Electronic Theft (NET) Act were not obtained until May of 2001. The rise of peer-to-peer technologies such as Gnutella and Morpheus for sharing files makes it even more unlikely that access to pirated software can be restricted.

Given the difficulty of raising piracy costs to consumers through disrupting easy access to pirated copies, the software industry has continued to pursue enforcement directly at end-users. In practice, this has meant enforcement targeted against large institutions. The BSA, the software industry's primary organization to combat piracy, states that "...the business software industry's anti-piracy activities focus on corporate rather than home users..."[13] The industry has also been active in combating "government piracy", successfully lobbying for an

[9] September 14, 1999 BSA press release.

[10] Presentation by Robert Holleyman, President of the BSA, at the World Intellectual Property Organization Conference on Electronic Commerce and Intellectual Property, Geneva, 1999.

[11] Reuters, February 11, 2000.

[12] Press release by Software & Information Industry Association, April 12, 2000. The survey found prices as low as $13 for software retailing at $609. That buyers were willing to pay at all for software freely available elsewhere may reflect buyer beliefs that they were purchasing legitimate used software.

[13] "Software Piracy in the European Union," BSA, January 1999.

executive order to institute procedures ensuring legal software usage within the US government, the world's largest software consumer. This order also directed the US Trade Representative to use its powers to push for similar decrees in other countries.[14]

Clearly one reason for not targeting home users is they place lower valuations on most software, implying smaller gains from forcing the use of legitimate software. Another problem is the likely difficulty of obtaining convictions against home users. One survey found that only 14% of respondents thought illegally copying a software program was a serious crime, compared to 30% who felt the same about driving at 40 MPH in a 25 MPH zone.[15] The disjunct between these attitudes and the draconian punishments for piracy[16] may explain why it appears that no home software user in the United States has ever been convicted of copyright violations for personal use of pirated software.

3 Broad-based copyright enforcement

Enforcement that disrupts distribution channels or limits access to copying technologies raises the cost of pirated copies to all customers. For instance, until recently most developed countries had successfully excluded 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. 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 greatly, but as a reference point we first 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 which is targeted solely at high-value buyers we assume enforcement raises costs uniformally.

[14]The Special 301 Report on Intellectual Property Rights by the US Trade Representative, May 2000.

[15]Survey conducted by Yankelovich Partners for the BSA as cited in "Take a Byte Out of Software" published by BSA at http://www.bsa.org.

[16]Under Title 18 of the US Code, Section 2319, a first offense for making or distributing over 10 copies of the same or different work is punishable by up to three years in prison.

Besen and Kirby's standard model of piracy differentiates between the case where buyers are willing to pay no more than their own valuation for the legitimate copy (direct appropriability) and the case where 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 the rise of internet piracy has driven the cost of pirated copies effectively to zero, we use their model of direct appropriability.[17] Although they only consider enforcement policies that either allow or do not allow copying, their model 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, we will interpret any costs to consumers from acquiring illegal copies as a measure of the intensity of copyright enforcement.[18]

Following their model, we assume buyers can purchase a legitimate copy of a copyrighted good from the copyright holder, purchase a pirated copy from a bootlegger, or not buy a copy at all.[19] Each buyer q values the legitimate copy more highly, and buyers with higher valuations of the legitimate copy also have higher valuations of the pirated copy. Let buyer values (or willingness to pay) for the legitimate and pirated copies be represented by the functions $V(q)$ and $v(q)$ respectively which are bounded, continuous, and differentiable over $q \in [0, Q]$. We assume that $V(q) > v(q) > 0$ for $q \in [0, Q)$, $V(Q) = v(Q) = 0$, and $V'(q) < v'(q) < 0$ for $q \in [0, Q]$.

[17] Indirect appropriability remains relevant for legal distribution such as software companies charging more for site licences.

[18] 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.

[19] 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 (Bakos and Brynjolfsson, 1998).

Since the marginal cost of producing and distributing pirated copies is zero, the equilibrium price of such copies is zero in the absence of copyright enforcement. Enforcement imposes a 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. Let q^b represent the marginal consumer whose valuation of a pirated copy equals the cost c of potentially being caught. 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,

$$p(q, c) = \left\{ \begin{array}{c} V(q) - (v(q) - c) \quad \text{for } q < q^b \\ V(q) \quad \text{for } q \geq q^b \end{array} \right\}.$$

Let q^m represent the profit maximizing output for a complete monopoly,

$$q^m = \arg\max_q \{V(q)q\},$$

and let q^c represent the profit-maximizing output when the copyright holder competes with bootleggers,

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

To ensure q^m and q^c are unique we assume that marginal revenue for legitimate copies is monotonically decreasing in q over both sections of the demand curve, $\partial^2 V(q)q/(\partial q)^2 < 0$ and $\partial^2(V(q) - v(q))q/(\partial q)^2 < 0$. 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 enforcement is not that strong then the copyright holder will produce either at q^c or at the kink q^b depending on which generates the most profits.

Figure 1 shows the copyright holder's demand function when the value of legitimate copies is $V(q) = 100 - q$, the value of pirated copies is $v(q) = (100 - q)/3$, and broad-based enforcement imposes a cost $c = 10$ on consumption of pirated copies. Since the bootleg market is competitive

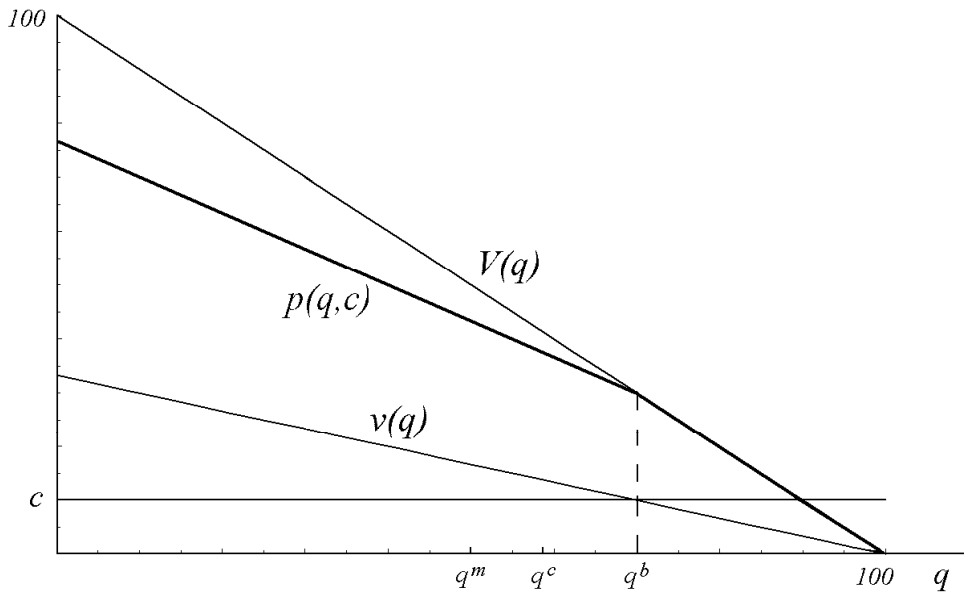

Figure 1: Broad-based enforcement with intensity $c = 10$.

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 $q^m = 50$, $q^c = 57.5$, and $q^b = 70$. Since $q^b > q^m$, the choice is between q^c and q^b, with the former generating the most profits. As c increases, the first section of the demand curve rises and the kink 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 can neither afford the legitimate copy nor 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 following proposition shows that the results from the above example hold quite gen-

erally. The only exception is that if the marginal revenue curve is less steep than the demand curve, as can occur with some non-linear demand curves, the firm might respond to higher enforcement costs with lower prices.

Proposition 1. More intensive broad-based enforcement (i) raises the legitimate copy price and decreases consumer surplus if the marginal revenue curve is steeper than the demand curve and (ii) always increases copyright holder profits and reduces piracy.

Proof: 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 $q^m < q^b \leq q^c$.

(i) Regarding the price, for $q^c, q^m < q^b$ 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, $\partial p(q,c)q/\partial q = 0$, gives

$$\frac{dq^c}{dc} = -\frac{1}{\partial^2(p(q,c)q)/(\partial q)^2},$$

so

$$\frac{dp(q,c)}{dc} = \frac{\partial p(q,c)}{\partial c} + \frac{\partial p(q,c)}{\partial q}\frac{dq^c}{dc} = 1 - \frac{\partial p(q,c)/\partial q}{\partial^2(p(q,c)q)/(\partial q)^2},$$

which is positive as long as $\partial p(q,c)/\partial q > \partial^2(p(q,c)q)/(\partial q)^2$. For $q^m < q^b \leq q^c$ the firm chooses to produce at the kink in the demand function at q^b. Totally differentiating the identity $v(q^b) = c$,

$$\frac{dq^b}{dc} = \frac{1}{v'(q)} < 0,$$

so an increase in c leads to a movement up the $V(q)$ curve, implying a higher price. Regarding the consumer surplus, if $\partial p(q,c)/\partial q > \partial^2(p(q,c)q)/(\partial q)^2$ then as shown the price rises in both cases, implying buyers of the legitimate good lose. Buyers of the pirated good always lose directly from increases in c.

(ii) Regarding profits, for $q^c, q^m < q^b$ profits are given by

$$\Pi = (V(q^c) - v(q^c) + c)q^c.$$

Since q^c is chosen to maximize profits, by application of the envelope theorem,

$$\frac{d\Pi}{dc} = q^c > 0.$$

For $q^m < q^b \leq q^c$ the firm chooses to produce at the kink in the demand function at q^b. Since q^b is decreasing in c the firm moves closer to monopoly output as c increases. By the assumption $\partial^2 V(q)q/(\partial q)^2 < 0$ this implies higher profits. Regarding piracy, it only occurs for $q^b > q^c, q^m$. As noted $dq^c/dc = -1/(\partial^2(p(q,c)q)/(\partial q)^2)$ which is positive by the assumption that marginal revenue is decreasing. Since $dq^b/dc < 0$ as shown above the piracy range $(q^c, q^b]$ shrinks. ■

4 Targeted "top-down" copyright enforcement

We now consider the same model except that only the highest value buyers face any enforcement against piracy. As argued, we believe this represents the current status of enforcement since home piracy is not normally penalized. With targeted enforcement the issue is not how intensive enforcement is, but rather how far down the demand curve enforcement extends.[20] Assuming enforcement extent q^e, meaning all buyers $q \leq q^e$ must purchase from the copyright holder,[21] the copyright holder again 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. For quantities greater than q^e the copyright holder must offer a price sufficiently low to entice buyers away from pirated copies. Since the price in the bootleg market is zero, consumer q

[20] An interesting possibility is enforcement directed only against low-value demanders. While enforcement against high-value demanders leads to a negative externality on other demanders by raising the monopoly price, enforcement against low-value demanders leads to a positive externality by reducing the price. Such "bottom-up" enforcement does not appear to be observed in practice.

[21] We will assume enforcement is sufficiently intense to prevent buyers $q < q^e$ from buying the pirated good. From the perspective of the broad-based enforcement model, the cost c is at least $V(q) - v(q)$ for buyers $q < q^e$ and zero for all other buyers.

receives surplus $v(q)$ from acquiring a pirated copy, implying the copyright holder can charge no more than $V(q) - v(q)$. The (inverse) demand function for the copyright holder is therefore

$$p(q, q^e) = \left\{ \begin{array}{c} V(q) \quad \text{for } q \leq q^e \\ V(q) - v(q) \quad \text{for } q > q^e \end{array} \right\}.$$

The quantity that maximizes monopoly profits is again $q^m = \arg\max\{V(q)q\}$ while the quantity that maximizes profits in competition with the inferior offerings of bootleggers is now $q^c = \arg\max\{(V(q) - v(q))q\}$. 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 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 are 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 $\widetilde{q} < q^m$ be the minimum of these, so that at $q^e = \widetilde{q}$ the copyright holder is indifferent between charging a super-monopoly price and competing with bootleggers.

Figure 2 shows the same case as that of Figure 1 except copyrights are strictly enforced for $q \leq 30$ and not enforced for $q > 30$. The demand curve is different than under broad-based enforcement because high-value rather than low-value buyers are most directly affected. In this example with linear demand and zero marginal costs the monopoly output is $q^m = 50$ so the copyright holder would like to charge monopoly prices to a larger group than is possible given the extent of enforcement. The copyright holder can choose to charge a super-monopoly

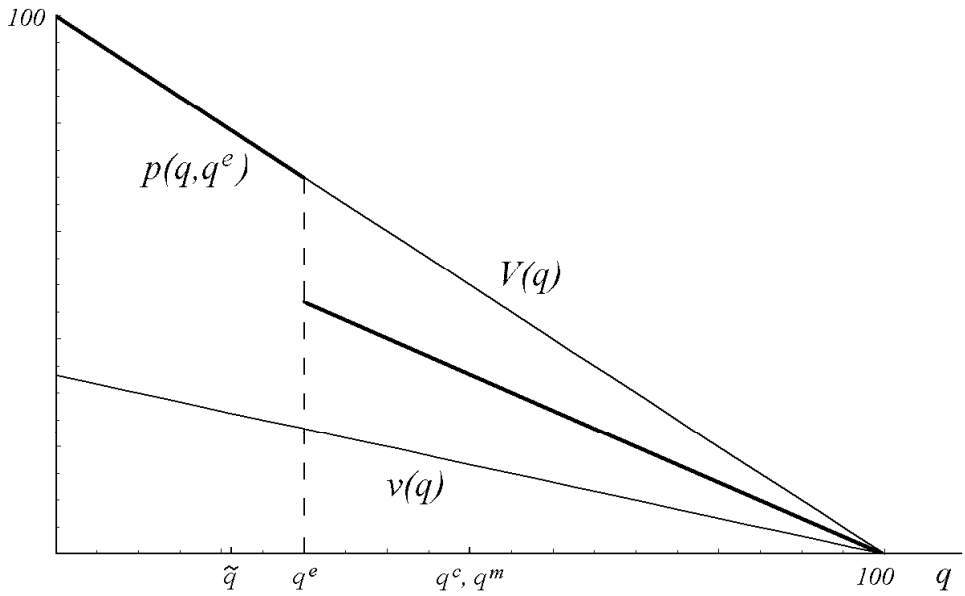

Figure 2: Targeted enforcement with extent $q^e = 30$.

price at $q = 30$ or to operate more competitively along the lower section of the demand curve. Since $\widetilde{q} \doteq 21.1$ in this example, enforcement is sufficiently extensive for the super-monopoly pricing strategy to generate more profits.[22]

The impact on copyright holder profits and consumer surplus of different levels of enforcement is shown in Figure 3. At a low level of enforcement 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 more extensive enforcement. When enforcement reaches $q^e = \widetilde{q}$ 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 customers until enforcement reaches $q^e = q^m$, after which the firm sells only q^m units regardless of the enforce-

[22]Under this strategy the price is 70 and profits are 2100. Following the competitive strategy the copyright holder would choose to operate at $q^c = 50$ (as shown in Proposition 2, $q^c = q^m$ since the goods are valued proportionately in this example) and charge price $p = 33\frac{1}{3}$, giving profits of $1666\frac{2}{3}$.

ment level. Considering consumer surplus, low levels of enforcement have no impact since the monopolist continues to compete with bootleggers. But consumer surplus 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 are forced by the higher price to switch to the lower quality pirated copy. As enforcement is extended further, the copyright holder lowers prices to sell to the newly captive customers, and after an initial dip, consumer surplus rises until $q^e = q^m$. Over the range $q^e \in [25, 50]$ there is no conflict between copyright holder profits and consumer surplus. Yet further extension of enforcement does not affect profits since the firm sticks with the profit-maximizing quantity q^m, but consumer surplus falls since lower-value buyers who would never purchase legitimate copies at the monopoly price are prohibited from purchasing pirated copies.[23]

Figure 3 shows that enforcement which is too low ($q^e < \widetilde{q}$) is superfluous since it has no effect on copyright holder behavior, and enforcement which is too high ($q^e > q^m$) is gratuitous since it hurts consumers but does not benefit the copyright holder. Regarding what enforcement level is "optimal", the gains and losses to consumers are clear, but the benefits of giving stronger incentives to generate intellectual property could vary widely depending on the particular circumstances. We can only note that any reasonable social welfare function should be a positive function of consumer surplus, a positive function of copyright holder profits, and a negative function of enforcement costs. We can then rule out an enforcement extent as inefficient if a lower extent could attain the same or higher levels of both copyright holder profits and consumer surplus.

The conclusion from Figure 3 that non-zero enforcement extent $q^e \notin [\widetilde{q}, q^m]$ is inefficient clearly holds generally. For $q^e \in [\widetilde{q}, q^m]$, copyright holder profits are strictly increasing because

[23] In this example with linear demand the total surplus (copyright holder profits plus consumer surplus) is the same with no enforcement or with enforcement $q^e = q^m$. Since $q^c = q^m$ the copyright holder will produce the same amount (at lower prices) with enforcement less than $q^e \leq \widetilde{q}$ as it will with enforcement $q^e \geq q^m$. In general the total surplus may be higher or lower with no enforcement than with enforcement $q^e = q^m$.

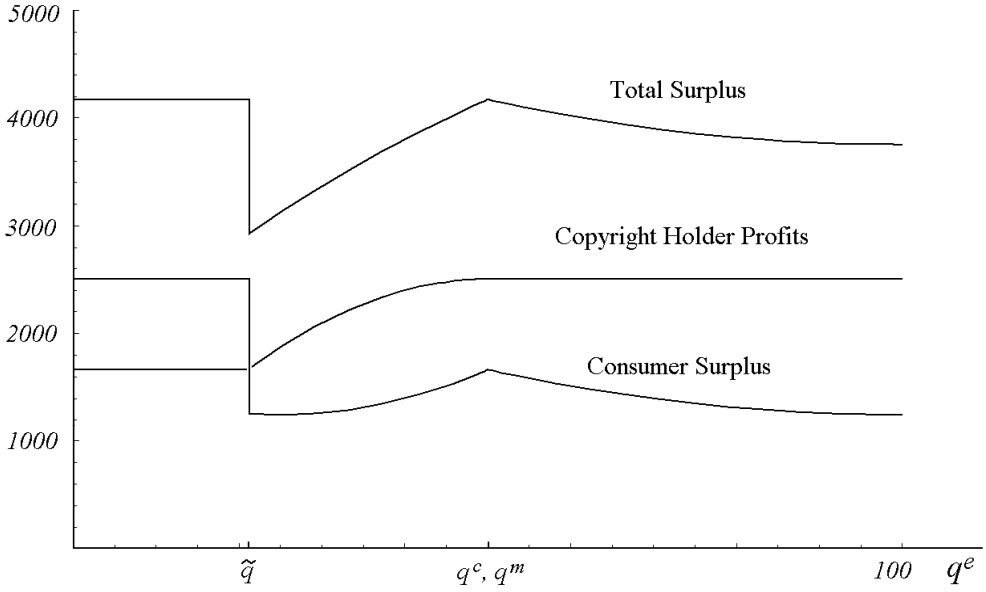

Figure 3: Profits, surplus from targeted enforcement with extent q^e.

marginal revenue is strictly decreasing in q and marginal revenue equals zero at $q = q^m$. Since more extensive enforcement in this range strengthens incentives to generate intellectual property, any enforcement extent $q^e \in [\widetilde{q}, q^m]$ is potentially efficient for some social welfare function. Therefore we are primarily interested in enforcement levels within this range.

Proposition 2. Relative to no enforcement, targeted enforcement (i) raises the legitimate copy price, increases copyright holder profits, and decreases consumer surplus for all $q^e \geq \widetilde{q}$, and (ii) increases piracy if (a) $q^e \in [\widetilde{q}, \min\{q^c, q^m\}]$ generally or (b) $q^e \in [\widetilde{q}, q^m]$ and pirated copies are valued proportionately to legitimate copies.

Proof: (i) For $q^e \in [0, \widetilde{q})$ the copyright holder chooses output q^c and price $V(q^c) - v(q^c)$ so enforcement has no effect. For $q^e \in [\widetilde{q}, q^m]$ the firm chooses output q^e and the super-monopoly price $V(q^e)$ which leads to higher profits and lower consumer surplus. For $q^e \in (q^m, Q]$ the firm chooses the monopoly output q^m and the monopoly price $V(q^m)$, again implying higher profits and lower consumer surplus. *(ii-a)* Without any enforcement the copyright holder chooses

output q^c, implying the piracy range is $(q^c, Q]$. For enforcement levels $q^e \in [\widetilde{q}, q^m]$ the copyright holder chooses output q^e, implying the piracy range is $(q^e, Q]$. If $q^c < q^m$ then piracy increases for $q^e \in [\widetilde{q}, q^c]$, while if $q^m < q^c$ then piracy increases for $q^e \in [\widetilde{q}, q^m]$. *(ii-b)* It is sufficient to show that $q^c = q^m$. If $v(q) = \alpha V(q)$ where $0 < \alpha < 1$ then $q^c = \arg\max_q\{(1-\alpha)V(q)q\}$. Since $q^m = \arg\max_q\{V(q)q\}$, the maximizing quantities are identical. ■

As seen from Figure 3, 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 increases sales. Although consumers on the margin of enforcement lose, inframarginal consumers benefit from the lower price. In the example of Figure 3 consumers gain from more extensive enforcement over most of the non-superfluous, non-gratuitous range. The following proposition shows that consumers always benefit over some range.

Proposition 3. More extensive enforcement in $q^e \in [\widetilde{q}, q^m)$ (i) lowers the legitimate copy price, increases copyright holder profits, and reduces piracy generally and (ii) increases consumer surplus if (a) q^e is sufficiently close to q^m or (b) pirated copies are sufficiently poor substitutes for legitimate copies.

Proof: (i) The price in this range is $V(q^e)$ which is decreasing in q^e. Monopoly profits are increasing for $q^e \in [\widetilde{q}, q^m)$ since marginal revenue is assumed to be monotonically decreasing in q and is zero at q^m. For $q^e \in [\widetilde{q}, q^m]$ the piracy range is $(q^e, Q]$ which is decreasing in q^e.

(ii-a) Consumer surplus is

$$CS = \int_0^{q^e} V(q) - V(q^e)dq + \int_{q^e}^{Q} v(q)dq,$$

so

$$\begin{aligned}\frac{dCS}{dq^e} &= V(q^e) - V(q^e) - q^e V'(q^e) - v(q^e) \\ &= -V'(q^e)q^e - v(q^e).\end{aligned}$$

From the first order condition for profit maximization,

$$V'(q^m)q^m + V(q^m) = 0$$

so

$$\frac{dCS}{dq^e} \mid_{q^e=q^m} = V(q^m) - v(q^m) > 0,$$

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

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

The coincidence of consumer and copyright holder interests has implications for who should bear the costs of enforcement. If only the copyright holder benefited, private enforcement by the copyright holder through civil cases would be adequate. But if consumers benefit from extending enforcement more broadly, private enforcement may be inadequate. To examine this issue, let the cost of enforcement be the continuous function $e(q^e)$ where $e(0) = 0$, $e'(q^e) > 0$, and $e''(q^e) \geq 0$ for all q^e.[24] And let q^* be the profit-maximizing extent of enforcement. The copyright holder will then choose $q^* < q^m$ because profits as a function of q are flat at $q = q^m$. If consumer surplus is increasing at q^* private enforcement will be insufficiently extensive, providing a rationale for public expenditures on enforcement. From Proposition 3 consumer surplus is increasing in q^e if q^e is sufficiently close to q^m. Since the copyright holder will choose q^e arbitrarily close to q^m for sufficiently low enforcement costs, the first part of the following proposition holds. Also from Proposition 3, consumer surplus is increasing in q^e throughout the efficient range if pirated copies are sufficiently poor substitutes for legitimate copies, thereby implying the second part of the following proposition.

[24] This formulation of enforcement costs captures only enforcement extent. As shown by Chen and Png (1999) opposing results are obtained for enforcement intensity.

Proposition 4. If the copyright holder chooses the enforcement extent and bears all enforcement costs, enforcement will be insufficiently extensive if (i) the marginal cost of extending enforcement $e'(q^*)$ is sufficiently low or (ii) pirated copies are sufficiently poor substitutes for legitimate copies.

The existence of differential enforcement raises the issue of price discrimination. In particular, if the copyright holder can differentiate between business and home users sufficiently to target enforcement at the former group, it may also be able to charge the groups different prices. Clearly the results of Proposition 2 regarding piracy no longer hold when targeted enforcement allows price discrimination to become possible. The firm can 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 piracy. As is standard with third-degree price discrimination, the impact on copyright holder profits is positive while the impact on consumer surplus is ambiguous.

Regarding marginal increases in the extent of enforcement, the main results of Propositions 3 and 4 are unaffected by price discrimination. In particular, as shown in Proposition $3'$ in the appendix, more extensive enforcement continues to raise rather than lower consumer surplus for q^e sufficiently close to q^m. And as shown in Proposition $4'$ in the appendix, private enforcement by the firm will still be insufficiently extensive for low enforcement costs. Note though that the effect of extending enforcement is more complicated with discrimination than without it. Marginal consumers who are switched from the non-captive to captive market are hurt more by the extension of enforcement because they were able to buy the legitimate copy at a reasonable price in the non-captive market. 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 3 the net result is that consumer surplus is rising in the range $q^e \in [33\frac{1}{3}, 50]$, a smaller range than without price discrimination.

5 Conclusion

This paper shows that broad-based and targeted copyright enforcement have different implications for firm pricing strategies, piracy, and social welfare. Broad-based copyright enforcement raises prices toward the monopoly level, reduces piracy, and lowers consumer surplus. In contrast, enforcement targeted at high-value buyers leads to super-monopoly prices and an increase in piracy. Extending the range of targeted enforcement down the demand curve can then lower prices toward the monopoly level, reducing piracy and potentially increasing both monopoly profits and consumer surplus.

Our model is most appropriate for copyright enforcement but is also 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, 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.[25] 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 primarily 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

[25] However, in the United States at least there is evidence that smaller firms are at a legal disadvantage in patent disputes (Lanjouw and Lerner, 1997) and might therefore be more attractive enforcement targets.

is primarily directed at prestigious retail outlets servicing high-value buyers.

6 Appendix

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.

Proof: (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

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

From total differentiation of the first order conditions,

$$\frac{dq^d}{dq^e} = -\frac{V''(q^e + q^d) - v''(q^e + q^d) + V'(q^e + q^d) - v'(q^e + q^d)}{V''(q^e + q^d) - v''(q^e + q^d) + 2\left(V'(q^e + q^d) - v'(q^e + q^d)\right)} > -1$$

implying that $q^e + q^d$ rises as q^e rises. The price in the non-captive market, $V(q^e + q^d) - v(q^e + q^d)$, is therefore decreasing in q^e. The piracy range is $(q^e + q^d, Q]$ for $q^e \in [0, q^m]$ so piracy falls.

(ii) Consumer surplus is

$$CS = \int_0^{q^e} V(q) - V(q^e)dq + \int_{q^e}^{q^e+q^d} V(q) - \left(V(q^e + q^d) - v(q^e + q^d)\right) dq + \int_{q^e+q^d}^{Q} v(q)dq,$$

so

$$\begin{aligned}
\frac{dCS}{dq^e} &= V(q^e) - V(q^e) - V'(q^e)q^e + V(q^e + q^d)\left(1 + \frac{dq^d}{dq^e}\right) - V(q^e) \\
&\quad - \left(V'(q^e + q^d) - v'(q^e + q^d)\right) q^d \left(1 + \frac{dq^d}{dq^e}\right) \\
&\quad - \left(V(q^e + q^d) - v(q^e + q^d)\right) \frac{dq^d}{dq^e} - v(q^e + q^d)\left(1 + \frac{dq^d}{dq^e}\right) \\
&= -V'(q^e)q^e - V(q^e) + V(q^e + q^d) - v(q^e + q^d) - \\
&\quad \left(V'(q^e + q^d) - v'(q^e + q^d)\right) q^d \left(1 + \frac{dq^d}{dq^e}\right).
\end{aligned}$$

Recall that $V(q) > v(q)$ and $V'(q) < v'(q)$ for all q and $V'(q^m)q^m = V(q^m)$. Therefore by the same argument as in Proposition 3 (ii-a), for q^e sufficiently close to q^m, $dCS/dq^e > 0$ if $dq^d/dq^e > -1$, as established in (i). ■

Proposition 4′. If the copyright holder chooses the enforcement extent and bears all enforcement costs, enforcement will be insufficiently extensive if the marginal cost of extending enforcement $e'(q^*)$ is sufficiently low.

Proof: By definition, $q^* = \arg\max_{q^e} V(q^e)q^e + \left(V(q^e + q^d) - v(q^e + q^d)\right) q^d - e(q^e)$. The first order condition for profit maximization is

$$V'(q^*)q^* + V(q^*) + \left(V(q^* + q^d) - v(q^* + q^d)\right) \frac{dq^d}{dq^e}$$
$$+ \left(V'(q^* + q^d) - v'(q^* + q^d)\right) q^d \left(1 + \frac{dq^d}{dq^e}\right) - e'(q^*) = 0$$

Substituting into the calculations of dCS/dq^e in Proposition 3′(ii),

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

which is strictly positive for $e'(q^*)$ sufficiently small. ■

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