Fair Play for Fair Pay: Fighting Digital Piracy through Revenue Sharing

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Short Research Paper

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Abstract

Considering a setting where a content provider (CP) sells their content to customers over a network owned by an ISP, we examine whether the CP can use monetary incentives to encourage the ISP to fight digital piracy without any intervention by the policymaker. In our model, the CP sets a fraction of its revenue that is shared with the ISP and the price of its content, the ISP determines its anti-piracy enforcement level, and users decide whether to purchase, copy, or not use the content. We find that voluntarily sharing its revenue with the ISP can lead to increased profits for the CP, non-decreasing profits for the ISP, and reduced piracy. More importantly, we find that although being characterized by low data usage raises the chance of achieving a revenue sharing contract, it also exposes the CP to higher levels of digital piracy.

Keywords: *digital piracy, pricing, revenue sharing contract*

Introduction

Digital piracy increased globally by 33% during the pandemic, making it an important challenge for content providers (CPs). TV set-top boxes that enable piracy abound - in a single month, the movie Avengers: Infinity War was downloaded illegally 5.29 million times. Meanwhile, Ed Sheeran's songs were illegally downloaded 7.46 million times, and Microsoft Windows remains one of the most pirated pieces of software (Go-globe.com 2023). To fight digital piracy, policymakers have taken legal actions, such as passing legislation aimed at consumers and distributors of illegal content. However, several studies have documented that such enforcement efforts have largely been ineffective in curbing piracy (Aguiar et al. 2015; McKenzie 2017).

One potential reason is that ISP cooperation is critical to the success of anti-piracy efforts. For instance, ISPs aid enforcement by identifying and reporting consumers of illegal content, and then enabling punitive action. Similarly, ISP cooperation is necessary for the identification of illegal suppliers of content, the provision of required information to law enforcement agencies, and for the execution of punitive measures such as the elimination of such illegal content from their networks. However, over 24% of internet traffic can be attributed to pirated content (Go-globe.com 2023). Thus, pirated content represents a large proportion of the ISP's network traffic, and consequently, their revenues. Clearly, this serves as a dis-incentive for ISP's to cooperate in a broad effort to curb piracy. Another factor affecting the ISP's cooperation in anti-piracy efforts is enforcement cost, including the cost of developing effective technological tools and mechanisms that can facilitate piracy detection and reporting. There are technologies that currently exist that can enable the ISP to enforce anti-piracy efforts selectively for certain CPs. For example, deep packet inspection technique allows the ISP to track online activities and identify their source and destination of the traffic (Corwin 2011).

The ISPs' lack of incentive to collaborate with policymakers has led CPs to develop a creative solution to fight digital piracy: revenue sharing. The idea is to incentivize ISPs to take an interest in the financial wellbeing of a CP by sharing a proportion of the CP's revenues. This may lead ISPs to take a more proactive approach to fight digital piracy. The implementation of strong anti-piracy measures such as monitoring and blocking unauthorized consumption and distribution of copyrighted content by ISPs can lead to higher revenues for CPs, and consequently, a higher CP revenue-share for ISPs.

This type of revenue sharing has been employed by some CPs. For example, in 2009, the Irish Recorded Music Association (Irma), whose members include EMI, Sony, Universal and Warner, reached an out-of-court settlement with an Irish ISP, Eircom (Gergely 2009). According to this agreement, Eircom subscribers who would share copyrighted music unlawfully would receive three warnings as part of the pilot program before their broadband service is terminated for a year (Collins 2010).

Consider then a market in which consumers pay a data usage fee to Comcast, an American multinational ISP, in order to access shows on Netflix such as its original series Squid Game. Although Netflix holds the rights to its shows, certain illegal websites, such as Gomovies.sx, enable customers to download these series for free and generate revenue through advertising. In this market, consumers who are willing to pay the data usage fee have two options: (i) use these illegal websites to download such Netflix content, or (ii) pay a subscription to Netflix and obtain its original series legally. Because illegal content accounts for a significant portion of internet traffic, Comcast may not have the motivation to act against the suppliers of pirated content or against its consumers that pay Comcast for their internet service. To analyze revenue sharing, consider a hypothetical scenario where a CP such as Netflix voluntarily shares a proportion of its revenue with Comcast. We explore the conditions under which both the CP and the ISP can be better off from such a revenue sharing setup. We examine (i) the conditions under which the revenue sharing occurs, (ii) the characteristics of CPs that voluntarily commit to share their revenue with the ISP, and (iii) whether such a contract removes piracy.

CPs are often characterized by their data usage, which is the amount of network traffic that they generate. For instance, CPs that provide video content consume enormous amounts of network bandwidth: Netflix data represents 19.2% of the North American internet traffic (Cantor 2022). This is because of two reasons: Firstly, video content is heavy, often consuming as much as 3GB per hour of video viewing (Netflix 2023). Secondly, videos are often single use products, and consumers tend to regularly demand fresh content. In contrast to videos are book CPs such as Barnes and Noble which have a small footprint in terms of data usage. Native installed softwares such as Microsoft Windows are different again because although such softwares can represent several GBs of data usage during download and installation, they are not single use products and are reused multiple times over the life of the product and therefore involve a lower level of data usage.

We begin by focusing on a monopoly market for digital content that contains one CP, heterogeneously distributed consumers, and an ISP. To perform our analyses, we develop a four-stage game-theoretic model that captures the interaction between key participants in this market. In stage 1 the profit-maximizing CP determines the fraction of revenue that it is shares with the ISP. In stage 2, the ISP determines its enforcement efforts. In stage 3 the CP chooses the price of its content. Finally, in stage 4 consumers maximize their payoffs by choosing whether to purchase, copy, or not use the content. Following Chen and Png (2003) we model consumers as either ethical and unethical and assume that ethical consumers either purchase or not use the content, while unethical consumers can choose whether to purchase, copy, and not use the content.

We find that a CP can voluntarily share its revenue with the ISP, and this can lead to increased profits for the CP, non-decreasing profits for the ISP, and a reduction in piracy. Secondly and perhaps most importantly, we find that revenue sharing is most likely to occur when CPs are characterized by low data usage. In other words, software and book CPs such as Microsoft and Barnes and Noble are more likely than video CPs such as Netflix to enter such a revenue sharing arrangement with ISPs. Thirdly, we show that although being characterized by low data usage raises the chance of achieving a revenue sharing contract, it also exposes the CP to higher levels of digital piracy.

Literature Review

The literature on strategies to fight digital piracy investigates various anti-piracy interventions that CPs and policymakers can use to mitigate the negative impact on CPs' sales and social welfare. Prior research on CPs' anti-piracy efforts explores different strategies, such as digital rights management (Aguiar et al. 2015; Chen and Png 2003; Poort et al. 2014). Prior studies on digital rights management examine the role policymakers' copyright enforcement in fighting digital piracy (Dey et al. 2019; Lahiri and Dey 2013). Our study contributes to this stream of the literature by focusing on the enforcement efforts of ISPs rather than policymakers.

The detection of consumers and distributors of illegal content often relies on the cooperation of ISPs. As discussed in the Introduction, ISPs may lack the incentive to make enforcement efforts. Analytical studies assume that policymakers can determine the level of piracy enforcement (e.g., Chen and Png 2003; Dey et al. 2019). We contribute to this literature by relaxing this assumption and examining whether CPs can motivate ISPs to combat digital piracy by sharing a portion of their revenue from selling content with ISPs.

Our work is also related to the Agency model whereby an upstream provider shares a proportion of their revenues with a downstream firm that provides access to customers. In contrast to the traditional wholesale model where the upstream provider sells to the downstream firm at a wholesale price, (Tan et al. 2016) find that the agency model can create a Pareto improvement for all parties including both firms and customers. (Tan and Carrillo 2017) find that the upstream provider's control of the price contributes to the benefits of the agency model. We extend the agency model to the piracy problem where the CP is an upstream firm that shares a proportion of its revenues with the ISP, which is the downstream firm. We contribute to this literature by investigating whether the agency model can lead to efforts by the downstream provider to improve the situation of the upstream provider by containing digital piracy.

Notation and Assumptions

We consider a market containing a CP, an ISP, and heterogenously distributed consumers. The CP offers a unit of its content to consumers at price $p > 0$ in a single-period setting. Potential consumers divide into two equal sized segments: (i) ethical consumers who do not copy content; and (ii) unethical consumers who may copy content. Within each segment, potential users differ based on their valuation for the content, denoted by $x \sim U[0, 1]$ so that users with higher x have higher valuations for the content. Following prior studies (e.g., Chen and Png 2003), Assumption 1 characterizes consumers' observability.

Assumption 1. *An individual user's valuation for the good is not verifiable.*

Ethical consumers maximize their utility by choosing between purchasing the content and not using it. Consumers in the unethical segment maximize their utility by choosing among purchasing the content, obtaining it through illegal distributors, and not using it. Consumers that purchase the content become legal users and those that copy the content become pirates, denoted by superscript l and c, respectively. The utility of legal user x from purchasing content is

$$u^l(p) = x - p - r\theta,$$

where $\theta > 0$ shows the data usage required to access the content, hereafter referred to as data usage, and $r > 0$ represents the data usage fee. Thus, $r\theta$, captures the total data usage fees.

We also assume the pirated version of the content has a lower quality than the legal version.

Assumption 2. *A pirate's total data usage fee and valuation for the content are $\beta r\theta$ and βx, respectively, where $0 < \beta < 1$ shows the quality of pirated content.*

Assumption 2 captures an important feature of pirated content distributed online. For example, pirated music uploaded on SoundCloud is often of lower quality due to intentional distortion and over-compression. The lower quality of pirated content also indicates that pirates pay lower data usage fee.

The CP is cognizant that unethical consumers may copy its content. Thus, to fight digital piracy the CP may share a portion of its revenue $0 \leq s < 1$ with the ISP as an incentive to make enforcement efforts and fight digital piracy. Let $\eta \geq 0$ represent the piracy cost for pirates as a result of the ISP's enforcement effort. Given this, the utility of pirate x from copying content is

$$u^c(\eta) = \beta[x - r\theta] - \eta.$$

Following prior studies (e.g., Lahiri and Dey 2013), we consider a quadratic cost function for the ISP's enforcement efforts.

Assumption 3. *The cost of enforcement efforts is increasing and convex in the level of enforcement.*

The figure below summarizes the stages of the game that were described in the Introduction. We use backward induction and begin by solving the consumers' problem.

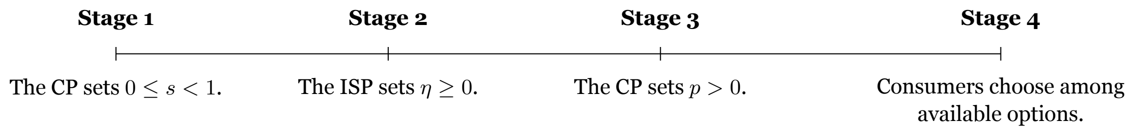

Figure 1. Sequence of Events

Model

Stage 4: Consumers Behavior

We begin with analyzing the choices of consumers within the ethical segment. Ethical user x purchases the content if the individual rationality (IR) condition holds, $x - p - r\theta \geq 0$. We define the ethical user indifferent between purchasing the content and not using it, $\tilde{x}_e$, by setting the above IR condition to equality, $\tilde{x}_e = p + r\theta$. Therefore, the proportion of legal consumers within the ethical segment, N_e^l, can be written as

$$N_e^l(p) = 1 - \tilde{x}_e = 1 - p - r\theta. \tag{1}$$

We now analyze the choices of consumers within the unethical segment. In the presence of digital piracy, unethical user x, purchases the content from the CP if, in addition to the IR condition described above, the incentive-compatibility (IC) holds, $x - p - r\theta \geq \beta[x - r\theta] - \eta$. We define the unethical user indifferent between purchasing and copying the content, denoted by $\overline{x}_{ue}$, by setting the above IC condition to equality. Therefore, the proportion of legal users within the unethical segment, $N_{ue}^l(p, \eta)$, is

$$N_{ue}^l(p, \eta) = 1 - \overline{x}_{ue} = 1 - r\theta - \frac{p - \eta}{1 - \beta}. \tag{2}$$

Similarly, an unethical user located at x, copies the content if the IR condition, $\beta[x - r\theta] - \eta \geq 0$, and the IC condition, $\beta[x - r\theta] - \eta \geq x - p - r\theta$, hold. We define the unethical user indifferent between copying and not using the content, denoted by $\underline{x}_{ue}$, setting the above IR condition to equality. Therefore, the proportion of pirates, $N_{ue}^c(p, \eta)$, can be written as

$$N_{ue}^c(p, \eta) = \overline{x}_{ue} - \underline{x}_{ue} = \frac{p - \eta}{1 - \beta} - \frac{\eta}{\beta}. \tag{3}$$

The slope of legal users' utility is greater than that of pirates; hence, after some point, here $x = \tilde{x}$, purchasing results in higher utility than copying. Therefore, if $\underline{x} < \tilde{x}$, then u^l and u^c intersect each other at $x > \tilde{x}$, a condition hereafter we refer to as the piracy condition. On the other hand, if the ISP and the CP's decisions increase legal users' utility or decrease pirates' utility to a point where $\underline{x} \leq \tilde{x}$, then no users choose to copy the content.

Stage 3: The Optimal Price

We now examine the CP's profit maximization problem in this section. When CP shares its revenue with the ISP, its profit is $1 - s$ fraction of its revenue from selling the content to legal users. Thus, the CP solves

$$\pi(p; \eta, s) = \max_p \left\{ p[1 - s] \left[N_e^l(p) + N_{ue}^l(p, \eta) \right] \right\}, \tag{4}$$

where the profit function $\pi(p;\eta,s)$ is concave in p. By the first-order condition for (4), the optimal price is

$$p(\eta) = \frac{2[1-r\theta][1-\beta]+\eta}{2[2-\beta]}. \tag{5}$$

Substituting for the optimal price, the piracy condition can be written as $\eta < 2\beta[1-\beta][1-r\theta]/[4-3\beta]$ indicating that if the ISP's level of enforcement effort is sufficiently small, some consumers copy the content.

Lemma 1 examines the impact of enforcement level and data usage on the CP's choice of price.

Lemma 1. *The CP's choice of price increases with the enforcement level and decreases with the data usage.*

proof. By differentiating the optimal price in (5) with respect to η and θ we get

$$\frac{dp(\eta)}{d\eta} = \frac{1}{2[2-\beta]} > 0 \quad \textit{and} \quad \frac{dp(\eta)}{d\theta} = -r\frac{1-\beta}{2-\beta} < 0,$$

respectively. Thus, the optimal price increases with η and decreases with θ. □

Lemma 1 shows that by increasing the level of enforcement effort, unethical consumers are discouraged from copying the content leading the CP to raise the price of the content. In other words, the ISP's enforcement effort softens competition between the CP and distributors of pirated content.

Our first proposition examines how user participation varies with the level of enforcement.

Proposition 1. *As the ISP's enforcement effort increases, (a) the proportion of legal users increases, (b) the proportion of pirates decreases; and (c) the aggregate proportion of legal users and pirates decreases.*

proof. We first define the aggregate proportion of legal users and pirates as $N_e^l(\eta)+N_{ue}^l(\eta)+N_{ue}^c(\eta) = N^t(\eta)$. By substituting for the optimal price of the content in (1-3) and differentiating the outcomes with respect to η, we get

$$\frac{dN_e^l(\eta)}{d\eta} + \frac{dN_{ue}^l(\eta)}{d\eta} = \frac{1}{2[1-\beta]}, \qquad \frac{dN_{ue}^c(\eta)}{d\eta} = -\frac{4-3\beta}{2\beta[1-\beta][2-\beta]} < 0, \qquad \frac{dN^t(\eta)}{d\eta} = \frac{-[4-\beta]}{2\beta[2-\beta]} < 0. \quad \square$$

Our analysis in Proposition 1 shows although an increase in the level of enforcement effort encourages consumers to purchase the content ($N_e^l + N_{ue}^l$ increases), it discourages consumers within the ethical segment from doing so as it leads the CP to raise the price. Proposition 1 shows that the aggregated proportion of legal users and pirates decreases when the CP shares a fraction of its revenue with the ISP. However, comparing the impact of η on $N^t(\eta)$ and $N_{ue}^c(\eta)$ reveals that $dN_{ue}^c(\eta)/ds < dN^t(\eta)/ds$, indicating that the proportion of pirates decreases faster with s.

Stage 2: The ISP's Enforcement Effort

This section examines the ISP's maximization problem under the revenue sharing contract. The profit of the ISP, denoted by $\Pi(\eta;s)$, is the gain from the revenue sharing contract and revenues from data usage fees, less the cost of making enforcement efforts. Thus, the ISP maximizes

$$\Pi(\eta;s) = \max_{\eta}\left\{p(\eta)s[N_e^l(\eta)+N_{ue}^l(\eta)] + r\theta[N_e^l(\eta)+N_{ue}^l(\eta)+\beta N_{ue}^c(\eta)] - c\frac{\eta^2}{2}\right\}, \tag{6}$$

where $c > 0$. Note that the above equation is concave in η if $s < 2c[2-\beta][1-\beta]$. Under such conditions, by the first-order condition of (6), the optimal enforcement effort is

$$\eta(s) = \begin{cases} \dfrac{2[1-\beta]\big[s[1-r\theta]-r\theta\big]}{2c[2-\beta][1-\beta]-s} & \text{if } 0 < r\theta < \dfrac{s}{s+1}, \\ 0 & \text{otherwise.} \end{cases} \tag{7}$$

Lemma 2. *The optimal level of enforcement effort (a) increases with the ISP's share from the CP's revenue and the quality of pirated content; and (b) decreases with data usage.*

Proof. By differentiating the optimal enforcement effort with respect to s, β and θ, we get

$$\frac{d\eta(s)}{ds} = 2[1-\beta]\frac{2c[2-\beta][1-\beta][1-r\theta]-r\theta}{\left[2c[1-\beta][2-\beta]-s\right]^2} > 0 \quad \textit{and} \quad \frac{d\eta(s)}{d\beta} = \frac{2\left[s+2c[1-\beta]^2\right]\left[s[1-r\theta]-r\theta\right]}{\left[2c[1-\beta][2-\beta]-s\right]^2} > 0,$$

$$\frac{d\eta(s)}{d\theta} = -\frac{2r[1-\beta][1+s]}{2c[1-\beta][2-\beta]-s} < 0.$$

which are positive, positive and negative, respectively when the second-order condition ($s < 2c[2-\beta][1-\beta]$) holds. □

Lemma 2 shows that by increasing the ISP's share from the CP's revenue, the level of enforcement effort increases. Following the result of Lemma 1, this leads the CP to increase the price of the content. Moreover, one might think that the ISP reduces its enforcement effort as the quality of pirated versions increases. However, our analysis in Lemma 2 reveals that as β increases, the ISP raises its enforcement effort and generates more revenue through the revenue sharing contract.

As previously demonstrated, the level of enforcement by the ISP is influenced by the amount of data required to access the content. Our analysis in Lemma 2 reveals that the ISP tends to enforce digital piracy at a lower level for content with a higher θ. That is because content that requires more data to be retrieved contributes more to the ISP's profits than content that requires less data. For example, video streaming services such as Netflix or Hulu require a large amount of data to be transferred to consumers for uninterrupted viewing. This makes them high-bandwidth content, which in turn contributes significantly to the ISP's revenue. To avoid potential loss of profits, ISPs may be less inclined to enforce piracy for these services compared to low-bandwidth content offered by audio streaming services such as eBooks or SoundCloud.

Before exploring the CP's profit maximization in stage 1, to compare the results of our revenue sharing model, we present the result of our benchmark model where in which is no contract between the CP and the ISP, and $\eta = s = 0$. Using the same logic as in stages 3 and 2, we obtain the optimal price for the content under the benchmark. The following table shows the content price, user participation, and profits of the CP and the ISP in our benchmark model.

Table 1. Results under the benchmark

Content Price	User Participation			Profits	
$p_{\eta=0}$	N_e^l	N_{ue}^l	N_{ue}^c	$\pi_{\eta=0}$ (CP)	$\Pi_{\eta=0}$ (ISP)
$\frac{[1-r\theta][1-\beta]}{2-\beta}$	$\frac{1-r\theta}{2-\beta}$	$\frac{[1-r\theta][1-\beta]}{2-\beta}$	$\frac{1-r\theta}{2-\beta}$	$\frac{[1-r\theta]^2[1-\beta]}{2-\beta}$	$\frac{2[1-r\theta]r\theta}{2-\beta}$

If the data usage fee, $r\theta$, is sufficiently low so that $r\theta < s/[1+s]$, the ISP accepts the contract and sets a positive enforcement effort. Under such conditions, the ISP makes higher profits than what it could generate under the benchmark, shown with $\Pi_{\eta=0}$ in Table 1.

Comparing the optimal content price under the benchmark, $p_{\eta=0}$ in Table 1, against the optimal content price under the revenue sharing contract, shown in (5), indicates that the ISP's enforcement effort hurts the surplus of legal consumers as it encourages the CP to raise the content price.

Stage 1: CP's Revenue Sharing Decision

The CP proposes a revenue sharing contract to the ISP as a way to incentivize it to fight digital piracy. Under this contract, a portion of the CP's revenue generated from content sales is shared with the ISP. In stage 1, the CP determines the profit-maximizing portion while ensuring the ISP's profit is not lower than what it would generate previously. With such a contract the CP's profit maximization problem in stage 1 is

$$\pi(s) = \max_{s} \left\{ p(s)[1-s]\left[N_e^l(s) + N_{ue}^l(s)\right] \right\}, \tag{8}$$

$$\textit{subject to} \qquad 0 < r\theta < \frac{s}{1+s} \quad \textit{and} \quad c > \frac{s}{2[1-\beta][2-\beta]}, \tag{9}$$

$$p(s) = \frac{1-\beta}{2-\beta}\left[\frac{c[1-r\theta][1-\beta][2-\beta]-r\theta}{c[2-\beta][1-\beta]-s}\right], \tag{10}$$

where $\pi(s)$ in (8) represents the CP's profit in stage 1. Conditions in (9) ensure that the ISP's IC condition holds and its profit is not lower that to what it would generate when $s = \eta = 0$. Finally, (10) shows the optimal price as a function of s. By the first-order condition of (8), the CP's choice of maximizes its profit by choosing the following share

$$s = \begin{cases} 2 - c[2-\beta][1-\beta] & \text{if } \dfrac{1}{2[2-\beta][1-\beta]} < c < \dfrac{1}{[2-\beta][1-\beta]}, \\ 0 & \text{otherwise.} \end{cases}$$

In Figure 2, the dotted area represents the condition under which the CP is willing to share a fraction of its revenue with the ISP. In other words, the dotted area shows when the CP benefits more from revenue sharing than the benchmark. However, the ISP does not necessarily set a positive enforcement effort in this region. The ISP enters into the contract as long as the cost of enforcement is sufficiently small. The shaded (in pink) area in Figure 2 represents a subset of the dotted area where the ISP sets a positive enforcement effort (hereafter, we refer to this area as the shaded region).

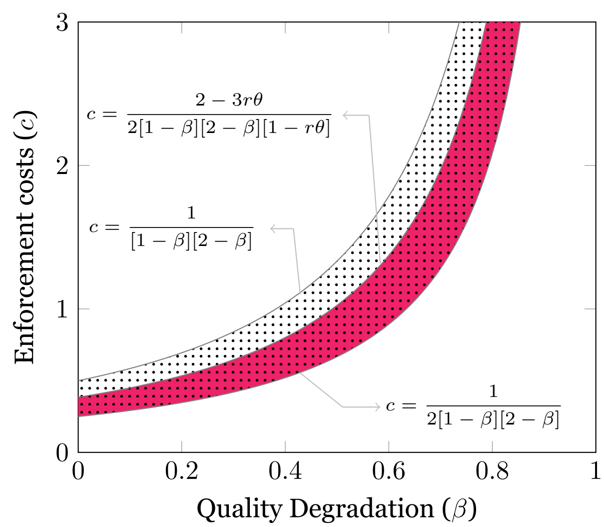

Figure 2. The revenue sharing contract region

Proposition 2. *The revenue sharing is more likely to occur if the CP is characterized by low data usage.*

Proof. Differentiation $c = \dfrac{2-3r\theta}{2[1-\beta][2-\beta][1-r\theta]}$ with respect to θ yields

$$\frac{dc}{d\theta} = \frac{-1}{[1-\beta][2-\beta][1-r\theta]^2} < 0,$$

indicating that as θ increases, the area of the shared region shrinks. As a result, when the CP is characterized by low data usage (θ is small) the, revenue sharing is more likely to occur. □

The result of Proposition 2 shows that as θ increases, the shaded region in Figure 2 shrinks, indicating a reduced likelihood of the ISP accepting the revenue sharing contract. In particular, Proposition 2 implies that as data usage increases, the ISP demands greater compensation, lowering the likelihood of revenue sharing between the CP and ISP. Thus, a low data usage CP is more likely to enter the revenue sharing arrangement with the ISP than a high data usage CP.

From Figure 2, the revenue sharing contract becomes unprofitable if

$$\frac{2-3r\theta}{2[1-\beta][2-\beta][1-r\theta]} \leq \frac{1}{2[1-\beta][2-\beta]} \quad \Longrightarrow \quad \frac{2-3r\theta}{1-r\theta} \leq 1.$$

Therefore, the ISP rejects the contract if $r\theta \geq 0.6$. In other words, the area of the shaded region in Figure 2 is zero at $r\theta = 0.6$ and the ISP rejects the revenue sharing contract.

Proposition 3. *The revenue sharing contract never eradicates digital piracy.*

Proof. As stated in stage 4, digital piracy occurs if $p(\eta) > \dfrac{p(\eta)-\eta}{1-\beta}$. Under such conditions, the proportion of pirates is positive, $N_{ue}^{c} > 0$. Substituting for the optimal η and s, the piracy condition can be written as

$$2-2c[2-\beta][1-\beta] > c\beta[1-\beta] + \frac{r\theta[4-3\beta]}{2[1-r\theta][2-\beta]},$$

which is true if the following inequality holds

$$r\theta < \frac{2-c[1-\beta][2-\beta]}{3-c[1-\beta][2-\beta]}, \textit{ or equally if } \; r\theta < \frac{s}{s+1}.$$

As discussed in stage 2 and shown in Figure 2, the above inequality ensures the profitability of the revenue sharing for the ISP. Thus, if $\eta(s) > 0$ implies that the piracy condition holds some users still copy the content, $N_{ue}^{c} > 0$. □

Our findings in Propositions 2 and 3 imply that although being characterized by low data usage raises the chance of achieving a revenue sharing contract, it also exposes the CP to higher levels of digital piracy. From the proof of Proposition 3, by differentiating the proportion of pirates under the revenue sharing contract, we get $dN_{ue}^{c}/d\theta < 0$. Thus, similar to the benchmark, under the revenue sharing contract the rate of digital piracy is higher for CPs associated with low data usage. This is merely a result of the ISP's difficulty in identifying pirates when data usage is low.

Conclusion

Most approaches to tackle piracy require policy-maker intervention or assume that ISPs can be coerced to act to defend the CPs intellectual property. Instead, we propose and evaluate a market-based mechanism whereby the CP and ISP can engage with each other in a mutually beneficial manner. In a setting with a monopoly CP, heterogeneous users valuation for the CP's content, and an ISP that can enforce anti-piracy efforts, we discuss whether there are conditions under which a CP may voluntarily share its revenues with the ISP. We assume that the CP is characterized by its *data usage*, or the amount of network traffic that it generates.

Our results indicate a broad region where CPs can increase profits by voluntarily sharing a proportion of its revenues with the ISP. The mechanism that enables this counter-intuitive result is as follows: by voluntarily sharing its revenue, the CP induces the ISP to act to increase the revenues of the CP - through anti-piracy enforcement effort. If the CP's lost revenues due to revenue sharing are smaller than the gains due to the ISP's enforcement effort, then the CP proceeds with this arrangement. Separately, ISPs incur two types of costs related to anti-piracy enforcement (i) the cost of technically enforcing anti-piracy and (ii) a loss of customers as a result of increased enforcement. Pirates utility from copying decreases in the ISP's enforcement effort which in turn increases lost data usage fees. The compensation for these losses comes in the form of revenue sharing in our setting. If the CP has complete information it knows the ISP's compensation requirements, and so sets an appropriate level of revenue sharing inducing the ISP to act. If profits of both the CP and ISP are improved due to revenue sharing, then the CP proceeds with the arrangement.

If the CP is characterized by high data usage, then the losses to the ISP from its enforcement effort are also large. This necessitates a higher compensation from the CP, thereby reducing the likelihood that a revenue sharing arrangement will be reached. Thus, video CPs such as Netflix and Youtube are unlikely to benefit from revenue sharing, whereas low data usage CPs such as Barnes and Noble or Microsoft are more likely to enter such a revenue sharing arrangement. We also show that even if the CP is characterized by low data usage, the revenue sharing contract never removes digital piracy. This can be explained by the ISP's difficulty in identifying pirates when data usage is low.

Future Direction: We plan to improve this paper in four broad ways. Firstly, we intend to extend our model to a duopoly setting where two CPs are located at the opposite ends of the unit circle. We have developed our model within the Salop circle with this anticipation. Secondly, we plan to include a more detailed exposition of the conditions under which the CP will voluntarily share revenues. While we have indicated that low data usage increases the attractiveness of revenue sharing, we intend to include other factors including data usage fees, prices, the cost of enforcement. We also intend to analyze whether the extent of piracy is a factor, and whether CPs are more likely to share revenues with ISPs in the Indian market or the American market, for example. Thirdly, while producer surplus increases and consumer surplus decreases in the revenue sharing arrangement, we plan to develop and include total surplus in our next draft. Fourthly, we plan to work to improve the generalize-ability of the model through the use of curvature conditions and general functions rather than the specific form we are currently using. This paper will form a core component of an author's post-doctoral studies next year, and part of the tenure package of the second author.

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