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Combating Online Piracy: Making Pirated Products *Less Available* versus *Less Attractive*

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Abstract

In light of the recent movements towards prosecuting online suppliers of pirated digital goods, we study the effects of such policies and compare them to the traditional ones that penalize consumption of illegal copies. There are, in fact, some fundamental differences between these two approaches. Any enforcement against the suppliers makes pirated goods less available, whereas penalizing illegal consumption makes them less attractive to consumers. We show that these two approaches can have very different impacts on innovation and welfare: The quality of the legal good is often increasing in the level of enforcement against the suppliers. In contrast, it is often monotonically decreasing in the enforcement against illegal consumption. Consequently, the impacts on consumer and social welfare are also considerably different. Making the pirated product less available often leads to higher consumer surplus and social welfare. However, it is not necessarily the case for the demand-side enforcement. Our findings suggest that the recent enforcements against the suppliers are indeed more appealing from a policymaking perspective.

Keywords: Online piracy, enforcement, economics of information systems, markets for digital goods.

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1 Introduction

In 2003, one of the biggest news items concerning online piracy was the Recording Industry Association of America (RIAA) suing college students for illegal music downloads (Hamilton 2003). In less than six years, however, RIAA announced that it will "stop suing for illegal downloading" (Stern 2009). Of course, these contrasting statements from RIAA do not mean that the manufacturers of digital information goods completely forewent prosecuting illegal users. The manufacturers still try to discourage consumers from using pirated goods through campaigning and by bringing individual illegal users to the court (Moon 2012, BBC 2012). However, there are observations that such approach has failed to effectively mitigate the problem of online piracy (PCWorld 2011).

Seeking a more effective measure, the digital goods industry is shifting its focus to address the issue of piracy at its source. Digital Millennium Copyright Act (DMCA 1998), Combating Online Infringements and Counterfeits Act (COICA 2010), and the Stop Online Piracy Act (SOPA 2012) that recently made the headlines for weeks, are all examples of laws that the manufacturers have supported to gain a stronger arm against the supply side of piracy. Possibly due to the manufacturers' efforts, we now see many instances where the suppliers of pirated goods are prosecuted, and the pirate sites are shutting down (Epstein 2012, Perry 2012, Seidler 2013). Also, to make pirated goods even less available online, the manufacturers have been seeking cooperation from the search engine providers. It seems that their efforts are beginning to bear fruit; for instance, Google has now started voluntarily filtering out pirate sites from its search results (Woollacott 2012, Reed 2012, Neal 2013). In fact, a big part of SOPA was to make the search engine providers legally accountable for providing links to pirated contents.

From a policymaker's point of view, thus, there are two different approaches for mitigating piracy. One is to raise the level of enforcement against the use of pirated products (*demand-side enforcement*), and the other is to increase the level of enforcement against their supply (*supply-side enforcement*). In this paper, we investigate whether these two approaches have different policy implications. There are a number of previous works that analyze the effect of piracy and provide suggestions on policy implementations, but most of them only look at the issue of penalizing the consumers of pirated goods. In their analyses, Jain (2008) and Bae and Choi (2006) report that piracy reduces the return on investment and lowers manufacturers' incentive to invest in

quality. On the contrary, a recent paper by Lahiri and Dey (2013) tells a different story—in certain circumstances, less enforcement against piracy may actually lead to a higher product quality, making both the consumers and society better off. Tunca and Wu (2013) do look at the supply side of piracy, where they consider price-setting commercial pirates. They find that increasing enforcement against individual piracy (e.g., illegal download through a P2P network) may have a detrimental effect on the manufacturer as it may make the commercial pirates more competitive. In this paper, we consider ad-revenue driven pirate sites, inspired by the recent debates on SOPA in the political and consumer circles. The main objective of this paper is to study the effect of enforcements against the suppliers and the users of downloadable pirated goods and to compare the effects of the two different approaches. Clearly, such analysis is of significant importance to a policymaker as it contrasts the effects of two different measures against piracy and suggests which should be implemented.

Intuitively, the demand-side enforcement makes piracy a *less attractive* choice to the consumers, whereas the supply-side enforcement makes pirated copies *less available*. Using the notions of attractiveness and availability of pirated goods, we can formally write our research questions as follows: Are there any differences between making pirated goods less available versus less attractive in terms of (i) product quality, (ii) consumer surplus, and (iii) social welfare?

In studying the effects of the two different approaches against piracy, we borrow much of the model setup from prior literature. For instance, we assume that the consumers are heterogeneous in their valuation for quality (August and Tunca 2006, 2008, Bhargava and Choudhary 2001, 2008, Chellappa and Shivendu 2005, Cho and Ahn 2010, Jones and Mendelson 2011, Lahiri and Dey 2013, Wu and Chen 2008), and we consider a profit-maximizing monopolist firm (August and Tunca 2006, 2008, Chellappa and Shivendu 2005, Chen and Png 2003, Conner and Rumelt 1991, Shy and Thisse 1999). Furthermore, following prior literature, we assume that there exists a quality difference between the pirated and legal versions (August and Tunca 2006, 2008, Bae and Choi 2006, Jaisingh 2009, Novos and Waldman 1984, Sundararajan 2004). Essentially, our model is an extension of the standard setup used in prior literature, the new elements being the ad-revenue driven pirated content suppliers and the presence of supply-side enforcement.

From our model, we find results that highlight some important differences between the two types of enforcements. First, in most practical situations, the quality of legal goods is monotonically

increasing in the level of supply-side enforcement. However, the quality strictly decreases as the demand-side enforcement increases, in line with findings of Lahiri and Dey (2013). The impacts on the consumer and social welfare are also quite different. In the most practical settings, an increase in the supply-side enforcement leads to both a higher consumer and social welfare. However, the same is not necessarily true for the demand side. That is, an increase in the demand-side enforcement can lead to a lower consumer and social welfare. These results suggest that the supply-side enforcement may indeed be a better policy choice.

2 Model Description

In our model, we consider (i) a profit-maximizing digital information goods manufacturer, (ii) pirated-copy suppliers that are supported by ad revenues, and (iii) utility-maximizing consumers.

2.1 Availability of Pirated Goods

We begin by assuming that consumers are heterogeneous in their willingness to search the Internet for pirated versions of the legal product. We assume that the number of searches done by a consumer follows a geometric distribution with parameter $g \in (0, 1)$. The probability that a consumer searches i times, $i = 0, 1, 2, \ldots$, is then $g(1-g)^i$. We use geometric distribution to capture the idea that most consumers would search a few times but only a handful would do so a large number of times.

We use $\eta \in [0, 1]$ to denote the normalized supply of pirated content. In other words, η represents the probability that a single search by a consumer is able to locate a pirated version. When $\eta = 0$, there is no supply of pirated copies whatsoever. On the other hand, when $\eta = 1$, pirated copies are abundant and are readily available upon a search.

Now, the probability that a consumer searches exactly i times and gives up without finding any pirated copy is $(1-\eta)^i g(1-g)^i$. Hence, the expected fraction of consumers who do not find any pirated version, λ, is:

$$\lambda = \sum_{i=0}^{\infty} (1-\eta)^i g(1-g)^i = \frac{g}{1-(1-g)(1-\eta)}.$$

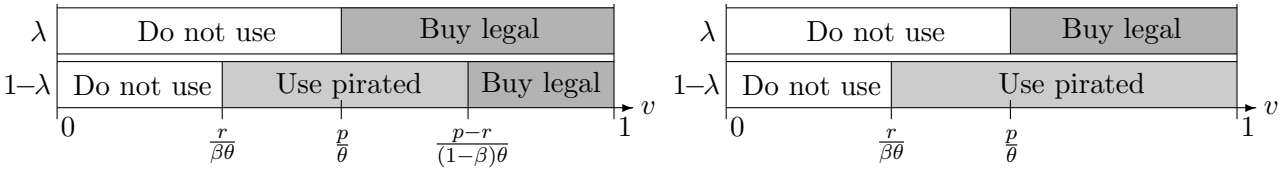
Hence, a λ fraction either i) *buys the legal product* or ii) *forgoes its use completely*, whereas the remaining $(1-\lambda)$ fraction also has a third option to *obtain a pirated copy*.

2.2 Attractiveness of Pirated Goods

We assume that consumers are heterogeneous in their preference for quality. Each consumer knows his or her preference, whereas the manufacturer only knows the distribution. Here, we assume that a consumer's preferences for quality, v, is uniformly distributed over $[0, 1]$. Under such a setting, a consumer who uses a product with quality θ gets a value of $v\theta$.

There is an associated expected legal penalty, r, in obtaining a pirated copy. The expected legal penalty is the potential legal liability as described by August and Tunca (2008). We assume it to be exogenous and dependent on the level of enforcement against the consumption of pirated goods, or simply the *demand-side enforcement*. Following prior work (Sundararajan 2004), we also assume that the quality of the pirated product is less than that of the legal version. This is modeled by denoting the quality of the pirated version as $\beta\theta$, where $\beta \in (0, 1)$.

A consumer enjoys a net utility of $v\theta - p$ from purchasing the legal version, where p is its price. The $(1 - \lambda)$ fraction of consumers who also has the option to use a pirated version of the product can enjoy a utility of $v\beta\theta - r$ from it. In cases where piracy exists, we can use individual rationality constraints (IRC) and incentive compatibility constraints (ICC) of consumers to characterize the market into two cases as depicted in Figure 1.



(a) $\frac{p-r}{(1-\beta)\theta} < 1$ (b) $\frac{p-r}{(1-\beta)\theta} \geq 1$

Figure 1: Consumers Self-Select Based on Their Relative Benefit and Search Result

If $\lambda < 1$ and $\frac{p-r}{(1-\beta)\theta} < 1$, the legal demand consists of those who are unable to find a pirated version as well some of those who are able to find one. We denote the legal demand as $q(p, \theta)$ and the illegal demand as $\hat{q}(p, \theta)$:

$$q(p,\theta) = \lambda\left(1 - \frac{p}{\theta}\right) + (1-\lambda)\left(1 - \frac{p-r}{(1-\beta)\theta}\right), \quad \text{and} \quad \hat{q}(p,\theta) = (1-\lambda)\left(\frac{p-r}{(1-\beta)\theta} - \frac{r}{\beta\theta}\right). \quad (1)$$

On the other hand, if $\frac{p-r}{(1-\beta)\theta} \geq 1$, the legal demand arises from only the λ group, as everyone in

the $(1-\lambda)$ group prefers the pirated product to the legal one. Hence:

$$q(p,\theta) = \lambda\left(1-\frac{p}{\theta}\right), \quad \text{and} \quad \hat{q}(p,\theta) = (1-\lambda)\left(1-\frac{r}{\beta\theta}\right). \tag{2}$$

Finally, if $\lambda = 1$ (i.e., $\eta = 0$), there is no piracy. As a result, we get:

$$q(p,\theta) = \left(1-\frac{p}{\theta}\right), \quad \text{and} \quad \hat{q}(p,\theta) = 0. \tag{3}$$

2.3 The Level of Piracy in Equilibrium

The supply of pirated content, η, matches its demand counterpart, $\hat{q}$, in equilibrium. We consider pirate sites that operate on ad revenues, and the total revenue across all pirate sites is expected to increase with the number of illegal users (i.e., "downloaders"). Without loss of generality, we assume the two to be the same.

We assume identical pirate sites. Hence, the revenue for each supplier is expected to decrease with the number of competing pirate sites. We also assume that suppliers face legal liabilities, denoted as e. Thus, e represents the level of *supply-side enforcement*. It is important to distinguish e from r—e is the level of enforcement against the suppliers of pirated goods, whereas r is the level of enforcement against the consumption of pirated goods.

Suppliers compare their expected revenue to e in order to decide whether to participate in hosting pirated contents. Hence, in equilibrium, if $\eta \in (0,1)$, it must satisfy:

$$\frac{\hat{q}}{\eta} - e = 0 \Rightarrow \eta = \frac{\hat{q}}{e}. \tag{4}$$

Thus, in equilibrium, when $\hat{q}$ is as described by (1), we get:

$$\lambda = \lambda_a = \left(\frac{eg}{1-g}\right)\frac{(1-\beta)}{\frac{p}{\theta}-\frac{r}{\beta\theta}}, \quad \text{and} \quad \eta = \eta_a = \frac{p-\frac{r}{\beta}}{e\theta(1-\beta)} - \frac{g}{1-g}. \tag{5}$$

Similarly, when $\hat{q}$ is as described by (2), we get:

$$\lambda = \lambda_b = \left(\frac{eg}{1-g}\right)\frac{1}{1-\frac{r}{\beta\theta}}, \quad \text{and} \quad \eta = \eta_b = \frac{\theta-\frac{r}{\beta}}{e\theta} - \frac{g}{1-g}. \tag{6}$$

Finally, it is also possible that neither (5) nor (6) provides a solution satisfying $0 < \eta < 1$; in those cases, η is either 0 or 1.

3 Manufacturer's Decision Problem

The time line is as follows. The manufacturer offers a product of quality $\theta > 0$ at a price $p > 0$. After the manufacturer decides on θ and p, the suppliers of pirated content decide whether to provide an illegal version or not. Finally, each consumer decides whether to buy, pirate, or forgo use. An equilibrium is reached, where the demand for the pirated product matches its supply.

Following prior literature, we assume a zero marginal cost of production. The product development cost, $c(\theta)$, is quadratic in θ and is taken to be of the form $\frac{c\theta^2}{2}$, where $c > 0$. Thus, the manufacturer's problem is to solve: $\max_{p,\theta} pq(p,\theta) - \frac{c\theta^2}{2}$. We assume that the manufacturer decides on the quality and price simultaneously.

When there is little enforcement against piracy, and the manufacturer sets its price and quality in a way that the legal product becomes fairly unattractive, the demand for pirated goods rises sharply. In such a case, all suppliers want to provide a pirated copy because they can all make a positive profit, which drives η to 1. On the other hand, when the enforcement is high or the legal product is priced competitively, it is not profitable for the suppliers to enter the market, which leads to $\eta = 0$. Because of such possibilities, we consider the following three cases separately: one in which $\eta \in (0,1)$, one where $\eta = 1$, and finally the one with $\eta = 0$. After a full exploration of the three cases, we piece them together to obtain a complete picture of the strategy space for the manufacturer. A list of all possibilities are shown in Figure 2.

Limited Supply; $0 < \eta < 1$: The manufacturer may sell to both the λ and $(1-\lambda)$ segments by setting a price such that $\frac{p-r}{(1-\beta)\theta} < 1$ (Case 1-A). It may also set p so that $\frac{p-r}{(1-\beta)\theta} \geq 1$ (Case 1-B), in which case no consumers from the latter segment buys the legal product.

Ample Supply; $\eta = 1$: When e is very low such that $\eta = 1$ for the p and θ chosen by the manufacturer, there are again two possible scenarios: the manufacturer may sell to both the λ and $(1-\lambda)$ segments of the market (Case 2-A), or it may consider the λ segment alone (Case 2-B). Because η is no longer dependent on e, the manufacturer's price does not depend on e here. In

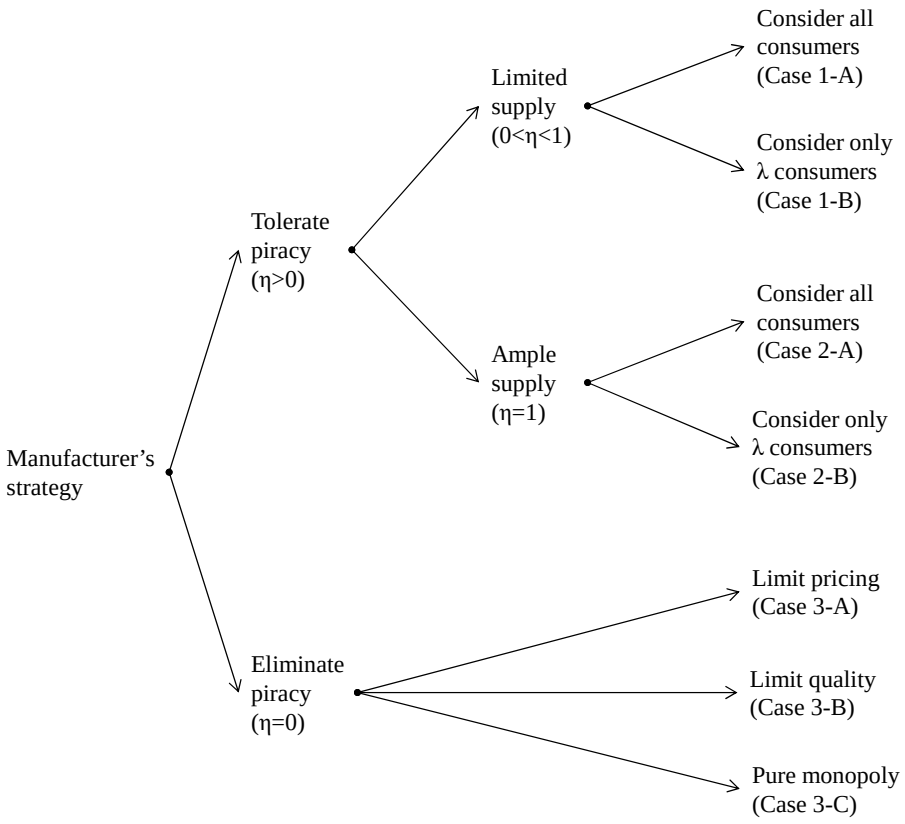


Figure 2: Manufacturer's Strategy Space

other words, unlike the case of limited supply, e is now too low to have any effect on the price.

No Piracy; $\eta = 0$: Piracy ceases to exist when no consumer has the option to use pirated version. This can happen if the manufacturer chooses the price and quality in a way that the pirated product is rendered completely uncompetitive. In this situation, η reduces to zero. It turns out that the manufacturer can either use the price as the primary tool to eradicate piracy (Case 3-A) or use quality to do so (Case 3-B). It is worth noting that, in Case 3-A or 3-B, piracy ceases to exist, but the threat of piracy still remains and affects the manufacturer's decisions—unless the manufacturer holds the price or quality to a certain level, piracy can resurface. However, when enforcement on either side is high enough to suppress all threats completely, we end up with the case of pure monopoly (Case 3-C).

Solving the Decision Problem: Thus far, we have described different possible equilibrium outcomes. Now the question is, how does the manufacturer choose its strategy? For the sake of

brevity, we here describe the solution method instead of elaborating on the algebraic manipulations. For one of the seven cases above (1-A, 1-B, 2-A, 2-B, 3-A, 3-B, and 3-C) to occur at optimality, two things must hold: (1) given the levels of demand- and supply-side enforcement, there must exist an interior maximum (i.e., an optimal p and θ pair) for that case, and (2) it must yield a higher profit than all other cases for which an interior maximum is obtainable.

As an illustration, Figure 3 shows how the optimal solution looks like for different levels of e and r, when $g = 0.1$, $\beta = 0.75$, and $c = 0.01$. This figure lays out the manufacturer's optimal strategy and shows how transitions happen from one case to another with changes in the two enforcement levels. For instance, when r is very small, increasing e from 0 to 10 results in the following chain of transitions: When e is really low, the optimal solution belongs to Case 2-A, the case in which the supply of the pirated product is abundant and the manufacturer sells to both the λ and $(1-\lambda)$ segments. As e increases, the optimal solution enters the region of limited supply, that is, to Case 1-A. As e goes up further and starts severely denting the size of the segment with the option to pirate, the manufacturer finds it more profitable to ignore that segment; as a result, the optimal solution moves to Case 1-B . Finally, when e becomes very high, the manufacturer gets to enjoy its full monopoly power, shifting the optimal outcome to Case 3-C.

4 Results

Because of practical considerations, we are mainly concerned with cases where piracy exists (Cases 1-A, 1-B, 2-A, and 2-B). Hence, we provide analytical results only for these cases. For completeness, however, we numerically illustrate other cases as well. We omit all proofs due to space limitations.

4.1 Product Quality

First, we analyze how the quality of the product changes with enforcements. We find that, in most of the cases where piracy exists—specifically, 1-A, 1-B, and 2-A—quality decreases in the demand-side enforcement, r. This is in line with the recent findings by Lahiri and Dey (2013). However, the same is not true for the supply-side enforcement, e. In fact, when $0 < \eta < 1$, the optimal quality (denoted θ^*) is strictly increasing in e.

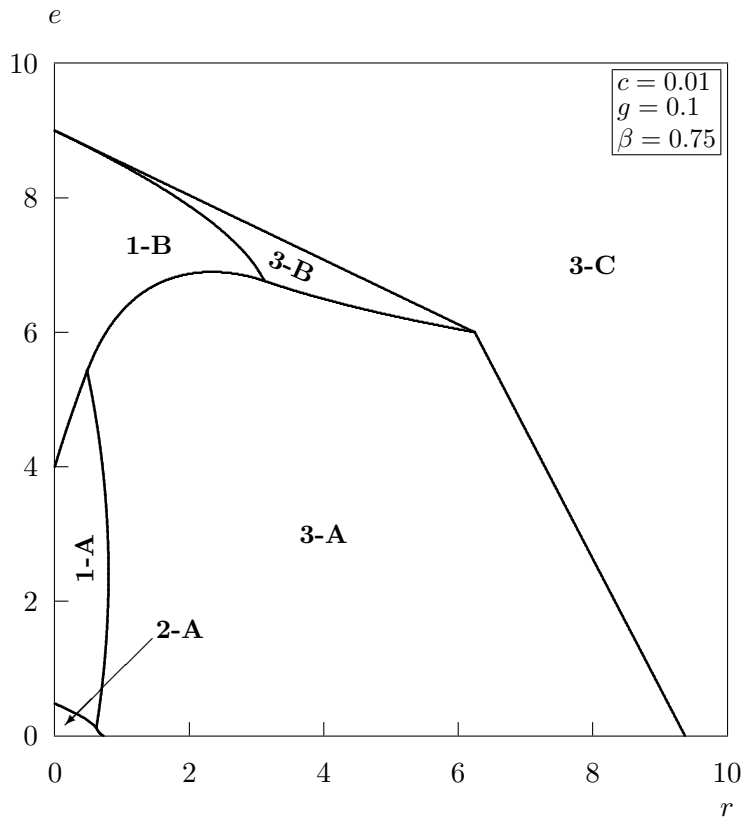
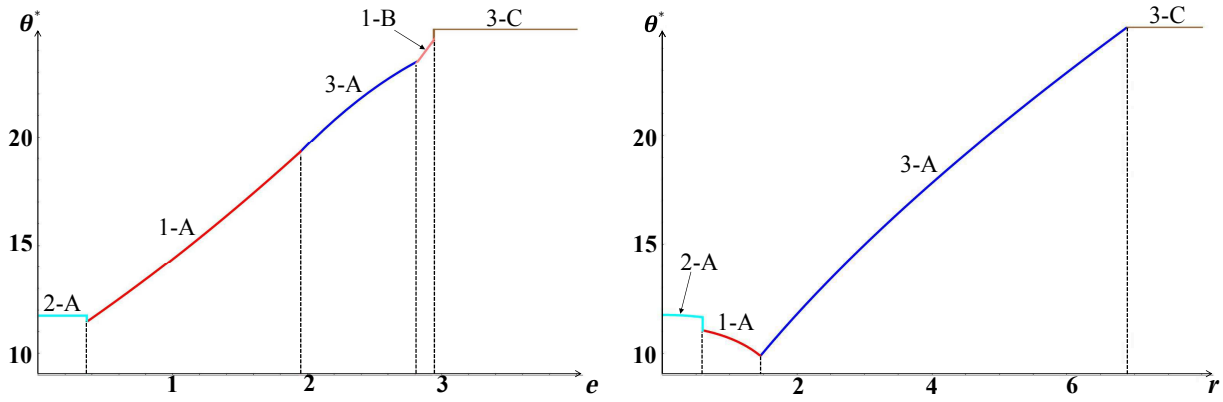


Figure 3: Relevant Partitions of the (r, e) Space

Theorem 1 *The effect of enforcements on the quality of the product, θ^*, can be summarized as below:*

- *In Case 1-A, θ^* increases in e but decreases in r.*
- *In Case 1-B, θ^* increases in e but decreases in r.*
- *In Case 2-A, θ^* does not change with e but decreases in r.*
- *In Case 2-B, θ^* does not change with e and r.*

Theorem 1 highlights the fact that the two different types of enforcements may influence the manufacturer's incentive to innovate quite differently. Figure 4 illustrates the result using a numerical example. The figure clearly shows that, in Case 1-A, perhaps the most interesting case from the practical standpoint, the two enforcements have exactly opposite effects on the optimal quality.



(a) θ^* vs. e $(r = 0.3)$ (b) θ^* vs. r $(e = 0.3)$

Figure 4: Optimal Quality, θ^*, as Functions of e and r; $\beta = 0.6, g = 0.25, c = 0.01$

There are two major implications of Theorem 1. First, the supply-side enforcement has a more desirable effect on innovation. Second, findings of prior research on the demand-side enforcement do not automatically extend to the supply-side enforcement. The primary reason the impacts of e and r differ is that a higher r makes the pirated product less competitive, which reduces the manufacturer's incentive to differentiate the legal product from it. Since the quality differentiation $(1 - \beta)\theta$ is increasing in θ, the manufacturer has a tendency to respond with a lower θ when r increases. On the contrary, e does not impact the relative appeal of the pirated product. It simply limits its reach, thereby allowing the manufacturer to easily recoup additional investments in quality. Hence, the manufacturer often finds it profitable to increase θ in response to an increase in e. To the best of our knowledge, this is the first work to identify this important difference between the two commonly used types of enforcement against piracy.

4.2 Consumer Surplus

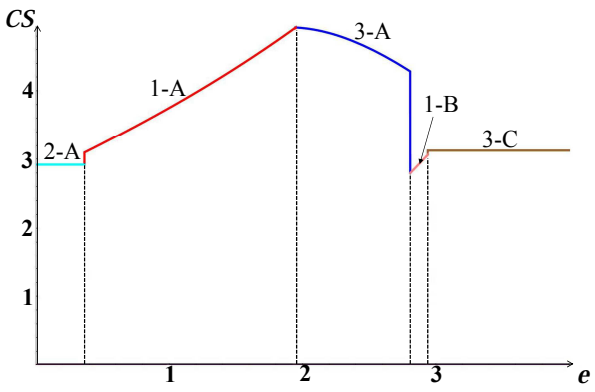
Since the impacts of the two enforcement approaches on the optimal quality level are different, their impacts on the consumer surplus are different as well.

Theorem 2 *The effect of enforcements on the consumer surplus (CS) can be summarized as below:*

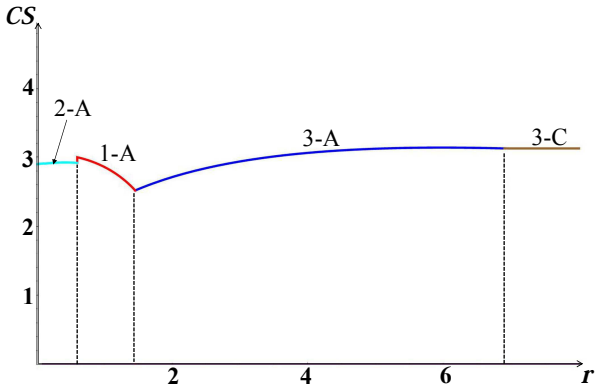
- *In Case 1-A, CS increases in e but may decrease in r.*
- *In Case 1-B, CS increases in e but may decrease in r.*

- *In Case 2-A, CS does not change with e but may decrease in r.*
- *In Case 2-B, CS does not change with e and r.*

Figure 5 shows an example of how the consumer surplus may change in e and r. Directing our attention to the most interesting case, Case 1-A, we notice that the consumer surplus is, in fact, strictly increasing in e. However, that does not necessarily happen when r increases; an increase in r may surprisingly result in a reduction in the consumer surplus.



(a) CS vs. e ($r = 0.3$)



(b) CS vs. r ($e = 0.3$)

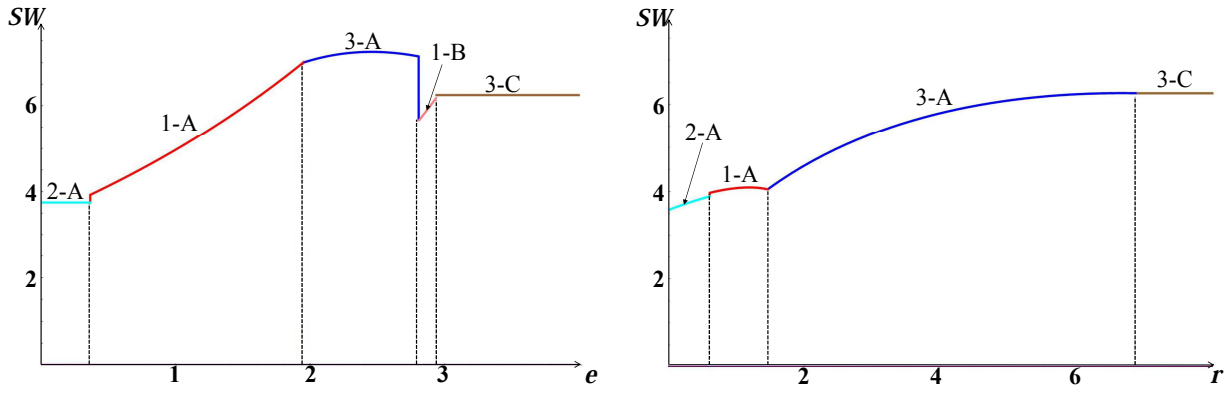
Figure 5: Consumer Surplus (CS) as Functions of e and r; $\beta = 0.6, g = 0.25, c = 0.01$

4.3 Social Welfare

The social welfare is simply calculated as a sum of the consumer surplus and the manufacturer's profit. We disregard the welfare of the pirates and the suppliers of the pirated product, as their welfare is often of little concern when designing and evaluating a public policy against piracy.

Theorem 3 *The effect of enforcements on the social welfare (SW) can be summarized as below:*

- *In Case 1-A, SW increases in e but may decrease in r.*
- *In Case 1-B, SW increases in e but may decrease in r.*
- *In Case 2-A, SW does not change with e but may decrease in r.*
- *In Case 2-B, SW does not change with e and r.*



(a) SW vs. e ($r = 0.3$) (b) SW vs. r ($e = 0.3$)

Figure 6: Social Welfare (SW) as Functions of e and r; $\beta = 0.6, g = 0.25, c = 0.01$

As illustrated in Figure 6, the impacts on the social welfare are similar to the ones we have found for the consumer surplus. These findings on welfare have a clear policy implication. Raising the enforcement against the supply side of piracy, e, is apparently better for both the manufacturer and legal consumers. However, the enforcement against the demand side, r, can be detrimental to consumers and, despite a positive impact on the manufacturer, may be detrimental to the society as a whole. Thus, when combined with the impacts on quality identified above, making piracy less attractive seems like a rather risky policy approach. In contrast, making pirated products less available appears far more desirable.

5 Conclusion

In recent times, the fight against online piracy has seen a shift in the focus—from the demand side to the supply side of piracy—for manufacturers and policymakers alike. Supply-side enforcements make a pirated version less available, whereas demand-side enforcements make it less attractive. In order to see whether such a shift is justified from a policymaking angle, it is necessary to compare these two approaches in terms of their impacts on innovation and welfare. To the best of our knowledge, prior research has mostly focused on the demand side and, hence, do not provide the necessary comparative picture. This paper attempts to bridge this discernible gap in literature.

We develop a parsimonious model capturing both sides of piracy, assuming that online providers

of pirated contents profit from ad revenues which increase with the traffic to their sites. Their decision to provide illegal content depends on how the expected revenue compares with the supply-side enforcement. On the other hand, when consumers use illegal content, they face a potential legal penalty that depends on the demand-side enforcement. Situated in this context, the manufacturer decides on price and quality in a way that maximizes its profit for given levels of these two enforcements. The manufacturer's strategic decisions, coupled with the response from the pirate suppliers and consumers, determine the consumer and social welfare in equilibrium.

We find that there are, in fact, some fundamental differences between penalizing illegal users and curbing the supply of pirated goods. In most situations where piracy exists, making the pirated good less available results in higher innovation and a better quality product, although the end effect of making it less attractive through demand-side enforcements is exactly the opposite. In terms of consumer and social welfare as well, the effect of supply-side enforcements turns out to be largely favorable, but that of demand-side enforcements can be adverse, with obvious implications for a policymaker.

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