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Piracy as promotion?
The Importance of Diffusion in the Music Industry

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Piracy as promotion? The importance of diffusion in the music industry*

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Abstract

We analyze the effect of piracy using a model of the music industry that consists of artists, consumers and platforms. Artists are heterogeneous in their degree of ex-ante popularity (either famous or emergent) and have two sources of income: sales of songs and concerts. For the emergent artist only increasing the number of songs sold (diffusion) also increases the revenue from concerts. Consumers can access songs hosted on two platforms. The for-profit platform sells high-quality copies at a positive price, whereas the open platform offers low-quality copies for free. We compare equilibria and welfare under copyright and under piracy. We find that the emergent artist prefers piracy more often than the famous artist, that the price charged by the for-profit platform does not necessarily decrease with piracy, and that piracy may damage the social welfare when the quality differential is large enough.

Keywords: music industry, piracy, popularity, price discrimination.

JEL classification: K42, L82, O34

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1 Introduction

In most countries, goods such as novels, movies, and music are protected by Intellectual Property rights. This means that a monopoly is assigned to the creators for a certain period of time. Often this monopoly lasts for many years, and can even be inherited by the descendants of the creator. Copyrights are meant to encourage creativity by offering protection to the creators to secure the fruits of their labor and compensate them adequately for their effort.

In the digital era, the Internet has dramatically changed the possibilities and patterns of consumption. People consume more music and downloaded singles have replaced CDs as the main sale format. At the same time, piracy —unauthorized use or reproduction of copyrighted material— is still widespread. The Motion Picture Association of America estimates that US studios lose more than $3 billion annually in potential revenues due to piracy. Similarly, a policy report by the Institute for Policy Innovation, the Recording Industry Association of America claims that global music piracy causes $12.5 billion in losses every year.[1]

Due to the alleged failure in protecting the efforts of the creators, one would expect them to react fiercely against piracy and also to find fewer people devoted to creative activities. On the contrary, we observe an increase in the sales of some initially-less-popular contents,[2] and heterogeneous reactions: some creators stand against piracy whereas others support it. The former stress that piracy is similar to stealing a CD from a store; the latter argue that piracy increases turnout at stage shows.[3]

We propose a model in which artists have two sources of revenue: sales of songs and concerts. There are two possible scenarios: either full copyright enforcement, or piracy. Artists choose which platform to host their songs on —open platform or for-profit platform. The open platform offers the songs for free, whereas the for-profit platform charges a positive price. For the emerging artist is there a trade-off between ex-post popularity (which determines the revenue obtained at the concerts) and the revenue obtained by selling songs.

We find that in equilibrium, piracy may increase or decrease the price charged by the for-profit platform depending on the intensity of competition for consumers and artists. When the price decreases, there is a welfare enhancement. When the emergent artist chooses the open platform with copyright but switches to the for-profit platform with piracy, a market for high-quality copies appears. The price may only increase when the famous and the emergent artists both accept the offer of the for-profit platform under

[1] These estimations should be taken carefully: those who download illegal copies may have never intended to acquire legal ones, so there is no direct translation from illegal downloads to sales.

[2] See Zhang (2018) for evidence of the so called "long tail effect" in the music industry.

[3] Artists who have spoken out against piracy include Metallica, Blink-182 and Elton John; those not opposed include David Bowie, Lady Gaga and The Offspring.

both copyright and piracy. In that case, the welfare consequences are ambiguous because there are three effects happening simultaneously: (i) participation by new consumers and (ii) further diffusion increase welfare, while (iii) switching from high to low-quality copies decreases it.

Our paper is structured as follows: Section 2 describes the model, and Section 3 characterizes the equilibria under copyright and piracy. Section 4 performs the welfare analysis, while extensions of the basic model are included in section 5. Section 6 is a conclusion.

Literature Review

Theoretical work on piracy

The primary goal of theoretical studies has been to identify channels through which piracy could benefit the creators.

Takeyama (1997) builds a dynamic two-period framework with high-valuation and low-valuation consumers to show how piracy helps the monopolist to fulfill the time-consistency constraint, and may even increase her total profits. If piracy decreases the second-period price below the marginal cost, then the monopolist can credibly commit to a uniform pricing policy in the first period, which in turn allows for effective intertemporal price discrimination. Piracy also allows for price discrimination in our static setup across consumers within the same period.

Peitz and Waelbroeck (2006) emphasize piracy's role in sampling. They consider the static problem of a multiproduct monopolist facing a continuum of consumers who buy at most one product. When downloading is permitted, there are two effects: first, not buying becomes more attractive because customers can obtain a positive utility from the download; second, customers' willingness to pay increases because they find a better match to their tastes. The second effect dominates when there is enough taste heterogeneity and enough product variety. A key difference with our model is that consumers do not pay for the original songs they previously downloaded; instead, they demand live performances if they liked the song.

Both Takeyama (1994) and Gayer and Shy (2006) highlight how demand network externalities can increase the creator's profits in static problems. Since customers are willing to pay more the larger the community of users, Takeyama (1994) shows that this allows the monopolist to focus on the high-valuation consumers and to ignore the low-valuation ones. In our framework, piracy is also the mechanism that makes price discrimination possible when selling songs. However, those who download illegally become potential buyers of concerts tickets rather than raising other customers' willingness to pay. As in Gayer and Shy (2006), we model separately the incentives of the artist and those of the publisher, and also assume that the demand of concerts depends on the distribution of recordings. Demand network externalities aside, our framework differs from theirs in the consideration of heterogeneous artists and in the bargaining used to determine how artist and publisher split the profit generated from the sales of songs.

Minniti and Vergari (2010) evaluate the effect of a private, small-scale file sharing community in static markets supplied by two horizontally differentiated producers of digital goods. Users must contribute one original unit to this community, before they can download the others. The downloading option has two effects: first, it increases the consumers' valuations of the goods as buying one is the key to accessing the other; and second, it intensifies market competition. The first effect dominates in not-completely-covered markets, whereas the second effect dominates in mature markets. The main differences compared to our setup are that consumers can access the open platform for free, and that creators are differentiated by their level of ex-ante popularity rather than horizontally.

Alcalá and González-Maestre (2010) analyze the effects of piracy in a static market with an exogenous number of superstars and free entry by young artists, who compete à la Cournot, and find that piracy reduces the superstars' earnings and increases the number of young artists.[4] Similarly, we find that piracy has different effects on heterogeneous artists, but we keep exogenous both the number of superstars and young artists. Also, rather than competing, each artist in our setup decides whether to accept the price proposed by the for-profit platform, and then bargains to split the generated profit.

Empirical work on piracy

The main question in the empirical analysis of piracy has been whether it displaces sales in the digital era.

First attempts focused on physical media, such as singles, LPs, cassettes and CDs. Peitz and Waelbroeck (2004) find that piracy could have caused a reduction of 20% in music sales worldwide between 1998 and 2002. Zentner (2006) concludes that peer-to-peer usage decreased the probability of buying music by 30% in seven European countries in 2001, while Liebowitz (2008) estimates that the net decline in album sales in the US from 1998 to 2003 attributed to file sharing is 1.19 albums per capita.

This approach was criticized because the Internet itself sparked a deep change in the consumption patterns of music. Since it is no longer necessary anymore to buy the "whole bundle" (CD or cassette), piracy cannot be automatically blamed for the entire decrease in sales of physical media. Thus, a new approach focusing on the acquisition of legal digital music emerged to answer the question of sales displacement.

Some authors have studied the consequences derived from the implementation of anti-piracy laws. After analyzing the effect of HADOPI on the iTunes sales of the four major

[4] They also study the long-run equilibrium, but the short-run equilibrium constitutes the relevant comparison point for our framework.

record labels in France,[5] Danaher et al. (2014) conclude that the awareness of the law caused a sales increase of 22-25%. In the same spirit, Adermon and Liang (2014) analyze the impact of the implementation of IPRED in Sweden,[6] finding a physical sales increment of 33% and a digital sales increment of 46%. However, after 6 months, only the positive effect on the latter persisted.

Other authors have analyzed the relationship between accessing music (either through downloading or legal streaming) and the licensed purchases of digital music. Aguiar and Martens (2016) find small, positive effects: a 10% increase in clicks on illegal downloading websites correlates with a 0.2% increase in clicks on legal purchasing websites, whereas a 10% increase in clicks on legal streaming websites correlates with a 0.48% increase in clicks on legal purchasing websites. Dang Nguyen et al. (2012) also find evidence of complementarity between streaming and buying legal music online, and between streaming and demand of live music. This last result provides empirical support for the theoretical assumption that popularity, independently of how it is achieved, directly influences the profit earned from concerts. Furthermore, our model clarifies how piracy, under certain parametric conditions, creates an environment in which more legal copies are sold.

2 The Model

We consider a model with three types of agents: a large number of consumers, two platforms, and two artists.[7] Consumers are aware of both artists. Each consumer demands songs and concerts, with demand being affected by the consumer's information about the artist quality. To model demand for songs, assume that if the consumer knows the artist ex-ante, he assigns quality $q > 0$ to their songs. Otherwise, he expects the artist to produce songs of quality βq with $0 < \beta < 1$.[8] Consumers only consider attending concerts by artists whose quality they know. This covers two possibilities: artists who are known ex-ante, and artists whose quality is learned through listening to their songs.[9]

Songs are not traded directly between consumers and artists in this market; instead, they are hosted on platforms. There are two platforms: one for-profit platform and one open platform. The for-profit platform hosts high-quality copies of the songs, normalized to 1, and sells them at a strictly positive price. On the other hand, the open platform hosts low-quality copies of the songs, $0 < \alpha < 1$, and offers them for free. The assumption

[5] HADOPI is the acronym of the law passed in France in 2009, intended to encourage compliance with copyrights. It was partially revoked in 2013.

[6] IPRED is the acronym of the European Union directive intended to implement a better copyright protection, which was implemented by the Swedish parliament in 2009.

[7] This is a simplification of the agents involved in the music industry. For a more complete description of it, the reader may wish to check Krueger (2005).

[8] This assumption can be interpreted in the following way: if the consumers know the artist ex-ante, it is because she is already famous and only the good ones can reach that status. However, if the consumers do not know the artist ex-ante, there is a higher likelihood that the artist is not good.

[9] This assumption is justified by the large difference in prices between digital songs and concerts.

of low-quality copies hosted at the open platform can be interpreted in different ways: consumers may download corrupted files with some probability, or the platform includes ads that consumers find annoying.

The utility derived by consumer ω when acquiring a song of quality $q^a = \{q, \beta q\}$ is

$$u = \begin{cases} \omega q^a - p & \text{if acquired at the for-profit platform,} \\ \omega \alpha q^a & \text{if acquired at the open platform,} \end{cases} \tag{1}$$

and $u = 0$ if he does not acquire the song. p denotes the price charged by the for-profit platform, and ω corresponds to the willingness to pay and it is assumed to be uniformly distributed over the population of consumers. We normalize the size of the population to be equal to 1.

Finally, there are two artists that are heterogeneous in their ex-ante degree of popularity. Specifically, there is one famous artist, whose quality is known ex-ante by all consumers, and one emerging artist, whose quality is not known ex-ante by anyone. A Nash bargaining process determines the share that each artist receives from the profit generated by the sales of their songs. Additionally, the famous artist earns a fixed revenue $R > 0$ from their live performances, and the emerging artist earns $r(\text{diff}) \geq 0$, with $r' > 0$ and $r(0) = 0$. That is, the revenue from concerts of the emerging artist is an increasing function of the degree of diffusion, which is measured by the amount of accessed songs.

We consider two mutually exclusive legal regimes, copyright and piracy, and characterize the equilibrium outcome for each. Copyright is the legal regime under which the songs of the artists are only available on the platform of their choice. Piracy is the legal regime under which any song hosted on the for-profit platform according to the will of the artist is also available at the open platform (but not vice versa). Note that copyright corresponds to a single-homing framework, whereas piracy corresponds to a multi-homing framework. All costs are normalized to zero.

The timing of the game is as follows: first, the for-profit platform announces the price at which songs will be traded. Second, each artist either accepts or rejects the platform's offer. If they accept, a Nash bargaining process determines how the profit will be split; otherwise, the songs are hosted at the open platform. Third, consumers acquire songs and update their information on the emerging artist to determine the demand of live performances. Note that the options to acquire songs depend on the legal regime: under copyright, consumers only decide between accessing or not; under piracy, if the song is available in more than one platform, consumers decide where to access it. Finally, payoffs are realized.

Before characterizing the equilibrium outcomes, we define the payoffs for the different agents both under copyright and under piracy.

Since copyright corresponds to a single-homing framework, each song is available only on one platform. Therefore, given the platform at which the track is hosted, consumers decide whether to access it or not. If the song is hosted on the for-profit platform, consumer ω buys it if and only if $\omega q^a - p \geq 0$. For the marginal consumer the previous equation holds with equality, $\omega q^a - p = 0$, which in turn determines the demand of songs: $z^a(p) = \max\{0, 1 - (p/q^a)\}$ for $a = \{F, E\}$. If the song is hosted on the open platform, all consumers access it as $\omega \alpha q^a \geq 0$ is always true.

The profit of the for-profit platform depends on how many artists accept its offer:

$$\pi^{FP}(p) = \begin{cases} pz^F(p)(1 - s^F(p)) & \text{if only the famous accepts } p, \\ pz^F(p)(1 - s^F(p)) + pz^E(p)(1 - s^E(p)) & \text{if both accept } p. \end{cases} \tag{2}$$

where $s^a(p)$ stands for the share of the profit from songs received by artist a after the Nash bargaining.[10] The open platform always makes zero profit.

The profits of the two artists depend on the chosen platform as follows:

$$\pi^F(p) = \begin{cases} pz^F(p)s^F(p) + R & \text{if the famous accepts } p, \\ R & \text{if the famous rejects } p. \end{cases} \tag{3}$$

$$\pi^E(p) = \begin{cases} pz^E(p)s^E(p) + r(z^E(p)) & \text{if the emerging accepts } p, \\ r(1) & \text{if the emerging rejects } p. \end{cases} \tag{4}$$

With copyright, the famous artist weakly prefers the for-profit platform at any price, whereas the emerging artist faces a trade-off between diffusion and the profit generated by the sales of her songs at a positive price.

Piracy corresponds to a multi-homing framework: the songs that the artists want to be hosted on the for-profit platform will also be available on the open platform (but not the other way around). If an artist a has chosen the for-profit platform to host their songs, the consumer ω buys them from the for-profit platform if and only if $\omega q^a - p \geq \omega \alpha q^a$, and acquires them for free at the open platform otherwise. For the marginal consumer the previous equation holds with equality, $\omega q^a - p = \omega \alpha q^a$, which in turn determines the demand for songs on the for-profit platform: $\hat{z}(p) = \max\{0, 1 - (p/((1-\alpha)q^a))\}$. As with copyright, if an artist a chooses to host their songs on the open platform, all consumers access it as $\omega \alpha q^a \geq 0$ is always true.

The profit of the for-profit platform depends on how many artists accept its offer:

$$\hat{\pi}^{FP}(p) = \begin{cases} p\hat{z}^F(p)(1 - \hat{s}^F(p)) & \text{if only the famous accepts } p, \\ p\hat{z}^F(p)(1 - \hat{s}^F(p)) + p\hat{z}^E(p)(1 - \hat{s}^E(p)) & \text{if both accept } p. \end{cases} \tag{5}$$

where $\hat{s}^a(p)$ is the share of the profit from songs received by artist a after Nash bargaining.

[10] Note that there is no price at which the emerging artist accepts the offer and the famous artist rejects it.

The open platform always makes zero profit.

Finally, the profits of the two artists depend on the chosen platform as follows:

$$\hat{\pi}^F(p) = \begin{cases} p\hat{z}^F(p)\hat{s}^F(p) + R & \text{if the famous accepts } p, \\ R & \text{if the famous rejects } p. \end{cases} \quad (6)$$

$$\hat{\pi}^E(p) = \begin{cases} p\hat{z}^E(p)\hat{s}^E(p) + r(1) & \text{if the emerging accepts } p, \\ r(1) & \text{if the emerging rejects } p. \end{cases} \quad (7)$$

As Equation 7 shows, piracy makes the trade-off faced by the emerging artist disappear, as they do not have to sacrifice diffusion when choosing to host their songs at the for-profit platform anymore.

3 Equilibrium

The concept used to solve the game is subgame perfect equilibrium (SPE), both under copyright and piracy.

3.1 Equilibrium under Copyright

We start by solving the Nash bargaining for each artist, given that the offer made by the for-profit platform has been accepted. Although the famous artist accepts any offer, the solution to the Nash bargaining is necessary to determine the parametric conditions under which the emerging artist accepts or rejects the offer they receive.

Consider first the Nash bargaining between the famous artist and the for-profit platform. Given the demand $z^F(p)$ defined previously, the Nash program can be written as follows:

$$\max_{s^F(p)} [s^F(p)z^F(p)p + R - R][(1 - s^F(p))z^F(p)p], \quad (8)$$

which gives the solution $s^F(p) = 1/2$. This result is intuitive: as the threat of the famous artist of not accepting the proposed price p is not credible, they and the for-profit platform split the profit generated by the sales of the songs evenly.

Next, consider the Nash bargaining between the emerging artist and the for-profit platform. Given the demand $z^E(p)$ defined previously, the Nash program can be written as:

$$\max_{s^E(p)} [s^E(p)z^E(p)p + r(z^E(p)) - r(1)][(1 - s^E(p))z^E(p)p], \quad (9)$$

which gives the solution

$$s^E(p) = \min\left\{1, \frac{1}{2z^E(p)p}(z^E(p)p + r(1) - r(z^E(p)))\right\}.$$

Since the interior part of the solution can be larger than 1, it is necessary to explicitly impose the upper bound of 1 in those cases. Note that the interior part of the solution is always larger than 1/2: since the threat of the emerging artist to host her songs at the open platform is credible, they have more bargaining power. This does not imply that the emerging artist obtains more money from the sales of the songs than the famous artist overall, as the famous artist always sells more songs. That is: the emerging artist may get a larger portion of the pie when bargaining with the platform, but the pie being shared is much smaller than the one the famous artist bargains over.

Therefore, given an offer p, the famous artist always accepts it and strictly prefers it to host their songs on the open platform if and only if $z^F(p) > 0 \Leftrightarrow p < q$;[11] however, the emerging artist accepts the offer if and only if she obtains a larger profit by doing so, than by hosting their songs at the open platform:

$$s^E(p)z^E(p)p + r(z^E(p)) \geq r(1) \Leftrightarrow z^E(p)p \geq r(1) - r(z^E(p)). \tag{10}$$

To close our model, we impose the following assumption:

Assumption 1. *$r(\cdot)$ is such that there exists, at most, one solution $\bar{p} > 0$ such that Equation (10) holds as a strict equality.*

This assumption implies that, if the solution $\bar{p} > 0$ exists, then the emerging artist accepts any offer p such that $p \leq \bar{p}$ and rejects all others. It also implies that, if the solution $\bar{p} > 0$ does not exist, there is no offer $p > 0$ that the for-profit platform can make to attract the emerging artist.

Observe that, if $\bar{p} > 0$ exists, then it is such that $\bar{p} < \beta q$: a strictly positive demand of high-quality copies of the emerging artist is a necessary condition. Moreover, the profit function of the for-profit platform is not strictly quasiconcave: for prices above $\bar{p}$ only the demand of high-quality copies of the famous artist is positive, whereas for prices below $\bar{p}$ the demand of high-quality copies of both the famous and the emerging artists are positive. Thus, at $\bar{p}$ the monotonicity of the profit function of the platform breaks down.

Now we have all the elements to characterize the equilibrium. Consider the problem when the for-profit platform offers a price p such that it is only accepted by the famous artist:

$$\max_p \frac{1}{2} z^F(p)p.$$

The solution to this problem is

$$p^F = \frac{q}{2}. \tag{11}$$

Consider now the problem when the for-profit platform offers a price p such that it is

[11] The for-profit platform never has an incentive to set the price $p \geq q$, as it makes $z^F(p) = z^E(p) = 0$ and leaves the platform with no profit.

accepted by both artists:

$$\max_p \frac{1}{2} z^F(p)p + (1 - s^E(p))z^E(p)p.$$

The solution to this problem, denoted by p^E, is implicitly determined by the equation below:

$$2\beta q - 2(1+\beta)p^E = r'(z^E(p^E)). \tag{12}$$

Without specifying a functional form for the function $r(\cdot)$, it is impossible to find the closed-form solution of p^E.

Proposition 1 below characterizes the price p offered by the for-profit platform in equilibrium:

Proposition 1. *In equilibrium with copyright, the for-profit platform proposes:*

- p^F when: $\bar{p} < p^E$, or $p^E < \bar{p} < p^F$ with $\pi^{FP}(p^F) \geq \pi^{FP}(p^E)$, or $\nexists \bar{p} > 0$;
- p^E when: $\bar{p} > p^F$, or $p^E < \bar{p} < p^F$ with $\pi^{FP}(p^F) < \pi^{FP}(p^E)$.

Proof: since p^E is only implicitly determined, the proof is based on the relative positions of $\bar{p}$, p^F and p^E.

First, suppose that $\bar{p} > 0$ does not exist. In this case, the for-profit platform offers p^F because there is no way to attract the emerging artist; the solution to Equation (12) is irrelevant. Also, this is the only case in which the profit function of the for-profit platform is strictly quasiconcave.

Second, consider that $\bar{p} > 0$ does exist. Then, the question is where it lies with respect to p^F and p^E. It is possible that $\bar{p} > 0$ lies between of p^F and p^E: the profit function will show two local maxima precisely at p^F and p^E, and a direct comparison is necessary to determine which one corresponds to the global maximum. It is also possible that $\bar{p} > 0$ lies below p^E: in this case, the profit function has a corner at p^E and a global maximum at p^F because the minimum price that the for-profit platform can propose to attract the emerging artist is precisely $\bar{p}$, which is not the solution to Equation (12). Finally, it can happen that $\bar{p} > 0$ lies above p^F: in this case, the profit function has a corner at p^F and a global maximum at p^E because the minimum price that the for-profit platform can propose to exclude the emerging artist is precisely $\bar{p}$, which is not the solution to Equation (11).

The characterization above is an exhaustive list of the possible outcomes, which concludes the proof.

□

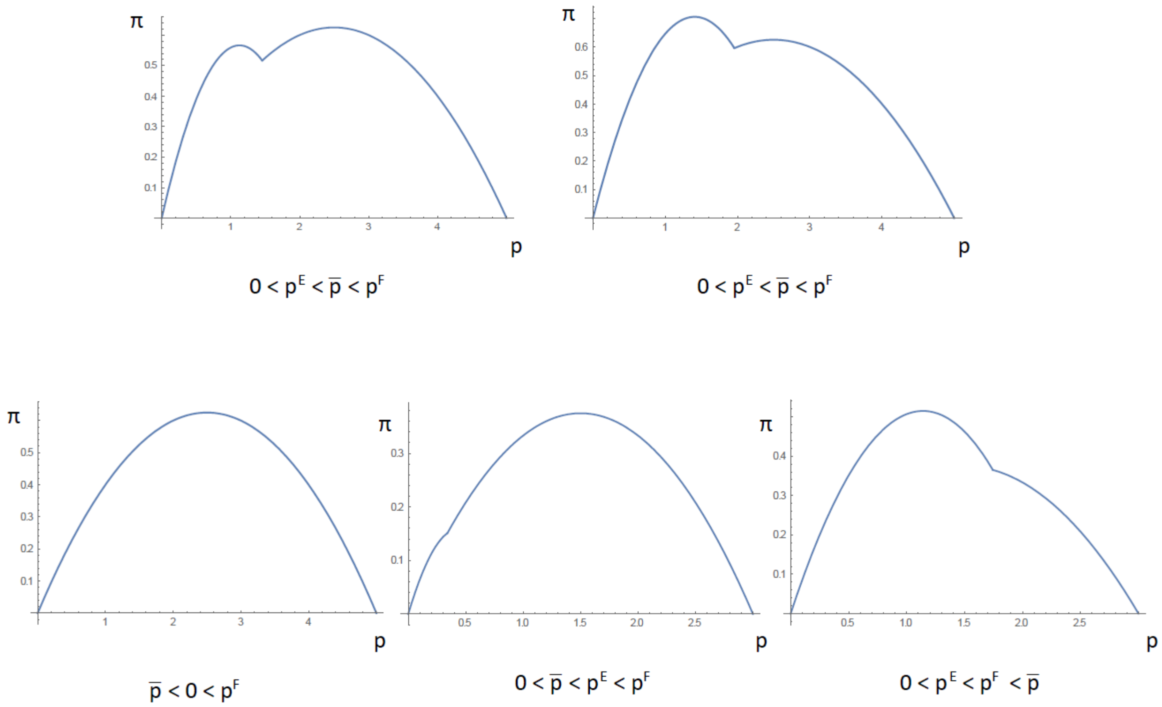

Figure 1: Profit function of the for-profit platform with copyright

3.2 Equilibrium under Piracy

Piracy makes the trade-off faced by the emerging artist under copyright disappear: as songs hosted on the for-profit platform will also be available on the open platform, the emerging artist obtains the maximum diffusion even when choosing the for-profit platform. So, as for the famous artist, now the emerging artist also weakly prefers the for-profit platform at any price p.

Let us start by solving the Nash bargaining problem of each artist. Given the demand $\hat{z}^F(p)$ defined in the previous section, the Nash program can be written as follows:

$$\max_{s^F(p)} [s^F(p)\hat{z}^F(p)p + R - R][(1 - s^F(p))\hat{z}^F(p)p], \tag{13}$$

which gives the solution $\hat{s}^F(p) = 1/2$. Of course, the result is the same as with copyright because the famous artist continues to weakly prefer the for-profit platform to the open platform, so her threat to choose the open platform is not credible and thus she and the for-profit platform split the generated profit evenly.

We consider now the Nash bargaining of the emerging artist. Given the demand $\hat{z}^E(p)$ defined in the previous section, the Nash program can be written as:

$$\max_{s^E(p)} [s^E(p)\hat{z}^E(p)p + r(1) - r(1)][(1 - s^E(p))\hat{z}^E(p)p], \tag{14}$$

which gives the solution

$$\hat{s}^E(p) = \frac{1}{2}.$$

Thus, piracy eliminates the trade-off and consequently reduces the bargaining power of the emerging artist, as her threat of choosing the open platform is not credible anymore.

Although both artists accept any offer p proposed by the for-profit platform, the famous artist strictly prefers it to host her songs at the open platform if and only if $\hat{z}^F(p) > 0 \Leftrightarrow p < (1-\alpha)q$ and, respectively, the emerging artist strictly prefers it to host her songs at the open platform if and only if $\hat{z}^E(p) > 0 \Leftrightarrow p < (1-\alpha)\beta q$.

Notice that the profit function of the for-profit platform continues to be not strictly quasiconcave, as for any price above $(1-\alpha)\beta q$ the demand for high-quality copies of the songs of the emerging artist is null.

Now we have all the elements to characterize the equilibrium. Consider the problem when the for-profit platform offers a price p such that only the demand of high-quality copies of the famous artist is positive:

$$\max_p \frac{1}{2}\hat{z}^F(p)p.$$

The solution to this problem is

$$\hat{p}^F = \frac{(1-\alpha)q}{2}. \tag{15}$$

Consider now the problem when the for-profit platform offers a price p such that both the demand of high-quality copies of the famous artist and the demand of high-quality copies of the emerging artist are positive:

$$\max_p \frac{1}{2}\hat{z}^F(p)p + \frac{1}{2}\hat{z}^E(p)p.$$

The solution to this problem is

$$\hat{p}^E = \frac{(1-\alpha)\beta q}{1+\beta}. \tag{16}$$

Notice that it is possible to find the closed-form solution of $\hat{p}^E$ because the functional form of $r(\cdot)$ does not appear in the solution of the Nash bargaining.

Proposition 2 below characterizes the price p offered by the for-profit platform in equilibrium:

Proposition 2. *In equilibrium with piracy, the for-profit platform proposes $\hat{p}^F$ if $\beta \leq 1/3$, and $\hat{p}^E$ otherwise.*

Proof: First, notice that $\hat{p}^F \leq (1-\alpha)\beta q$ if and only if $\beta \geq 1/2$, which means that only $\hat{p}^E$ can be a solution in this case as $\hat{p}^F$ does not achieve $\hat{z}^E = 0$. However, if $\hat{p}^F \geq (1-\alpha)\beta q$, then the profit function has two local maxima and a direct comparison is necessary to determine which one corresponds to the global maximum. It is easy to see that $\hat{z}^F(\hat{p}^F)\hat{p}^F/2 \geq (\hat{z}^F(\hat{p}^E)\hat{p}^E + \hat{z}^E(\hat{p}^E)\hat{p}^E)/2 \Leftrightarrow \beta \leq 1/3$. These two results combined complete the proof.

□

4 Welfare Analysis

This section compares how the welfare of each agent varies when moving from a situation with copyright to piracy. There are three possible scenarios: from p^F to $\hat{p}^F$, from p^F to $\hat{p}^E$, and from p^E to $\hat{p}^E$.

4.1 From p^F to $\hat{p}^F$

Here piracy implies a price decrease because the for-profit platform now has a competitor that hosts low-quality copies of the songs of the famous artist. However, the amount of high-quality copies traded - one half of the size of the population - is the same both under copyright and piracy. Similarly, all consumers access the music of the emerging artist on the open platform under both legal regimes, but the consumers who did not buy the high-quality copies of the songs of the famous artist under copyright access them on the open platform under piracy. Thus, the total welfare is larger with piracy than with copyright.

Looking at the welfare of different agents, there is a transfer of welfare from the famous artist and the for-profit platform to the consumers who acquire the high-quality copies because of the price effect. Also, the consumers that can access the music of the famous artist on the open platform are better off under piracy. The welfare of the emerging artist does not change.

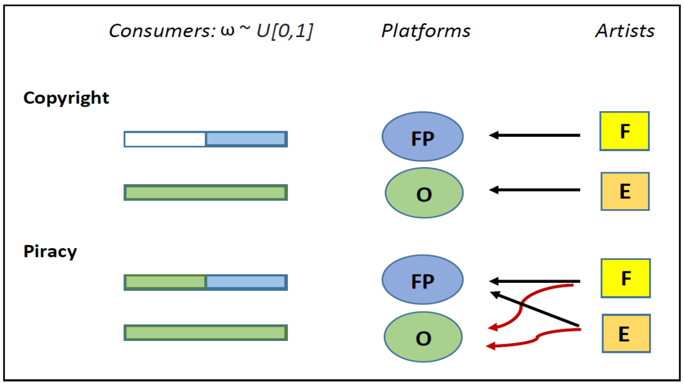

Figure 2: Copies traded under copyright and piracy.

4.2 From p^F to $\hat{p}^E$

Here piracy implies a more pronounced price decrease than in the previous case, as $\hat{p}^F > \hat{p}^E$. This is because now the for-profit platform competes with the open platform to offer the songs of both artists, not only the the famous one. Therefore, the amount of high-quality copies traded is larger under piracy, and this holds for both artists. Interestingly, piracy creates a market for the high-quality copies of the emerging artist that did not exist under copyright, as this artist rejected the offer made by the for-profit platform. In other words, the model predicts that, because of piracy, consumers have more qualities to choose from when acquiring the songs of the emerging artist. In addition to the larger number of high-quality copies of the famous artist traded, those who did not pay the positive price and were excluded under copyright can now access their music on the open platform under piracy. The total welfare is obviously higher under piracy, as there are more high-quality copies traded and some consumers who were previously excluded can now access the music on the open platform.

Looking at different agents, the famous artist is worse off because the increased demand is not enough to compensate the price decrease (recall that their profit is maximized at $\hat{p}^F$ under piracy, and so $\hat{p}^E$ leads to lower profit than that obtained under $\hat{p}^F$, which in turn is also lower than profits obtained under copyright when charging p^F). The emerging artist is better off, as they obtains the same degree of diffusion and also the extra profit earned from the trade of high-quality copies (quality-based discrimination). The effect for the for-profit platform is ambiguous, and depends on whether the new profit generated in the market corresponding to the emerging artist more than offsets the decrease in profits in the market corresponding to the famous artist (which happens whenever $\alpha < (-1+3\beta)/4\beta$). Consumers also gain from piracy: some of those who consumed low-quality copies under copyright now access high-quality ones, and those who were excluded either acquire the high-quality copies motivated by the price decrease, or simply access the low-quality copies on the open platform.

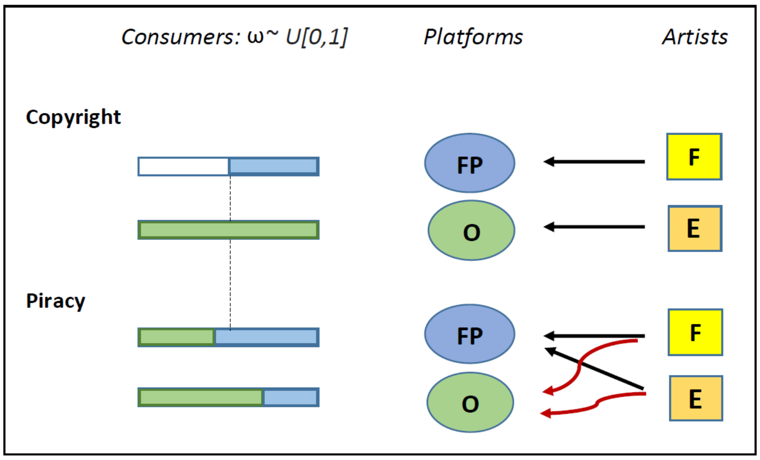

Figure 3: Copies traded under copyright and piracy.

4.3 From p^E to $\hat{p}^E$

This is the most complex scenario: the welfare of each artist, consumers and the for-profit platform under piracy, may either increase or decrease compared to that obtained under copyright. Consequently, so can the total welfare.

This is the only case in which piracy implies a larger diffusion of the songs of the emerging artist. Additionally, the price set by the for-profit platform under piracy may be higher or lower than the one set under copyright. The reason for this ambiguous price effect is that competition with the open platform favors a price decrease but, with piracy, the for-profit platform does not need to decrease the price to attract the emerging artist (it is enough to generate a positive demand) and can focus on consumers with higher willingness to pay.

In equilibrium, both artists sell less copies of their songs on the for-profit platform; that is, there is a switching effect from high to low-quality copies. Notice that, although p^E is implicitly defined by Equation 12, it follows that $p^E < \beta q/(1+\beta)$ since $r' > 0$. Then,

$$z^F(p^E) > \hat{z}^F(\hat{p}^E) \Leftrightarrow 1 - \frac{p^E}{q} > 1 - \frac{\beta}{1+\beta} \Leftrightarrow p^E < \frac{\beta q}{1+\beta},$$

and

$$z^E(p^E) > \hat{z}^E(\hat{p}^E) \Leftrightarrow 1 - \frac{p^E}{\beta q} > 1 - \frac{1}{1+\beta} \Leftrightarrow p^E < \frac{\beta q}{1+\beta}.$$

Specifically, types $\omega \in [p^E/q, \beta/(1+\beta)]$ switch in the market of the famous artist, and types $\omega \in [p^E/\beta q, 1/(1+\beta)]$ switch in the market of the emerging artist.

To determine how the total welfare varies, we need to check whether the improvement, composed of the gains in diffusion plus the utility of consumers who were previously excluded, dominates the welfare decrease, composed of the decrease in utility due to the switch in consumption from high-quality to low-quality copies.[12] It turns out that, for the total welfare to increase under piracy, it is necessary that either the gains in diffusion, or the quality of the copies hosted in the open platform (α), are large enough.

The famous artist is worse off with piracy whenever $p^E > \hat{p}^E$: their bargaining power does not change but they sell fewer high-quality copies, each at a lower price. However, if $p^E < \hat{p}^E$, the famous artist is better off if the price effect is strong enough to compensate the switching effect, which happens if and only if α is below a certain threshold.

The analysis is more complex for the emerging artist: first, their bargaining power decreases with piracy, so they receive a lower fraction of the profits obtained from selling songs at the for-profit platform; second, like the famous artist, they sell a fewer high-quality copies with piracy; and third, piracy causes their diffusion gains to be larger.

[12] The gains in diffusion are simply $r(1) - r(z^E)$, the gain in utility from previously-excluded consumers is $\alpha\left(p^E\right)^2(1+\beta)/2\beta q$, and the loss utility due to the switching effect is $(1-\alpha)\left[(\beta q)^2 - \left(p^E(1+\beta)\right)^2\right]/2\beta q(1+\beta)^2$.

Thus, the effect of a price change is less straightforward than for the famous artist (though even with a price decrease, the emerging artist can still be better off). However, all the effects can be summarized in a condition stating that the emerging artist gains larger profit with piracy if and only if α is below a certain threshold.

Similar considerations apply for the for-profit platform. The number of high-quality copies sold with piracy is lower in the markets of both the famous and the emerging artist, and the for-profit platform receives a larger share of the profit from the sales of the songs of the emerging artist. As for the emerging artist, the for-profit platform is better off with piracy if and only if α is below a certain threshold.

To evaluate consumer surplus, consider the expression for consumer surplus under piracy:

$$\begin{aligned}\widehat{CS} = & \int_0^{\frac{p^E}{q}} \omega\alpha q \, d\omega + \int_{\frac{p^E}{q}}^{\frac{\beta}{1+\beta}} \omega\alpha q \, d\omega + \int_{\frac{\beta}{1+\beta}}^{1} (\omega q - \hat{p}^E) \, d\omega \\ & + \int_0^{\frac{p^E}{\beta q}} \omega\alpha\beta q \, d\omega + \int_{\frac{p^E}{\beta q}}^{\frac{1}{1+\beta}} \omega\alpha\beta q \, d\omega + \int_{\frac{1}{1+\beta}}^{1} (\omega\beta q - \hat{p}^E) \, d\omega\end{aligned}$$

The first and forth terms represent the consumers that were excluded under copyright, and so have a positive effect in the variation of the consumer surplus. The third and sixth terms represent the consumers who stick to the high-quality copies with both regimes, and their change in surplus depends only on whether the price increases or decreases. The second and fifth terms represent the switching consumers, and their effect on the consumer surplus requires closer inspection. Let us focus on the second term, which refers to switching consumers in the market corresponding to the famous artist, as the analysis for the fifth term is analogous.

Consider first the case in which piracy causes a price decrease (which happens when $\alpha > 1 - (p^E(1+\beta)/\beta q)$). Then, $\omega q - p^E < \omega q - \hat{p}^E$. Also, for the types ω that choose the low-quality copies over the high-quality ones with piracy, it holds that $\omega\alpha q \geq \omega q - \hat{p}^E$. Combining the two equations, $\omega\alpha q \geq \omega q - p^E$, which means that switching consumers are not worse off with piracy.

When piracy causes a price increase (which happens when $\alpha < 1 - (p^E(1+\beta)/\beta q)$), it follows that $\omega q - p^E > \omega q - \hat{p}^E$. But it is still true that, for the types ω that choose the low-quality copies over the high-quality ones with piracy, it holds that $\omega\alpha q \geq \omega q - \hat{p}^E$. Combining the equations, we note that $\omega\alpha q \gtreqless \omega q - p^E$, which means that there is a marginal type $\tilde{\omega}$ who is indifferent between the two regimes.

The marginal type is found by solving $\omega\alpha q = \omega q - p^E$: $\tilde{\omega} = p^E/(q(1-\alpha)) > p^E/q$. The question now is whether the marginal type is always below $\beta/(1+\beta)$, which holds whenever $\alpha < 1 - (p^E(1+\beta)/\beta q)$. Therefore, types on the left of the marginal type are better off with piracy, whereas types on the right of the marginal type are worse off.

To determine whether the welfare of the switching consumers as a whole increases or decreases, it is enough to compare the gains corresponding to the types on the left of the marginal consumer and the losses corresponding to the types on the right of the marginal consumer. The gains are represented by the integral

$$\int_{\frac{p^E}{q}}^{\frac{p^E}{q(1-\alpha)}} (\omega\alpha q - (\omega q - p^E))\, d\omega,$$

whereas the losses are represented by the integral

$$\int_{\frac{p^E}{q(1-\alpha)}}^{\frac{\beta}{1+\beta}} (\omega q - p^E - \omega\alpha q)\, d\omega.$$

The total welfare of this group increases if and only if $\alpha > (\beta q - p^E(1+\beta))/(\beta q + p^E(1+\beta))$, which is always compatible with $\alpha < 1 - (p^E(1+\beta)/\beta q)$.

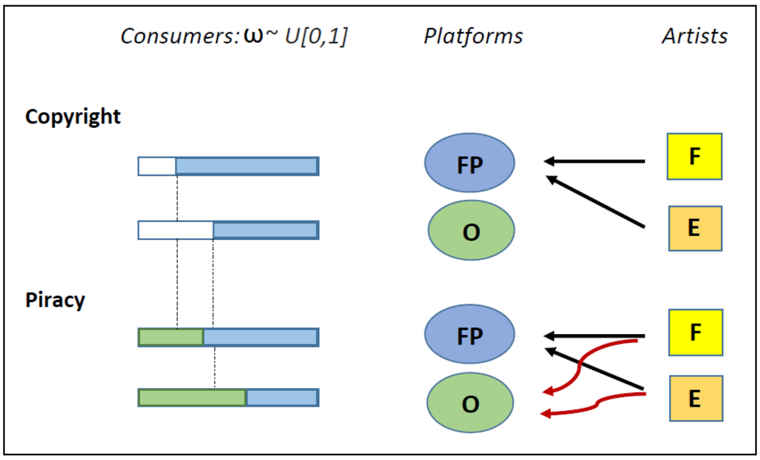

Figure 4: Copies traded under copyright and piracy.

5 Extension

In this section, we extend the basic model by considering intermediate rather than extreme ex-ante levels of fame. One artist is more famous (identified by the superscript m) and the other less famous (identified by the superscript ℓ), such that $0 \leq \gamma^\ell < \gamma^m \leq 1$, where γ^a is the share of consumers who know the quality of the artist q^a ex-ante.[13] To make the artists differ only in their degree of ex-ante popularity, we assume that the same functional form describes the profits from concerts for both artists: $r^m(\cdot) = r^\ell(\cdot) = r(\cdot)$, with $r' > 0$ and $r(0) = 0$.

We also assume the following:

Assumption 2. *Ex-ante information is independent of the consumers' type.*

[13] Notice that the basic model is a particular case of this setup, with $\gamma^\ell = 0$ and $\gamma^m = 1$

Since artists differ only in their degree of ex-ante popularity, consumers assign quality $q^m = q^\ell = q > 0$ to the artists they know and expect quality $\beta q^m = \beta q^\ell = \beta q$ to the artists they do not know, with $0 < \beta < 1$. Therefore, the utility of a consumer of type ω derived from acquiring the music of an artist that they know ex-ante is

$$u^I = \begin{cases} \omega q - p & \text{if acquired on the for-profit platform,} \\ \omega \alpha q & \text{if acquired on the open platform,} \end{cases} \tag{17}$$

where the superscript I stands for "informed consumer".

The utility of a consumer of type ω derived from acquiring the music of an artist that they do not know ex-ante is

$$u^{NI} = \begin{cases} \omega \beta q - p & \text{if acquired on the for-profit platform,} \\ \omega \alpha \beta q & \text{if acquired on the open platform,} \end{cases} \tag{18}$$

where the superscript NI stands for "non-informed consumer".

The utility is equal to zero independently of the information status when the consumer does not access the music.

We begin by deriving the demand of high-quality songs and the ex-post popularity (which determines the profit from concerts) for each artist $a = \{m, \ell\}$. Since copyright corresponds to a single-homing framework, consumers only decide whether access the music or not given the platform on which it is hosted. If copies are hosted at the for-profit platform, the indifferent consumer among those who are informed is $\omega^I = p/q$, and the indifferent consumer among those who are non-informed is $\omega^{NI} = p/\beta q$. Therefore, the demand of songs of artist a is $z^a(p) = \gamma^a \max\{0, 1 - \omega^I\} + (1 - \gamma^a) \max\{0, 1 - \omega^{NI}\}$. If $\omega^{NI} < 1$, this demand can also be expressed as $z^a(p) = 1 - \omega^{NI} + \gamma^a(\omega^{NI} - \omega^I)$, which means that all types $\omega \in [\omega^{NI}, 1]$ demand high-quality copies and types $\omega \in [\omega^I, \omega^{NI}]$ demand high-quality copies only if they are informed.

However, the ex-post popularity differs from the demand of songs because there are some informed consumers who do not acquire the songs on the for-profit platform, but may consider going to the concert, as they know the quality of the artist ex-ante. Specifically, the ex-post popularity of artist a is $w^a(p) = \gamma^a + (1 - \gamma^a) \max\{0, 1 - \omega^{NI}\}$. If $\omega^{NI} < 1$, the ex-post popularity can be expressed as $w^a(p) = 1 - \omega^{NI} + \gamma^a \omega^{NI}$: all types $\omega \in [\omega^{NI}, 1]$ who acquired the songs are ex-post informed, and among types $\omega \in [0, \omega^{NI}]$ only those who were ex-ante informed are also ex-post informed (independently of having acquired the songs or not). Of course, $w^a(p) \geq z^a(p)$

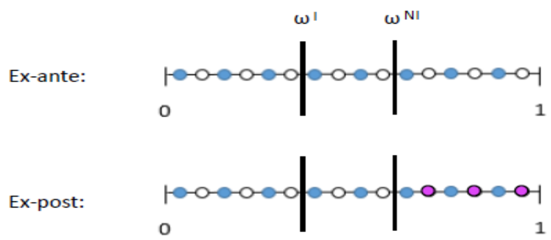

Figure 5: Ex-ante and ex-post informed consumers with copyright.

The profit of the for-profit platform can be expressed as

$$\pi^{FP}(p) = \begin{cases} pz^m(p)(1 - s^m(p)) & \text{if only the more famous accepts } p, \\ pz^m(p)(1 - s^m(p)) + pz^\ell(p)(1 - s^\ell(p)) & \text{if both accept } p. \end{cases} \tag{19}$$

where $s^a(p)$ stands for the share of the profit from songs received by artist a after Nash bargaining. The open platform always makes zero profit.

Finally, the profits of the two artists depend on the chosen platform as follows:

$$\pi^m(p) = \begin{cases} pz^m(p)s^m(p) + r(w^m(p)) & \text{if the more famous accepts } p, \\ r(1) & \text{if the more famous rejects } p. \end{cases} \tag{20}$$

$$\pi^\ell(p) = \begin{cases} pz^\ell(p)s^\ell(p) + r(w^\ell(p)) & \text{if the less famous accepts } p, \\ r(1) & \text{if the less famous rejects } p. \end{cases} \tag{21}$$

Under piracy the two artists weakly prefer the for-profit platform to the open one, as they obtain the maximum degree of diffusion anyway and may obtain additional earnings from the trade of the high-quality copies.

Since artist a chooses the for-profit platform, the indifferent consumer among those who are informed is $\hat{\omega}^I = p/(1-\alpha)q$, and the indifferent consumer among those who are non-informed is $\hat{\omega}^{NI} = p/(1-\alpha)\beta q$. Therefore, the demand of songs of artist a is $\hat{z}^a(p) = \gamma^a \max\{0, 1 - \hat{\omega}^I\} + (1-\gamma^a)\max\{0, 1 - \hat{\omega}^{NI}\}$. If $\hat{\omega}^{NI} < 1$, this demand can also be expressed as $\hat{z}^a(p) = 1 - \hat{\omega}^{NI} + \gamma^a(\hat{\omega}^{NI} - \hat{\omega}^I)$, which means that all types $\omega \in [\hat{\omega}^{NI}, 1]$ demand high-quality copies and types $\omega \in [\hat{\omega}^I, \hat{\omega}^{NI}]$ demand high-quality copies only if they are informed.

However, the ex-post popularity differs from the demand of songs because those who are not willing to pay the price charged by the for-profit platform will access the low-quality copies on the open platform, so $w^m = w^\ell = 1$.

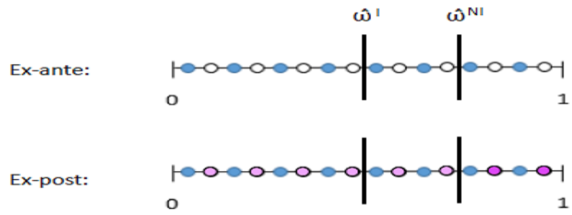

Figure 6: Ex-ante and ex-post informed consumers with piracy.

If the music of artist a is hosted on the open platform, all consumers access the low-quality copies since $\omega\alpha q \geq 0$ and $\omega\alpha\beta q \geq 0$ always hold, which in turn guarantees maximum ex-post diffusion: $w^a = 1$.

The profit of the for-profit platform can be expressed as

$$\hat{\pi}^{FP}(p) = \begin{cases} p\hat{z}^m(p)(1-\hat{s}^m(p)) & \text{if only the more famous accepts } p, \\ p\hat{z}^m(p)(1-\hat{s}^m(p)) + p\hat{z}^\ell(p)(1-\hat{s}^\ell(p)) & \text{if both accept } p. \end{cases} \tag{22}$$

where $\hat{s}^a(p)$ stands for the share of the profit from songs received by artist a after the Nash bargaining. The open platform always makes zero profit.

Finally, the profits of the two artists depend on the chosen platform as follows:

$$\hat{\pi}^m(p) = \begin{cases} p\hat{z}^m(p)\hat{s}^m(p) + r(1) & \text{if the more famous accepts } p, \\ r(1) & \text{if the more famous rejects } p. \end{cases} \tag{23}$$

$$\hat{\pi}^\ell(p) = \begin{cases} p\hat{z}^\ell(p)\hat{s}^\ell(p) + r(1) & \text{if the less famous accepts } p, \\ r(1) & \text{if the less famous rejects } p. \end{cases} \tag{24}$$

The equilibrium concept we use is again subgame perfect equilibrium.

5.1 Equilibrium under copyright

As in the basic model, we start by solving the Nash bargaining problem. Given the ex-ante level of popularity γ^a, the Nash program can be written as

$$\max_{s^a(p)} [s^a(p)z^a(p)p + r(w^a(p)) - r(1)][(1-s^a(p))z^a(p)p], \tag{25}$$

which gives the solution

$$s^a(p) = \min\left\{1, \frac{1}{2z^a(p)p}(z^a(p)p + r(1) - r(w^a(p)))\right\}.$$

The share is larger than $1/2$ for any $\gamma^a < 1$: since the artist sacrifices diffusion when choosing the for-profit platform, that is reflected in a larger bargaining power. The larger the γ^a, the smaller the incentives to choose the open platform, and so the smaller the $s^a(p)$.

Therefore, artist a accepts the offer p if and only if she obtains a larger profit than by hosting her songs on the open platform:

$$s^a(p)z^a(p)p + r(w^a(p)) \geq r(1) \Leftrightarrow z^a(p)p \geq r(1) - r(w^a(p)), \tag{26}$$

which has an interpretation analogous to that of Equation 10. We impose the following assumption:

Assumption 3. *There always exist $\bar{p}^m > 0$ such that Equation 26 holds with equality for the more famous artist, and so they accept any offer below this threshold. However, the corresponding threshold for the less famous artist $\bar{p}^\ell > 0$ may or may not exist.*

This assumption makes the problem non trivial: if $\bar{p}^m > 0$ does not exist, then it is impossible for the for-profit platform to attract any artist. It also becomes obvious that the for-profit platform does not have any incentive to offer a price $p > \bar{p}^m$, as in that case both artists would prefer the open platform. Assumption 3 guarantees that $s^m(p)$ is always interior and again, if $\bar{p}^\ell > 0$ exists, the monotonicity of the profit function of the for-profit platform breaks down at that point.

It is easy to see that $\bar{p}^\ell < \bar{p}^m \leq q$ and that $\bar{p}^\ell \geq \bar{p}$, which implies that the range of prices that effectively exclude the less famous artist decreases the closer γ^m and γ^ℓ are.

Now we have all the elements to characterize the equilibrium. Consider the problem when the for-profit platform offers a price p such that it is only accepted by the more famous artist:

$$\max_p (1 - s^m(p))z^m(p)p.$$

The solution to this problem, denoted by p^m, is implicitly determined by:

$$\beta q - 2(1 - \gamma^m(1-\beta))p^m = (1 - \gamma^m)r'(w^m(p^m)). \tag{27}$$

Consider now the problem when the for-profit platform offers a price p such that it is accepted by both artists:

$$\max_p (1 - s^m(p))z^m(p)p + (1 - s^\ell(p))z^\ell(p)p.$$

The solution to this problem, denoted by p^ℓ, is implicitly determined by:

$$2\beta q - 2(1 - \gamma^m(1-\beta) + 1 - \gamma^\ell(1-\beta))p^\ell = (1-\gamma^m)r'(w^m(p^\ell)) + (1-\gamma^\ell)r'(w^\ell(p^\ell)). \tag{28}$$

As in the basic model, the price proposed by the for-profit platform depends on the relative positions of p^m, p^ℓ and $\bar{p}^\ell$. We obtain a qualitatively analogous result to that in Proposition 1:

Proposition 3. *In equilibrium with copyright, the for-profit platform proposes:*

- p^m if: $\bar{p}^\ell < p^\ell$, or $p^\ell < \bar{p}^\ell < p^m$ with $\pi^{FP}(p^m) \geq \pi^{FP}(p^\ell)$, or $\nexists \bar{p}^\ell > 0$;
- p^ℓ if: $\bar{p}^\ell > p^m$, or $p^\ell < \bar{p}^\ell < p^m$ with $\pi^{FP}(p^m) < \pi^{FP}(p^\ell)$.

5.2 Equilibrium under piracy

We begin by solving the Nash bargaining problem. Following the payoffs derived previously, the Nash program for artist a is

$$\max_{s^a(p)} [s^a(p)\hat{z}^a(p)p + r(1) - r(1)][(1 - s^a(p))\hat{z}^a(p)p], \tag{29}$$

which gives the solution

$$\hat{s}^a(p) = \frac{1}{2}.$$

The result is unsurprising: because of piracy, artists do not sacrifice diffusion when choosing the for-profit platform, which translates into an even split of the profit generated by the trade of the high-quality copies.

As in the basic model, though both artists weakly prefer the for-profit platform to the open platform under piracy, the profit function of the for-profit platform is not strictly quasiconcave. The reason is that the demand of high-quality copies of artist a is strictly positive only for prices below $(1 - \alpha)\beta q/(1 - \gamma^a(1 - \beta))$. Therefore, with piracy, the monotonicity of the profit function of the for-profit platform breaks down at price $(1 - \alpha)\beta q/(1 - \gamma^\ell(1 - \beta))$.

We now have all the elements required to characterize the equilibrium. Consider the problem when the for-profit platform offers a price p such that only the demand for high-quality copies of the famous artist is positive:

$$\max_p \frac{1}{2}\hat{z}^m(p)p.$$

The solution to this problem is

$$\hat{p}^m = \frac{(1 - \alpha)\beta q}{2(1 - \gamma^m(1 - \beta))}. \tag{30}$$

Consider now the problem when the for-profit platform offers a price p such that the demands of high-quality copies of both artists' songs are positive:

$$\max_p \frac{1}{2}\hat{z}^m(p)p + \frac{1}{2}\hat{z}^\ell(p)p.$$

The solution to this problem is

$$\hat{p}^\ell = \frac{(1-\alpha)\beta q}{1-\gamma^m(1-\beta)+1-\gamma^\ell(1-\beta)}. \tag{31}$$

Contrary to what happened under copyright, it is now possible to find the closed-form solution of both prices because the functional form of $r(\cdot)$ does not appear in the solution of the Nash bargaining problem.

Proposition 4 characterizes the price p offered by the for-profit platform in equilibrium:

Proposition 4. *In equilibrium with piracy, the for-profit platform proposes $\hat{p}^m$ if $(2+\gamma^\ell)/3 < \gamma^m < 1$ and $0 < \beta < 1-(2/(3\gamma^m - \gamma^\ell))$, and $\hat{p}^\ell$ otherwise.*

Proof: First, note that if $2\gamma^m \leq 1+\gamma^\ell$, then $\hat{p}^m \leq (1-\alpha)\beta q/(1-\gamma^\ell(1-\beta))$, which means that only $\hat{p}^\ell$ can be a solution in this case as $\hat{p}^m$ does not achieve $\hat{z}^\ell = 0$ for any value of β. However, if $2\gamma^m > 1+\gamma^\ell$, then the profit function has two local maxima and a direct comparison is necessary to determine which one corresponds to the global maximum. Doing so, we can show that: $\hat{z}^m(\hat{p}^m)\hat{p}^m/2 \geq (\hat{z}^m(\hat{p}^\ell)\hat{p}^\ell + \hat{z}^\ell(\hat{p}^\ell)\hat{p}^\ell)/2 \Leftrightarrow \beta \leq 1-(1/(2\gamma^m-\gamma^\ell))$. These two results combined complete the proof.

□

6 Conclusion

We present a model of the music industry including artists, consumers and platforms. Artists are heterogeneous in their degree of ex-ante popularity and each has two sources of income: songs and concerts. However, only for the emerging artist is there a link between the number of songs sold (diffusion) and the revenue from concerts. Copies of the songs of both artists are hosted on platforms. The for-profit platform chooses a positive price to sell high-quality copies, whereas the open platform offers low-quality copies for free.

We find that piracy does not necessarily imply a decrease in the price charged for the high-quality copies at the for-profit platform. Interestingly, high-quality markets may appear because of piracy, since the emerging artist is willing to accept prices higher than those accepted under copyright. We also verified that the qualitative features of the pricing strategy of the for-profit platform in equilibrium,, are robust to extensions of the model in which the degrees of ex-ante popularity are not extreme. Additionally, our model reproduces the so-called "long-tail effect", which claims that ex-ante emerging artists benefit more from piracy.

The model reproduces the outcome that we observe nowadays in reality, which is that the for-profit platforms offer a constant share of the generated profit to the artist independently of any other factor, specifically how famous the artists are. Our basic model cannot, however, capture the intuitive idea that famous artists have more bargaining power under copyright, as they generate a larger demand and are more valuable to the for-profit platform. To incorporate this feature in future research, it may be useful to consider alternative models of bargaining, which either incorporate informational asymmetries, or models where both artists bargain with the platform simultaneously. Although the total welfare almost always increases when moving from a situation with copyright to piracy, it may decrease if with copyright both artists accepted the offer made by the for-profit platform, depending on the relative importance of the diffusion gains, the participation of those consumers who were excluded under copyright, and the substitution of high-quality copies by low-quality ones.

Our model, so far, considers a static framework. In future work, we intend to consider a dynamic setup in which artists first decide how much time they will spend creating new albums and how much they will spend touring. Such an extension, we hope, will offer further insights into the impact of piracy on the music industry.

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