PIRACY IN THE MUSIC INDUSTRY'S STREAMING ERA: WHO SUFFERS AND WHO BENEFITS?

[1]INSAF BEKIR, [2]JALILA BOUAZZI

[1]Institute of Higher Commercial Studies of Sousse, University of Sousse
Research Laboratory in Economics, Management and Quantitative Finance (LaREMFiQ)
[2]University of Sousse, Sousse, Tunisia.
E-mail: [1]Insaf.Bekir@ihecso.u-sousse.tn/insafbekir@gmail.com, [2]Jalilabouazzi25@gmail.com

Abstract -
With the development of digital music streaming services, it was expected that musical Streaming will be a perfect substitute of illegal file-sharing and will bring all partners in music industry towards legal solutions. Nonetheless, it was noted that Music piracy is still present in the market and has even evolved as the selling and consuming infringing content adapt to new technologies. Using an analytical model, this paper studies the impact of piracy in the music industry. The analysis addresses the payoff consequences on stakeholders of the coexistence of both piracy and streaming businesses in music industry. The investigation focused on equilibrium payoffs with respect to (i) the nuisance created by advertisement, (ii) the risk incurred by pirates and (iii) the consumers' benefit of enjoying a large music library. We use a two-sided market business model that considers the cross-network benefit the advertisers gain from the free of charge subscribers. One of the main findings is that artists benefit from the piracy regime, while advertisers are harmed by it. Moreover, threshold values with respect to the nuisance caused by advertising for which the streaming service's receipts coming from subscribers and/or from advertisers in case of piracy could exceed those without piracy, are determined.

Key words - Two-sided Market**;** Music; Piracy.
JEL numbers - L13; K42; L86

I. INTRODUCTION

In the past decades, the music industry has known many technological innovations. The distribution and consumption of music has evolved over time, from records, tapes, and CDs to downloading and consuming music through streaming services (Spotify, YouTube, …) mobile devices (smartphone, tablet computer), and a growing range of connected devices everywhere. All these innovations forced the industry to continuously reinvent itself. As the industry entered the digital age, it has been seen an evolution that resulted in a radical change in the existing business models. The digital transition has been accompanied by the use of unlicensed Peer to Peer (P2P) file sharing practices. As a consequence, the music industry has experienced a serious fall in revenues. According to the business organizations of the music industry (Recording Industry Association of America - RIAA, International Federation of Phonographic Industry - IFPI, etc.), music file-sharing on various Peer-to-Peer (P2P) networks explains the fall in revenue in the music industry. About 34% of all recorded music products sold worldwide were pirated copies in 2004 which costs the industry over $4.6 billion per ansays the International Federation of the Phonographic Industry **(**IFPI**).** In the US market for example, total revenues of the music industry fell from $ 14.6 billion to $ 6.3 billion from 1999 (the year of birth of the file-sharing network Napster) to 2009 [1]. Hence, the leading firms in music industry (Sony/BMG, Universal Music, Warner Music and EMI) launch a major campaign against fraudsters and bring copyright infringement lawsuits against several illegal file sharers. But those lawsuits did not significantly reduce file-sharing activities. Between September 2003 and June 2004, and solely in the US, the leading record companies have brought copyright infringement lawsuits against 2,947 alleged illegal file sharers.

Besides, there is no empirical evidence to show that music file sharing is meaningfully responsible for the slowing down of the music industry. Some studies (Fine, 2000; Zentner, 2003; Liebowitz, 2003; Peitz and Waelbroeck, 2003b) find a negative impact of file-sharing on music sales, yet all of them state that the responsibility of file-sharing is limited. Contrariwise, some researchers conclude to the absence of any negative impact or even to a positive impact of piracy on the music product sales (Oberholzer and Strumpf, 2004; Molteni and Ordanini, 2003; Boorstin, 2004). Such a positive impact could occur from a sampling effect generated by Peer-to-peer activities. Free music downloads allow listeners to discover new artists or new products of established artists, and thus possibly increase future sales. So, the responsibility of file-

[1]See: "Music's lost decade: Sales cut in half" by David Goldman (http://money.cnn.com/2010/02/02/news/companies/napster music industry/, February 3, 2010; last consulted on March 25, 2011)).
See: RIAA, American Music Business Brochure (http://76.74.24.142/2DB721AD-3A69-11D3-1FA4-E3E59BEC0CE6.pdf, last consulted on April 3, 2011).

sharing in the worldwide drop of music content sales is not well established. Other alternative explanations could be related to the growth of competing cultural products (especially DVDs), an excessive price charged for CDs, the poor creativity of new CDs released stand (see, among others, Leibowitz, 2003).

The fight against pirates proved to be rather inefficient. At the same time, an increased willingness on the part of the consumers for new technologies allowing to listen to unlimited costless music, started to arise. To offer an alternative to piracy a new business model that bet on streaming, substituting ownership by access, started to arise. It was supported by the development of the digital music streaming service Spotify which was launched in Sweden in 2006.The main notion of streaming services relies on inducing music consumers to listen to streaming music on demand. The most common business model is based on the freemium model. It offers two types of services. The first "free" is free of charge and supported by advertising. The second "premium" service charges users a monthly flat-rate fee and offers supplementary advantages such as unrestricted access to the catalog, offline listening, and applications for mobile devices. Nowadays, a listener can access millions of songs by streaming them paying a monthly subscription fee or have an account supported by advertisers.

In Fact, the streaming model recovers two different business models. First, users can listen free-of-charge to music but will have to endure commercial interruptions between the songs. Music consumers could, besides, sign flat-rate contracts to enjoy unlimited access to the content of the streaming service as well as additional benefits like offline listening and applications for smartphones, tablet, or computers which permit listening of streaming music on mobile devices. Moreover, the music offered by the flat-rate business is of higher technical quality than the one provided by the free of charge business.So it was expected that musical Streaming will be a perfect substitute of piracy since it opens new and better opportunities to artists and to users as it brings users towards legal solutions and offers them attractive services (free as well as paid services), and allows artists to make their way without having to call on to the traditional majors since they could built a direct relationship with their fans. Nonetheless, it was noted that Music piracy has also evolved as the selling and consuming infringing content adapt to new technologies. Indeed, the rise in many legal streaming services, such as Spotify……, has been matched by a corresponding rise in another form of piracy that is "stream-ripping" which are systems that allow the illegal use of audio or video from streaming sources, readily obtainable on Internet.

The effect of streaming on traditional piracy in music market has been the subject of a large speculation and debate. Some see music streaming as a superior substitute whose continuing growth may limit or even eliminate the piracy. They argue that streaming platforms utilize a Freemium model to get consumers to pay for music again, allowing the platform and artists to capture value lost to piracy. Some empirical studies have corroborated this idea ((Wlömert. I and Papies. D (2019). Aguiar and martens 2018 references). Others have disagreed, arguing that streaming cannot eradicate music piracy and could even complement it. On the consumer side, it has been established that there is rather a complementarity between the two consumption ways of music (Borja and Dieringer (2016), Sinclair. G and Green.T (2015).

Such context initiated this paper which aims to provide a theoretical economic analysis of the impact of online piracy, in the era of music streaming platforms. The purpose of this study is to shed light on the broader music business model and to understand the more encompassing implications of piracy and online streaming both on the relationship between these two prevailing music online services and on their impact on stakeholders' payoffs. In this way, we hope to provide some conclusions regarding the new bargaining power in music industry and offer some insights with respect to the position of the different stakeholders in music industry's future. A recent set of papers have examined the effects of streaming on piracy (Nguyen et al, 2013; Aguiar 2017; Aguiar and Waldfogel 2018). Unlike these studies that have focused on the impact of streaming on the consumers' piracy behavior, we consider a broader frame of music industry. We take into account various stakeholders involved in the music industry (consumers, artists streaming services, pirate's platform; recording label, advertisers) and highlight the potential relationship that may emerge from the coexistence of legal and illegal online streaming services. The paper accurately deals with the following research question: can piracy be beneficial in the streaming area and if yes for whom?

The remainder of this paper is organized as follows. The next section presents the literature review. Section 3 introduces the model and derives the main results. The last section focuses on policy implications and serves as a conclusion.

II. RELATED LITERATURE

The digitization of music has introduced more complexity in the interactions between the different partners involved in the music market. This resulted in the emergence of various business models.

The business model of music industry based on streaming services, as a part of the wider media platforms' business models, has been studied by many scholars both in economics and marketing. Some of them have dealt with media platforms competing for customers in advertising as well as in content. Gal-Or and Dukes (2003) and Gantman and Shy (2007) investigated spatial competition with

respect to the programming of media platforms assuming that advertisers competed strategically by placing their advertisements on the respective media platforms while Jay Pil Choi (2006) examined the reverse effects of the number of market entrants and the level of advertising on social welfare in the setting of a free-entry model. Considering a setting of duopoly with vertical differentiation, Armstrong and Weeds (2007) found that quality is higher under charged access business than under advertising funding business. Other scholars have investigated the social optimality implication of advertising with respect to the nuisance caused to listeners (Anderson and Coate, 2005 and by Peitz and Valleti, 2008). They showed that the level of advertising depends on the nuisance customers have to bear from commercials, on one side, and on the willingness to pay of advertisers to reach customers, on the other side. Some other studies have been interested on the advertising business model. Particularly, Ferrando et al. (2008), Godes et al. (2009), Kind et al. (2009), and Reisinger (2012) studied advertising and pricing in media markets but do not consider price discrimination between users, which is practice that commonly leads to the emergence of the mixture of advertising and subscription that characterize the media's business models. Peitz and Valletti (2008) have focused on the differences between free–to–air and paying media whereas Calvano and Polo (2019) demonstrated how "pay" and "free–to–air" coexist in broadcasting markets, with two identical platforms, optimally choosing between different business models.

The literature's recent trend is towards considering the music industry as one of the prototypical cases of the two-sided markets (Rochet and Tirole 2003, Armstrong 2006, Caillaud and Jullien, 2003, Nocke et al., 2007, Hagiu, 2009, Weyl, 2010, Belleflamme and Peitz, 2010). Some papers have studied the within-side price discrimination in the perspective of two-sided markets. Liu and Serfes (2013) study within-side perfect price discrimination of horizontally differentiated platforms and showed how this practice can be harmful for the two sides of the market. Thomes(2013)makes an economic analysis of streaming markets, studying the problem of a monopolistic platform proposing a menu of qualities coupled to different prices and advertising strengths. Lin (2020) considers a two-sided market with content versioning in which advertisers are offered a match with users. He demonstrates that the advertisement level, high-valuation consumers could receive depends on the nuisance cost of advertising. Similar approach with two-sided matching is followed by Gomes and Pavan (2016). Using a theoretical model, Carroni (2018) finds that discriminating prices between previous and new subscribers affects the multi-homing decisions of advertising firms. In a general two-sided market setup, Jeon et al. (2019) consider the within-side second-degree price discrimination. They show that discriminating on one side may help to solve possible conflicts between incentive compatible contracts and optimal allocations on the other side of the market. In the same vein, Carroni and Paolini (2020) take into consideration cross-side network effects and the role of the market size in the optimal decisions of the streaming platform. They mainly focus on the impact that the audience reachable by the platform has on the relationship with artists and on the endogenous emergence of a business model either subscription-based only or with versioning. They find that a wider audience gives incentives to the platform to increase both the advertising intensity and the quality in the Premium business, leading to a shift of some people towards it. As the audience reaches a certain level, the platform could opt for a purely subscription-based business model.

Despite the increasing success of music streaming services, one has to assess that streaming services still do not pay artists sufficiently. Consequently, the artists find themselves forced to gain revenues from complementary products and services to their music. These include ticket sales for live performances. This arises the debate on the benefits of the free-of-charge music listening. The underlying idea is that listeners can use free-of-charge music in order to select the range of music they are attracted by, and then they are assumed to be willing to pay for the original item if the music corresponds to their preferences. Free-of-charge streaming music model financed by advertising business can be considered as an approach to promote sampling in order to generate a benefit for the music industry. The beneficial sampling effect of the music free-of-charge provision has mostly been documented as part of the copyright infringement literature. Peitz and Waelbroeck (2005) develop a theoretical model wherethey show that free-of-charge listening can let the profits of music labels increase. Gayer and Shy (2005) argue that network effects can be related to the music market. They presume that an increasing number of free-of-charge listeners increases the value of music for legal buyers and increases profits of a monopolistic provider if the network effect is sufficiently large. Obviously, in all these models, the free-of-charge listening is identical to file-sharing and illegal downloading. Belleflamme and Peitz (2010) provide a survey concerning the theory of digital piracy.

Our paper lies at the intersection of all these streams of literature. It attends to contribute to the theory of two-sided market. In contrast to the above-mentioned articles, our model endogenizes the artist's live performance activity and highlight the role of the cross network externality that appears between the two sides of the market (advertisers and consumers), in one side and between streaming and live performance activity, in the other side. Besides, our model contributes to the economic literature on copyright infringement in the music industry by an

extension of the streaming model that offers to music consumers the alternative of downloading music illegally. Our purpose is to identify the impact of the coexistence of the two music services (streaming and piracy) on the stakeholders' payoffs.

III. THE MODEL

We develop a model in which we highlight the music industry's business model to analyse the situation of coexistence of legal and illegal online music consumption and its impact on the stakeholders.

Consider a market of music product available to listeners on digital online forms. The product can be obtained from streaming platform or shared on the file-sharing platform. To simplify the analysis, we consider a single streaming service and a single P2P platform. This hypothesis allows focusing on the strategic choice of the subscribers between different forms of content without having to consider horizontal differentiation. We consider that the musician sells live performance services in addition to getting royalties from streaming platforms.

The streaming platform business is based on the freemium business model mainly financed via two sources. First, music consumers are given the possibility of access to free-of-charge music product which will be interrupted by commercial breaks. Following Anderson and Coate (2005), we consider commercial breaks as a nuisance for subscribers.

They are also offered the possibility to sign flat-rate contracts that allow getting unlimited access to the content of the streaming service as well as additional benefits like offline listening and applications for mobile devices. Besides, the music content given by the flat-rate business is of better technical quality.Music consumers are supposed to be homogenous except for their preference type which ranges them according to an increasing valuation of the music product that can be considered as their "love for the music". Advertisers demand for advertising space and face the charge as costs. They seek to reach all subscribers to the free-of-charge business.

The music market is modeled as a multisided-sided market model with cross-group externalities, where the streaming service acts as a platform which tries to acquire subscribers on the one side of the market, advertising firms on another side and artists in the third side. The advertisers placing advertisements on the online platform intend to reach free-of-charge subscribers in order to win them over customers. Similarly, the artists placing their music content on the online streaming seek to attain all kind of subscribers as they constitute the potential audience of their future live performance activities.

The modelling structure is a four-stage game. In the first stage, the streaming service announces the flat fee$p$, the charge$i$ which has to be paid by one advertising firm in order to broadcast its commercial as well as the royalties$R$ to be offered to the artist for the use of her music product and setting it on the platform. In the second stage, artists observe the royalties offered by the platform, and decide whether to place their music content on the platform or not. In the third stage, advertising firms observe the flat-rate price$p$, the charge $i$and decide whether to place a commercial or not. The number of advertising firmsn_A, that place their ad on the platform is determined by the willingness for getting an advertising space. For simplicity we make the assumption that advertising firms place only one commercial which is perceived by each free of-charge subscriber. Thus, $A$is the number of commercials which has to be tolerated by free-of-charge users. Finally, in the fourth stage, all potential subscribers decide independently whether to subscribe to the flat-rate business, to the free-of-charge business or not to become a user of the streaming service at all. The model is solved by backward induction and thus, the investigation starts with the determination of the demand of potential users.

3.1 The streaming model

Subscribers

Consider a monopolistic online streaming platform that intends to attract a mass of potential subscribers.A continuum of subscribers is uniformly distributed on the interval [0,1]. subscriber's type x indexes her utility for getting a music product through the streaming platform. Subscribers benefit a network externalityδSrelated to the number of music products placed in the platform, where $\delta$is the marginal value a subscriber places on a larger music library placed on the platform and$S$is the size of the music collection.Consumers who wish to obtain the music product have three options: they can subscribe to flat-rate contract and pay a price p, subscribe free of charge business and tolerate a certain level of advertising or refuse to subscribe to the streaming services.

Subscribers who decide to use the free-of-charge business have to endure a decrease in the gross value of music due to advertisement measured byγA. where$A$ denotes the level of advertisement and δindicates the marginal nuisance costs since listening to music will be interrupted by commercial breaks between the songs. γ is supposed to be identical for all potential subscribers.

In this context, the utility of type x consumer is as follows:

$$U_S = \begin{cases} x + \delta S - pif\ the\ consumer\ subscribes\ and\ pays\ fees \\ \alpha x + \delta S - \gamma A if\ the\ consumer\ subscribes\ free\ of\ charge \\ 0 \qquad\qquad if\ the\ consumer\ does\ not\ subscribe \end{cases} \quad (1)$$

With $\alpha, \delta, \gamma, A$, positive parameters. Given that free of charge items are frequently of lower quality (e.g., advertising, defaults…), it is intuitively convincing to assume that the intrinsic value of the free of charge streaming service is lower than the intrinsic value of the high-quality-streaming service provided by a charged subscription$0 < \alpha < 1$.
At this stage, we make some assumptions regarding the consumer's preferences described in equation (1)

Assumption 1: $\delta S < \gamma A$
The advantage related to the size of music library available on the platform is less than the disadvantage related to the nuisance caused by advertisement. This assumption is needed as, otherwise, the market would be totally covered.

Assumption 2:$\alpha + \delta S > \gamma A$
The benefit derived from the value of the free of charge streaming service and the size of music library placed on the platform is higher than the disadvantage related to the nuisance caused by advertisement.

Assumption 3: $1 - \alpha > \gamma A$
The net benefit derived from contracting a flat-rate contract rather than getting a free of charge option is greater than the disadvantage related to the advertisement' nuisance.

Advertisers
On the other side of the market, we find the advertisers. We suppose that there are many advertisers who seek to place their commercial and reach the free of charge subscribers. They benefit the cross-network externality. We assume that the advertiser pays an installation fee i assumed to be the same for all advertisers it is set by the platform.
Advertisers are heterogeneous in terms of the benefits coming up with setting up a music content on the platform. We suppose that they are uniformly distributed on the unit interval and have a unit mass. An advertiser indexed by$y$ takes a profit offy where$y$ is the index of the advertiser's location on the unit interval which indicates its preference for joining the platform and$f$ is the marginal benefit derived by placing commercial on the platform.

We assume that each advertiser benefits a cross-network effect θn_{S1} which comes from the presence of many free of charge subscribers on the other side of the market. Where n_{S1} is the number of free of charge subscribers and $\theta$is the surplus generated by an additional free of charge subscriber joining the platform.Thus, an advertiser's payoff for joining the platform is:

$$U_A = \begin{cases} fy + \theta n_{S1} - i & if\ the\ artist\ is\ on\ platform \\ 0 & if\ tnot \end{cases} \quad (2)$$

With f, θ positive parameters.
Reaching one free-of-charge subscriber with its commercial generates a certain value for an advertiser. The parameterθ represents this value. It is the marginal utility related to the positive cross-network externality. Without loss of generality, we can suppose that the marginal costs of the production of a commercial can be set equal to zero. It follows that placing a commercial on the free-of-charge business provide a profit of$\pi_A = \theta n_{S1} - i$ for a representative advertiser.
At this stage, we make the following assumptions regarding the advertiser' preferences described in equation (2).

Assumption 4:$\alpha f > \theta(\alpha - \gamma A + \delta S)$
The cross benefit of being on the two sides of the platform exceeds the benefit derived from the cross-network externality associated with the free of charge streaming service.

Artists
Artists who make their library available on the streaming platform are paid a royalty every time a user streams one of their songs. We consider$R$ the lump sum of these royalties. Though these small per-stream royalty rates are considered unfair to artists, this is not the only source of value. Indeed, the main objective of artists is to offer their music content to a wider audience. They seek visibility to the widest possible population on the internet. The streaming platform is a great channel for artists' music discovery by allowing users to try out artists for free, creating opportunities for up-and-coming artists to gain traction which contribute to the extension of their live performance activities.
We consider that the artist, in this specific context, earns profit from two sources: first, from selling tickets for her live performances, π_p; second, from receiving royalties R.
We consider that the demand of live performances is determined by the cross-network size which corresponds to the number of subscribers n_S (be they paying or getting the product free of charge).
Let us denote by p_p the ticket price for live performance. As in Gayer and Shy (2006), we assume that the demand for live performances is linear and takes the following form:

$$q_p = \beta n_S - p_p$$

where the parameter βmeasures the marginal effect of the cross-network size on the demand of live performance.
In respect of live performances activity, the artist is assumed to act as a monopoly and bears no production costs. Consequently, her profit from live performance is given by:

$$\pi_p = p_p(\beta n_S - p_p).$$

As for her profit coming from streaming service it can be expressed as follow:

$$\pi_{ar} = R$$

Where R denotes the lump sum of royalties received from the streaming service in return to the artist placing her library in the streaming platform.
Then the artist's profit is expressed as follows:

$$\pi_a = \pi_{ap} + \pi_{ar}$$

3.1.1The demand with streaming

To obtain the demand functions of different types of users, we characterize the marginal consumers .$\underline{x}$ determines the marginal consumer indifferent between enjoying a free of charge item and not subscribing at all, whereas$\bar{x}$indexes the marginal consumer in different between receiving the item for free and getting a payed version.

$$\underline{x} = \frac{\gamma A - \delta S}{\alpha} \tag{3}$$

$$\bar{x} = \frac{p - \gamma A}{1 - \alpha} \tag{4}$$

Consumers are divided into three categories: consumers who subscribe and pay fees to the platform; consumers who subscribe free of charge; consumers who do not subscribe.
The following figure shows the distribution of the three categories of consumer:

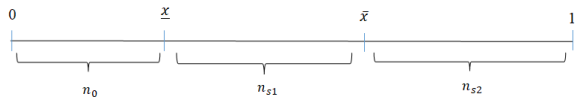


Figure 1: Distribution of consumers

To ensure this distribution, the marginal consumers must be located such as:$0 < \underline{x} < \bar{x} < 1$.
Therefore, we must implement two constraints:

$$\bar{x} < 1 \Leftrightarrow p < (1 - \alpha) + \gamma A \tag{5}$$

and

$$\underline{x} < \bar{x} \Leftrightarrow \frac{\alpha}{\gamma A - \delta S} > \frac{1}{p - \delta S} \tag{6}$$

Combining (5) and (6) in a single constraint gives:

$$\frac{\gamma A - (1 - \alpha)\delta S}{\alpha} < p < (1 - \alpha) + \gamma A \tag{7}$$

- **The Demand for users**

The demand for the flat-rate business is given by:

$$n_{S2} = 1 - \frac{p - \gamma A}{1 - \alpha} = \frac{1 - \alpha - p + \gamma A}{1 - \alpha} \tag{8}$$

The demand function for the free-of-charge business is given by:

$$n_{S1} = \frac{p - \gamma A}{1 - \alpha} - \frac{\gamma A - \delta S}{\alpha} = \frac{\alpha p - \gamma A + (1 - \alpha)\delta S}{\alpha(1 - \alpha)} \tag{9}$$

The demand function of all users is:

$$n_s = 1 - \frac{\gamma A - \delta S}{\alpha} = \frac{\alpha - \gamma A + \delta S}{\alpha} \tag{10}$$

- **The demand of advertisers**

To obtain the demand functions for advertisers, we identify the preference type of the marginal firm. A potential advertiser*y*receives a positive utility from placing commercials on the platform if $fy + \theta n_S - i > 0$ or $y > \hat{y}$ whereby $\hat{y}$ indexes the marginal firm which is indifferent between offering advertisements and settling on the platform or not:

$$\hat{y} = \frac{i - \theta n_S}{f} \tag{11}$$

We have $0 < \hat{y} < 1$so $i - \theta n_S < f$

So the number of advertisers that offer advertisements on the streaming platform is:

$$n_A = 1 - \frac{i - \theta n_S}{f} = \frac{f - i + \theta n_S}{f} \tag{12}$$

We replace (n_s) expression in (n_A) expression to obtain the demand function of advertisers depending on the advertisers cost of installing "i".

$$\mathrm{n_A} = \frac{\alpha(\mathrm{f} - \mathrm{i}) + \theta(\alpha - \gamma \mathrm{A} + \delta \mathrm{S})}{\alpha \mathrm{f}} \tag{13}$$

3.1.2The artist's optimum

Given the number of users n_S, the artist should set the price of live performancep_p.The maximisation of the artist's live performance profit$\pi_p = p_p(\beta n_S - p_p)$leads to the equilibrium price p_p and profit level π_p such as:

$$p_p * = \frac{\beta n_S}{2} \tag{14}$$

and

$$\pi_p * = \frac{\beta^2 {n_S}^2}{4} \tag{15}$$

These results show the interaction that exists between the market of live performance and the market of streaming services music. Indeed, the more subscribers on the music streaming, the higher the price of live performance. Under these conditions, the artist's profit increases quadratically with n_S.The artist's profit is:

$$\pi_p = \frac{\beta^2 {n_S}^2}{4} + R \tag{16}$$

3.1.3 The Streaming platform optimum

The Streaming platform should set the subscription price of the usersp and the fees of installationif the advertisers to maximize the profit function.

$$\pi_{SP} = n_{S2}\mathrm{p} + n_A \mathrm{i} - \mathrm{R} \tag{17}$$

Inserting (6) as well as (11) in (15) yields:

$$\pi_{SP} = \frac{1-\alpha-p+\gamma A}{1-\alpha}\mathrm{p} + \frac{\alpha(\mathrm{f}-\mathrm{i})+\theta(\alpha-\gamma\mathrm{A}+\delta S)}{\alpha \mathrm{f}}\mathrm{i} - R \quad (18)$$

The streaming platform uses the two strategic variables p and i to maximize its profit.

First order conditions of the maximization of the streaming platform's profit (18) lead to:

$$\mathrm{p}^* = \frac{1-\alpha+\gamma A}{2} \quad (19)$$

$$\mathrm{i}* = \frac{\alpha f+\theta(\alpha-\gamma A+\delta S)}{2\alpha} \quad (20)$$

The second order conditions are fulfilled.

Proof:

$$\frac{\partial^2 \Pi}{\partial P^2}P^2 - 2\frac{\partial^2 \Pi}{\partial P \partial i} + \frac{\partial^2 \Pi}{\partial i^2}i^2 = -\frac{2}{1-\alpha}P^2 - \frac{2}{f}i^2 < 0$$

So, $\mathrm{p}^* = \frac{1-\alpha+\gamma A}{2}$, and $\mathrm{i}^* = \frac{\alpha(f+\theta)-\theta(\gamma A-\delta S)}{2\alpha}$ are the price of the subscription and the advertiser's fees of installation on the Streaming service.

From Assumption (2) and Assumption (3), one can perceive that p* is positive. The same is true for $i* > 0$. We note that the condition imposed on the price (7) is verified.

We note that the equilibrium advertising charge depends positively on Subscribers' benefit of network externality related to the number of music products placed in the platform δS, the value of reaching free of charge subscribers θ , the benefit derived from the value of the free of charge streaming service α and the marginal benefit derived from placing commercial on the platform f. It depends negatively on the level of nuisance created by advertisement.

However, the equilibrium flat-rate price p* increases as the additional gain for getting the flat-rate contract instead of the free of charge option $(1-\alpha)$ increases and decreases as the level of nuisance created by advertisement γA increases.

3.1.4 Optimal results

We replace the price of the subscription (19)in the users demand functions to get the following:

- **The demand of users who subscribe and pay fees in the platform**

$$n_{S2}* = \frac{1-\alpha+\gamma A}{2(1-\alpha)} \quad (21)$$

We can see that this equilibrium level of flat- rate demand is strictly positive and less than one as long as Assumption 3 holds.

- **The demand of all users who access to the platform:**

$$n*_s = \frac{\alpha-\gamma A+\delta S}{\alpha} \quad (22)$$

From Assumption (1) and Assumption (2), we can see that $0 < n_s < 1$ and then the market is not covered.

- **The demand of users who subscribe to the platform free of charge**

$$n_{S1}* = \frac{(1-\alpha)(\alpha+2\delta S)-\gamma A(2-\alpha)}{2\alpha(1-\alpha)} \quad (23)$$

One can see that the equilibrium level of the free of charge subscribers is such $0 < n_{s1}* < 1$as long as condition (6) and Assumption (2) hold.

- **The demand of advertisers**

Similarly, for the advertisers' demand function, we replace (20) in (13) to obtain:

$$n_A* = \frac{\alpha f+\theta(\alpha-\gamma A+\delta S)}{2\alpha f} \quad (24)$$

As we can see the equilibrium level of the advertisers' demand is such as $0 < n_A* < 1$,as long as assumption (2) and Assumption (4) hold.

- **The Advertiser's profit**

The Advertiser's profit is done by :

$$\pi_{Ad*} = \theta n_{S1}* - i* \quad (25)$$

Plugging (23) and (20) in (25), we get:

$$\pi_{Ad}* = \frac{\theta(1-\alpha)(\alpha+2\delta S)-\theta\gamma A(2-\alpha)}{2\alpha(1-\alpha)} - \frac{\alpha f+\theta(\alpha-\gamma A+\delta S)}{2\alpha}$$

$$\pi_{Ad}* = \frac{\theta(1-\alpha)\delta S-\theta\gamma A-(1-\alpha)\alpha f}{2\alpha(1-\alpha)} \quad (22)$$

- **The Artist's profit**

Substituting (22) in (14) and (15), we get:

The price of live performance:

$$p*_p = \frac{\beta(\alpha-\gamma A+\delta S)}{2\alpha} \quad (23)$$

The profit coming from live performance:

$$\pi_p* = \frac{\beta^2(\alpha-\gamma A+\delta S)^2}{4\alpha^2} \quad (24)$$

We then deduce:

$$\pi_A* = \pi_p + R = \frac{\beta^2(\alpha-\gamma A+\delta S)^2}{4\alpha^2} + R \quad (25)$$

- **The Streaming platform's profit**

Streaming platform's total profit is the profit made from both sides of the platform users and advertisers. Plugging (21), (24), (19), (20) in (18), we get the platform profit expression:

$$\pi_{Sp} *= \frac{(1-\alpha+\gamma A)^2}{4(1-\alpha)} + \frac{(\alpha f+\theta(\alpha-\gamma A\ +\delta S))^2}{4\alpha^2 f} - R \quad (26)$$

Where:

$$\frac{(1-\alpha+\gamma A)^2}{4(1-\alpha)} \quad (27)$$

is the platform's recipe from users.

$$\frac{(\alpha f+\theta(\alpha-\gamma A\ +\delta S))^2}{4\alpha^2 f} \quad (28)$$

is the platform's recipe from advertisers.

- **The subscribers' surplus**

Aggregated subscriber surplus is the summation of the net valuations of all subscribers to the free-of-charge and the flat-rate business:

$$SS = \int_{\bar{x}}^{1}(x+\delta S-p)dx + \int_{\underline{x}}^{\bar{x}}(\alpha x+\delta S-\gamma A\ )dx \quad (29)$$

Inserting the equilibrium flat-rate price (19) and the equilibrium level of commercials (20) in (28) yields:

$$CS *= \frac{(1-\alpha-\gamma A)^2}{8(1-\alpha)^2} + \frac{(\gamma A-\delta S)^2}{2\alpha} + \frac{\alpha-\gamma A+2\delta S}{2} \quad (30)$$

3.2. Piracy model

Consider now that piracy which appears in the form of illegally file-sharing platform enter the market of music industry, subscribers who are not willing to pay in order to listen to music have another alternative. We suppose that each consumer has four options, that are (i) subscribing to the streaming platform free of charge (ii) subscribing to the streaming platform and paying fees(iii) pirating the music product through the file sharing platform or (iv) not subscribing at all.

The utility function of a consumer indexed by$x$ corresponding respectively to each situation is given by the following expressions:

$$\begin{cases} x+\delta S-p & if\ the\ consumer\ subscribes\ and\ pays\ fees \\ \alpha_1 x+\delta S-\phi & if\ the\ consumer\ pirate \\ \alpha_2 x+\delta S-\gamma A & if\ the\ consumer\ subscribes\ free\ of\ charge \\ 0 & if\ the\ consumer\ does\ not\ subscribe \end{cases} \quad (31)$$

We suppose that illegal download of music provides an intrinsic value that exceeds the intrinsic value of the free of charge streaming service but fall below that of the high-quality-streaming service provided by a charged subscription. We suppose also that the intrinsic value of the free of charge streaming service in the piracy context is lower than the same value without piracy.

$$0 < \alpha_2 < \alpha < \alpha_1 < 1 \quad (32)$$

This assumption is due to the fact that illegally downloading allows for the unconditional ownership of the music product, what is assumed to be of greater value than the free of charge low quality- streaming where the listener has to endure the advertising γA . In contrast, the intrinsic value provided by the payed streaming music is higher because of the quality and additional features like mobile application that offers. The competition introduced by piracy in the free music industry business implies that the intrinsic value provided by the free of charge streaming music is higher in the streaming context than in the piracy context.

Moreover, we note that illegal downloads are associated with a certain level of risk related to the probability of being caught and forced to pay a fine. Consequently, the pirate incurs a disutility ϕ that could be understand as a direct cost of piracy.

3.2.1Equilibrium With Piracy

In order to obtain the demand functions of legal and illegal users, we characterize the marginal consumers. A potential consumer characterized by$\hat{x}$ is the lowest type of user who will subscribe free of charge, while potential users to the right of $\hat{x}$ engage in P2P file-sharing. $\underline{x}'$ determines the marginal consumer indifferent between enjoying a free of charge item and not subscribing at all, whereas $\bar{x}'$indexes the marginal consumer indifferent between receiving the item for free and getting a payed version.

All respective marginal consumers can be determined as it was done in the previous model without piracy by equating utility functions. Thus, we obtain:

$$\underline{x}' = \frac{\gamma A-\delta S}{\alpha_2} \quad (33)$$

$$\hat{x} = \frac{\phi-\gamma A}{\alpha_1-\alpha_2} \quad (34)$$

$$\bar{x}' = \frac{p-\phi}{1-\alpha_1} \quad (35)$$

Figure 2 illustrates how consumers are divided among non-users, subscribers for free, illegal users and paying subscribers when piracy prevails, implying that consumers with $x \in [0, \underline{x}']$do not subscribe, those with $x \in [\underline{x}', \hat{x}]$subscribe free of charge, those with$x \in [\hat{x}, \bar{x}']$pirate the music product, and $x \in [\bar{x}', 1]$subscribe and pays fees in the platform.

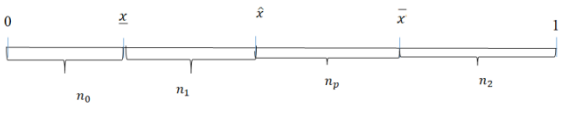


Figure 2: Distribution of consumers under piracy

To ensure this distribution the marginal consumers must be located such as:

$$0 < \underline{x} < \hat{x} < \bar{x} < 1.$$

Therefore, we must implement these constraints:

$$\bar{x}' < 1 \Leftrightarrow p < (1-\alpha_1) + \emptyset \quad (36)$$

$$\hat{x} < \bar{x}' \Leftrightarrow \quad p > \frac{(1-\alpha_1)(\phi-\gamma A)}{\alpha_1-\alpha_2} + \phi \quad (37)$$

Combining the two previous constraints we get:

$$\frac{\emptyset(1-\alpha_2) - \gamma A(1-\alpha_1)}{(\alpha_1-\alpha_2)} < p < (1-\alpha_1) + \emptyset \quad (38)$$

$$\underline{x}' < \hat{x} \Leftrightarrow \emptyset > \frac{\alpha_1(\gamma A - \delta S) + \alpha_2 \delta S}{\alpha_2} \quad (39)$$

To ensure that all values of demands are positive and less than unit, we have to impose the following assumptions:

Assumption 1': $\phi > \gamma A$

Moreover, we note that illegal downloads are associated with a certain level of risk related to the probability of being caught and forced to pay a fine. Consequently, the pirate incurs a disutility ϕ related to the risk of being caught and forced to pay a fineis greater that the disadvantage related to the nuisance caused by advertisement.

Assumption 2': $\alpha_2 + \delta S > \gamma A$

The benefit derived from the value of the free of charge streaming service and the size of music library placed on the platform is higher than the disadvantage related to the nuisance caused by advertisement.

Assumption 3': $1 - \alpha_1 > \phi$

The net benefit derived from contracting a flat-rate contract instead of pirating the music product is greater than the disadvantage related to the risk of feeing caught and forced to pay fines.

Assumption 4': $\frac{\alpha_1}{\alpha_2} > \frac{\phi}{\gamma A}$

The ratio of the product valuations in the cases of pirating and free access is higher than the ratio of the disutility related to the risk of capture in the case of piracy per the nuisance caused by advertising.

Assumption 5': $1-\alpha_1 < \frac{\alpha_1-\alpha_2}{2}$ and $\phi < \frac{1-\alpha_1+\gamma A}{2}$

The net benefit derived from contracting a flat-rate contract instead of pirating the music product is lower than the net benefit derived from getting the product free of charge from streaming service instead of pirating it in parallel with a low value of the disutility related to the risk of capture in case of piracy.

Like the previous model, we suppose that there are many advertisers who seek to place their commercial and reach the free of charge subscribers. We suppose that they are uniformly distributed on the unit interval and have a unit mass. An advertiser indexed by $y$takes a profit of fy where$y$ is the index of the advertiser's location on the unit interval which indicates its preference for joining the platform and$f$ is the marginal benefit derived by placing commercial on the platform.they pay an installation fee i'.

We assume that each advertiser benefits a cross-network effect $\theta n_{S1}'$ which comes from the presence of many free of charge subscribers on the other side of the market. Where n_{S1}' is the number of free of charge subscribers andθ is the surplus generated by an additional free of charge subscriber joining the platform.Thus an advertiser's payoff for joining the platform is:

$$U_A = \begin{cases} fy + \theta n_{S1}' - i' & if\ the\ artist\ is\ on\ platform \\ 0 & if\ tnot \end{cases} \quad (40)$$

With f, θ positive parameters.

Placing a commercial on the free-of-charge business provides a profit of $\pi_A' = \theta n_{S1}' - i'$ (41) for a representative advertiser in piracy context.

At this stage, we make the following assumptions regarding the advertiser' preferences described in equation (40)

Assumption 5': $\alpha_2 f > \theta(\alpha_2 - \gamma A + \delta S)$

The cross benefit of being on the two sides of the platforming the piracy context exceeds the benefit derived from the cross-network externality associated with the free of charge streaming service.

Like the previous model, the artist's profit coming from live performance is given by:

$$\pi_p' = p_p'(\beta n_S' - p_p') \quad (42)$$

And the artist's hole profit is:

$$\pi_a = \pi_{ap} + \pi_{ar} \quad (43)$$

3.2.2The Demand for users

The demand for the flat-rate business is given by:

$$n_{S2}' = \frac{(1-\alpha_1) - p + \emptyset}{(1-\alpha_1)} \quad (44)$$

The demand function for the pirate business is given by:

$$n_p = \frac{(\alpha_1-\alpha_2)p - (1-\alpha_1)\emptyset - (1-\alpha_1)\gamma A}{(1-\alpha_1)(\alpha_1-\alpha_2)} \quad (45)$$

The demand function for the free-of-charge business is given by:

$$n_{S1}' = \frac{\emptyset - \gamma A}{(\alpha_1-\alpha_2)} - \frac{\gamma A - \delta S}{\alpha_2}$$
$$= \frac{\alpha_2(\emptyset - \gamma A) - (\alpha_1-\alpha_2)(\gamma A - \delta S)}{\alpha_2(\alpha_1-\alpha_2)}$$
$$= \frac{(\alpha_1-\alpha_2)\delta S + \alpha_2\emptyset - \alpha_1\gamma A}{\alpha_2(\alpha_1-\alpha_2)} \quad (46)$$

The demand function of all users is:

$$n_s' = \frac{\boldsymbol{\alpha_2 - \gamma A + \delta S}}{\boldsymbol{\alpha_2}} \quad (47)$$

3.2.3 The demand of Advertisers

In order to obtain the demand functions for advertisers, we identify the marginal firm$\hat{y}'$ which is indifferent between offering advertisements and settling on the platform or not :

$$\hat{y} = \frac{i' - \theta n_S{}'}{f} \tag{48}$$

So the number of advertisers that offers advertisements on the streaming platform is:

$$n_A{}' = 1 - \frac{i' - \theta n_S{}'}{f} = \frac{f - i' + \theta n_S{}'}{f} \tag{49}$$

We replace ($n_s{}'$) expression in ($n_A{}'$) expression to obtain the demand function of advertisers depending on the advertisers cost of installing "i'":

$$\mathrm{n_A}' = \frac{\alpha_2(\mathrm{f} - \mathrm{i}') + \theta(\alpha_2 - \gamma \mathrm{A} + \delta \mathrm{S})}{\alpha_2 \mathrm{f}} \tag{50}$$

3.2.5 The Streaming platform optimum

The Streaming platform should set the subscription price of the users P' and the cost of installation i' of the advertisers to maximize the profit function.

$$\pi_{rP}{}' = n_{S2}{}'\mathrm{p} + n_A{}' i - \mathrm{R} \tag{51}$$

Inserting (44) as well as (50) in (51) yields

$$\begin{aligned} &\pi_{rP}{}' \\ &= \left(\frac{(1-\alpha_1) - p' + \emptyset}{(1-\alpha_1)}\right)p \\ &+ \left(\frac{\alpha_2(f - i') + \theta(\alpha_2 - \gamma A + \delta S)}{\alpha_2 f}\right)i - R \end{aligned} \tag{52}$$

The first order conditions of the profit (52) maximization lead to:

$$\mathrm{p}^{*\prime} = \frac{1 - \alpha_1 + \emptyset}{2} \tag{53}$$

$$\mathrm{i}^{*\prime} = \frac{\alpha_2 f + \theta(\alpha_2 - \gamma A + \delta S)}{2\alpha_2} \tag{54}$$

From Assumption 2' and Assumption 3', one can perceive that p*'and $\mathrm{i}*' > 0$ are positive. We note that the condition imposed on the price (38) is fulfilled.

Note that the equilibrium flat-rate price p*' in the piracy model depends positively on the level of disutility related to the risk incurred by pirates ∅and the additional gain for getting the flat-rate contract instead of the free of charge option $1 - \alpha_1$.

Like the streaming model, the advertising charge depends positively on Subscribers' benefit of network externality related to the number of music products placed in the platform δS, the value of reaching free of charge subscribers θ , the benefit derived from the value of the free of charge streaming serviceα_2 and the marginal benefit derived by placing commercial on the platform f. It depends negatively on the level of nuisance created by advertisement.

Additional inside can be obtained from the equilibrium demand functions and equilibrium payoffs.

3.2.6 Optimum results with piracy

We replace the equilibrium price and the equilibrium advertising charge in the different expressions to get the optimal expressions:

- **The demand of users who subscribe and pay fees in the platform**

$$\mathrm{n_{S2}}*' = \frac{1 - \alpha_1 - \emptyset}{2(1 - \alpha_1)} \tag{55}$$

We can see that this equilibrium level of flat- rate demand is strictly positive and less than one as long as Assumption (3') holds.

- **The demand of all users**

$$\boldsymbol{n_s}* = \frac{\boldsymbol{\alpha_2 - \gamma A + \delta S}}{\boldsymbol{\alpha_2}} \tag{56}$$

From Assumption 1 and Assumption 2', we can see that $0 < n_s < 1$ and then the market is not covered.

- **The demand function for the pirate business:**

$$\begin{aligned} &n*'_p \\ &= \frac{(\alpha_1 - \alpha_2)(1 - \alpha_1) + \emptyset(\alpha_1 + \alpha_2 - 2) + 2(1 - \alpha_1)\gamma A}{2(1 - \alpha_1)(\alpha_1 - \alpha_2)} \end{aligned} \tag{57}$$

As long as Assumption 5' holds, we have $0 < n*'_p < 1$

- **The demand function of the users who subscribe free of charge**

We can determine the participation of users who subscribe to the platform with free of charge.

We have $n_{S1\prime} = n_s{}' - n_{S2}{}'$ so we replace the demand expression of group 2 and the demand expression of all users to obtain the participation of group 1

$$\begin{aligned} n_{S1}*' &= \frac{(\alpha_1 - \alpha_2)\delta S + \alpha_2 \emptyset - \alpha_1 \gamma A}{\alpha_2(\alpha_1 - \alpha_2)} \\ &= \frac{\alpha_2(\emptyset - \delta S) - \alpha_1(\gamma A - \delta S)}{\alpha_2(\alpha_1 - \alpha_2)} \end{aligned} \tag{58}$$

- **The advertisers' demand function**

Similarly, for the artists demand function, we replace the installation cost $i*'$ (54) in expression (46) to obtain expression $\mathrm{n_A}*'$ which indicates the number of artists that offer music on the streaming.

$$\mathrm{n_A}*' = \frac{\alpha_2 f + \theta(\alpha_2 - \gamma A + \delta S)}{2\alpha_2 f} \tag{59}$$

As long as Assumption 2' and Assumption 5' hold, we have $0 < n_A*' < 1$

- **The Advertiser's profit**

$$\pi_A*' = \theta n_{S1}*' - i*'$$

$$\pi_{\mathrm{A}}*' = \frac{(\alpha_1 - \alpha_2)\delta \mathrm{S} + \alpha_2 \emptyset - \alpha_1 \gamma \mathrm{A}}{\alpha_2(\alpha_1 - \alpha_2)} - \frac{\alpha_2 \mathrm{f} + \theta(\alpha_2 + \gamma \mathrm{A} - \delta \mathrm{S})}{2\alpha_2}$$

$$\pi_A*' = \frac{\theta(\alpha_1 - \alpha_2)(3\delta S - \gamma A - \alpha_2) + 2\theta(\alpha_2 \emptyset - \alpha_1 \gamma A) - \alpha_1(\alpha_1 - \alpha_2) f}{2\alpha_2(\alpha_1 - \alpha_2)} \tag{60}$$

- **The Artist's profit**

$$p*'_p = \frac{\beta(\alpha_2 - \gamma A + \delta S)}{2\alpha_2} \tag{61}$$

$$\pi_p*' = \frac{\beta^2(\alpha_2 - \gamma A + \delta S)^2}{4{\alpha_2}^2} \tag{62}$$

- **The optimal profit of the Streaming platform is:**

Total profit is the profit made from both sides of the platform users and advertisers. We replace expressions (51), (52), (53), (57) in the profit function to get the platform profit:

$$\pi_{Sp}*' = \frac{(1 - \alpha_1 + \gamma A)^2}{4(1 - \alpha_1)} + \frac{(\alpha_2(f + \theta) - \theta(\gamma A - \delta S))^2}{4{\alpha_2}^2 f} - R \tag{63}$$

- **The subscribers' surplus**

Subscribers obtain surplus SS equal to :

$$\mathrm{CS}*' = \int_{\underline{x}}^{\hat{x}} (\alpha_2 x + \delta S - \gamma A)\,dx + \int_{\hat{x}}^{\bar{x}} (\alpha_1 x + \delta S - \phi)\,dx + \int_{\bar{x}}^{1} (x + \delta S - p)\,dx$$

$$CS*' = \frac{(\phi - \gamma A)^2}{2(\alpha_2 - \alpha_1)} + \frac{(\gamma A - \delta S)^2}{2\alpha_2} + \frac{(1 - \alpha_1 - \phi)^2(1 + \alpha_1)}{8(1 - \alpha_1)} + \frac{(\alpha_1 + 2\delta S - \phi)}{2} \tag{64}$$

3.3. Who is harmed by piracy and who benefits from it?

To address this issue, we compare the payoff levels of the different stakeholders under the two scenarios that are streaming without piracy and streaming with piracy.The main findings regarding the stakeholders' payoffs under the two options streaming and piracy are recapitulated in the following table.

	Streaming	Piracy
Artist's profit	$\pi_A* = \pi_p* + R = \frac{\beta^2(\alpha - \gamma A + \delta S)^2}{4\alpha^2} + R$	$\pi_A*' = \pi_p*' + R = \frac{\beta^2(\alpha_2 - \gamma A + \delta S)^2}{4{\alpha_2}^2} + R$

Streaming service's profit	$\pi_{Sp}{}^{*} = \frac{(1-\alpha+\gamma A)^2}{4(1-\alpha)} + \frac{(\alpha(f+\theta)-\theta(\gamma A-\delta S))^2}{4\alpha^2 f} - R$	$\pi_{Sp}{}^{*\prime} = \frac{(1-\alpha_1+\gamma A)^2}{4(1-\alpha_1)} + \frac{(\alpha_2(f+\theta)-\theta(\gamma A-\delta S))^2}{4{\alpha_2}^2 f} - R$
Consumers' surplus	$CS^{*} = \frac{(\gamma A-\delta S)^2}{2\alpha} + \frac{(1-\alpha-\gamma A)^2}{8(1-\alpha)^2} + \frac{\alpha-\gamma A+2\delta S}{2}$	$CS^{*\prime} = \frac{(\gamma A-\delta S)^2}{2\alpha_2} + \frac{(\phi-\gamma A)^2}{2(\alpha_2-\alpha_1)} + \frac{(1-\alpha_1-\phi)^2(1+\alpha_1)}{8(1-\alpha_1)} + \frac{(\alpha_1+2\delta S-\phi)}{2}$
Advertisers' profit	$\pi_{Ad}{}^{*} = \frac{\theta(1-\alpha)\delta S-\theta\gamma A-(1-\alpha)\alpha f}{2\alpha(1-\alpha)}$	$\pi_{Ad}{}^{*\prime} = \frac{\theta(\alpha_1-\alpha_2)(3\delta S-\gamma A-\alpha_2)+2\theta(\alpha_2\emptyset-\alpha_1\gamma A)-\alpha_1(\alpha_1-\alpha_2)f}{2\alpha_2(\alpha_1-\alpha_2)}$

TABLE 1. Stakeholders' payoffs under different regimes

3.3.1 Impact of piracy on Artist's payoff

Comparing the Artist's profit in the case of streaming with and without piracy, we obtain:

$$\pi_A{}^{*\prime} - \pi_A{}^{*} = \frac{\beta^2[2\alpha\alpha_2(\alpha_2-\alpha)(\delta S-\gamma A)+(\alpha^2-{\alpha_2}^2)(\delta S-\gamma A)^2]}{4\alpha^2{\alpha_2}^2} \tag{65}$$

As $\alpha_2 < \alpha$, (31) and $\delta S < \gamma A$ (assumption 1), the artist's profit in the piracy context is higher than her profit in the streaming era.

Proposition 1*: the artist's profit is higher under piracy compared to a situation of streaming without piracy*

3.3.2 Impact of piracy on advertiser'spayoff

Comparing the Advertiser's profit in the case of streaming and piracy in (60) and (22), we obtain an expression with an ambiguous sign.:

$$\pi_{Ad}{}^{*\prime} - \pi_{Ad}{}^{*} = \frac{\theta(\alpha_1-\alpha_2)(3\delta S-\gamma A-\alpha_2)+2\theta(\alpha_2\emptyset-\alpha_1\gamma A)-\alpha_1(\alpha_1-\alpha_2)f}{2\alpha_2(\alpha_1-\alpha_2)} - \frac{\theta(1-\alpha)\delta S-\theta\gamma A-(1-\alpha)\alpha f}{2\alpha(1-\alpha)} \tag{66}$$

3.3.3 Impact of piracy on Streaming service'spayoff

Comparing the streaming service's payoff in streaming context with and without piracy, we note that the piracy is not always undesirable for the streaming platform. Furthermore, it could even be beneficial in some cases. Indeed, comparing the first term of the streaming platform's profit expression in the streaming context to the first term in the same expression under piracy implies that receipts coming from subscribers are not always higher in the streaming context:

$$\frac{(1-\alpha_1+\gamma A)^2}{4(1-\alpha_1)} - \frac{(1-\alpha+\gamma A)^2}{4(1-\alpha)} = \frac{(\alpha-\alpha_1)(1-\alpha_1)[(1-\alpha)(1-\alpha_1)-\gamma A^2]}{4(1-\alpha_1)(1-\alpha)} \tag{67}$$

We note that if $(1-\alpha_1)(1-\alpha) < \gamma A^2$. That is when the nuisance caused by advertising exceeds a certain level that depends on the consumer's additional utility gain associated with paying for the music product instead of pirating it and the additional gain associated with opting for flat-rate contract instead of the free of charge option, the streaming service could even benefit from piracy through the increasing of its receipts coming from subscribers.

Proposition 2: *If the nuisance caused by advertising exceeds a certain level that depends on the consumer's additional utility gain associated with paying for the music product instead of pirating it and the additional gain associated with opting for flat-rate contract instead of the free of charge option* $(1-\alpha_1)(1-\alpha) < \gamma A^2$*, the streaming service could benefit from piracy through the increasing of its receipts coming from subscribers.*

On can consider that piracy play the role of stimulator to transform the free of charge subscribers into flat rate subscribers.

Similarly, comparison between the second term of the streaming platform's profit expression in the piracy context to the second term in the same expression under the streaming context, does not show that receipts coming from advertisers are always higher in the streaming context:

$$\frac{(\alpha_2(f+\theta)-\theta(\gamma A-\delta S))^2}{4{\alpha_2}^2 f}-\frac{(\alpha(f+\theta)-\theta(\gamma A-\delta S))^2}{4\alpha^2 f}=\frac{(\alpha-\alpha_2)\theta(\gamma A-\delta S)[\theta(\gamma A-\delta S)(\alpha+\alpha_2)-2\alpha\alpha_2(f+\theta)]}{4\alpha^2{\alpha_2}^2 f} \quad (68)$$

In some cases, when $\frac{f+\theta}{\theta}<\frac{(\alpha+\alpha_2)(\gamma A-\delta S)}{2\alpha\alpha_2}$, receipts coming from advertisers are higher in the piracy context. That is when the net nuisance caused by advertisement exceeds the value of placing the music product and enjoying the cross-network benefit of reaching the subscribers, the streaming platform could benefit from piracy through the increasing of its receipts coming from advertisers.

Proposition 3:when the net nuisance caused by advertisement exceeds the value of placing the music product and enjoying the cross-network benefit of reaching the subscribers $\frac{f+\theta}{\theta}<\frac{(\alpha+\alpha_2)(\gamma A-\delta S)}{2\alpha\alpha_2}$, the streaming platform could benefit from piracy through the increasing of its receipts coming from advertisers.

3.3.4 Impact of piracy on consumers'payoff

Comparing the consumers' surplus in streaming context (29) and the consumers' surplus under piracy (62) leads to an expression with an ambiguous sign.

$$CS*'-CS*=\frac{(\gamma A-\delta S)^2}{2\alpha_2}+\frac{(\phi-\gamma A)^2}{2(\alpha_2-\alpha_1)}+\frac{(1-\alpha_1-\phi)^2(1+\alpha_1)}{8(1-\alpha_1)}+\frac{(\alpha_1+2\delta S-\phi)}{2}-\frac{(\gamma A-\delta S)^2}{2\alpha}-\frac{(1-\alpha-\gamma A)^2}{8(1-\alpha)^2}-\frac{\alpha-\gamma A+2\delta S}{2} \quad (69)$$

3.3.5 Numerical simulation

In order to go further in our analysis, we examine a numerical example that simulate the values taken by different parameters. Let's consider the following values for the different intrinsic valuation of the music productα_i :

$$\alpha=\frac{1}{2};\ \ \alpha_1=\frac{3}{4};\ \ \alpha_2=\frac{1}{4} \quad (70)$$

These values are chosen to fulfill the condition (31). Let's examine the payoffs' comparisons presenting an ambiguous sign.

- **Impact of piracy on advertiser'spayoff**

Plugging (70) in (66), we get:

$$\pi_{Ad}*'-\pi_{Ad}*=\ 5\theta\delta S+6\theta\gamma A+2\theta(\emptyset-\frac{1}{4})-f \quad (71)$$

From assumption 4, we deduce that the marginal benefit derived by placing commercial on the platform must be sufficiently high to ensure that the market is uncovered which leads to a higher advertisers' profit in the case of streaming than in the case of piracy. The justification of this result lies in the cross network-effect that is more important in the streaming model. Indeed, the presence of piracy has the effect of crowding out some of the potential consumers reached by advertisement firms.

$$n_{S1}*'-n_{S1}*=\frac{\alpha_2(\emptyset-\delta S)-\alpha_1(\gamma A-\delta S)}{\alpha_2(\alpha_1-\alpha_2)}-\frac{(1-\alpha)(\alpha+2\delta S)-\gamma A(2-\alpha)}{2\alpha(1-\alpha)} \quad (72)$$

Plugging (70) in (72), we get:

$$n_{S1}*'-n_{S1}*=\ 2\emptyset+2\delta S\ -3\gamma A-\frac{1}{2} \quad (73)$$

This expression is negative as long as:

$$\emptyset<\frac{3}{2}\gamma A\ -\delta S\ +1$$

So, when the risk for pirate to be caught and incurs punition is low piracy nibble in the reserves of the potential consumers reached by advertisement firms that are the free of charge subscribers.

- **Impact of piracy on consumers'payoff**

Plugging (70) in (69), we get:

$$CS*'-CS*=\ (\gamma A-\delta S)^2-(\phi-\gamma A)^2+\frac{3}{8}(\frac{1}{2}-\phi)^2-\frac{1}{2}(\frac{1}{2}-\gamma A)^2-\frac{1}{2}(\phi-\gamma A) \quad (74)$$

We note that the sign of (74) is not clear-cut.

III. CONCLUDING REMARKS

This paper has investigated the impact of piracy in the streaming era on different stakeholders. Illegal file-sharing is added to a model considering a

monopolistic which offers streaming music based on freemium model that offers to its subscribers two categories of businesses, a free-of-charge advertising funded business and a flat-rate business. The subscribers, decide, then, whether to subscribe to one of these two businesses or to refuse to streaming music at all. By considering piracy, subscribers are offered another alternative which is to share the music item on the file-sharing platform. The modeling was based on the two-sided market business model that focused on the cross-network benefit the advertisers gain from the subscribers that opt for a free of charge business and then incurred the nuisance caused by the commercials placed on the streaming platform. The investigation focused on an analysis of the music industry stakeholders' equilibrium payoffs with respect to the nuisance created by commercial, the risk incurred by pirates and the consumers' benefit of enjoying a large music library.

By doing so, threshold values with respect to the nuisance caused by advertising for which the streaming service's receipts coming from subscribers and/or from advertisers in case of piracy could exceed those without piracy, are determined. Beyond this, the analysis established that artist is better off under the piracy regime, while advertisers are harmed by it. Nevertheless, no clear-cut effect has been found with respect to the consumer surplus.

Returning to our main question: is the cohabitation of piracy and streaming beneficial or harmful? The answer is likely to differ substantially for stakeholders. More profits for the artists can mean fewer profits for the advertisers. The reappearance of piracy in the era of streaming is likely to profoundly redefine the allocation of value among partners in the music industry. Piracy can be used by artists to face the impaired revenue allocation in the music industry. Artists can, then, negotiate better contracts with streaming platforms by threatening to distribute their music by themselves and do not involve streaming service if this one persists in keeping per stream royalties given to the artist very low. Furthermore, new technologies have expanded the broadcasting of music product well beyond streaming and file-sharing to include different ways of directly reach a large audience through social media. Nowadays, Artists can actively promote their music and inform their fans about their activities on various platforms. Likewise, fans can also actively promote the artist by interacting on, social media and blogs. New online promotion include various forms of artist-generated content (AGC) like pictures or videos posted on social networks(e.g., Twitter, Instagram, or Facebook) and video-sharing websites (e.g., YouTube)and user-generated content (UGC) on online platforms like messages, like reviews, blog posts or video-sharing. The rise of these new means of promoting and broadcasting, has added a level of complexity to the music market that it would be interesting to examine in future studies.

REFERENCES

[1] Aguiar.,L and Waldfogel.,W. (2018). As streaming reaches flood stage, does it stimulate or depress music sales?*International Journal of Industrial Organization*. vol. 57, issue C, 278-307.

[2] Aguiar., L. (2017).Let the music play? Free streaming and its effects on digital music consumption.*Information Economics and Policy*Volume 41, December 2017, Pages 1-14.https://doi.org/10.1016/j.infoecopol.2017.06.002.

[3] Armstrong., M. (2006). Competition in two-sided markets. RAND.*Journal of Economics*. 37(3):668–691.

[4] Armstrong., M, Weeds., H. (2007). Public service broadcasting in the digital world.*The Economic Regulation of Broadcasting Markets.* pp 81-149; DOI: https://doi.org/10.1017/CBO9780511611124.004.

[5] Belleflamme., P. and Peitz., M. (2010). Platform competition and seller investment incentives. *European Economic Review*, 54(8):1059–1076.

[6] Boorstin,. E. (2004). Music Sales in the Age of File Sharing. Senior thesis, Princeton University.

[7] Caillaud., B, and Jullien., B. (2003). Chicken & egg: Competition among intermediation service providers. RAND.*Journal of Economics*. 34(2):309–328.

[8] Carroni, Elias and Ferrari, Luca and Righi, Simone. (2019). The price of discovering your needs online *Journal of Economic Behavior & Organization.* Elsevier, vol. 164(C), pages 317-330.

[9] Calvano., E, Polo., P. (2019). Strategic Differentiation by Business Models: Free-To-Air and Pay-TV.*The Economic Journal,* Volume 130, Issue 625, January 2020, Pages 50–64, https://doi.org/10.1093/ej/uez037.

[10] Carroni., E, Paolini., D. (2020).Business models for streaming platforms: content acquisition, advertising and users.*Information Economics and Policy*. 100877.

[11] Fine and Michael (2000).SoundScan Study on Napster Use and Loss of Sales. report by the chief executive officer of SoundScan, engaged by the plaintiffs in the action, A&M Records Inc. et al. v. Napster, Inc., (accessed October 11, 2005), http://news.corporate.findlaw.com/hdocs/docs/napster/riaa/fine.pdf].

[12] Ferrando., J, Laussel., D, Sonnac., N. (2008).Intermarket Network Externalities and Competition: An Application to the Media Industry.*International Journal of Economic Theory*. 4(3):357-379, DOI: 10.1111/j.1742-7363.2008.00084.x.

[13] Gayer, Amit and Shy O. (2005). Copyright Enforcement in the Digital Era. *CESifo Economic Studies*. Vol. 51, 477 - 489.

[14] Gayer., A, and Shy., O. (2006). Publishers, artists, and copyright enforcement. *Information Economics and Policy*. 18(4):374–384.

[15] Godes., D, Mayzlin., D. (2009. Firm-Created Word-of-Mouth Communication: Evidence from a Field Test.*Marketing Science*. 28(4):721-739; DOI: 10.1287/mksc.1080.0444.

[16] Gal–Or., E andDukes., A. (2003). Negotiations and Exclusivity Contracts for Advertising.*Marketing Science*, 2003, vol. 22, issue 2, 222-245.

[17] Gantman., N, Shy., O. (2007). Broadcasting Competition and Advertising Quality: A Two-sided Market Approach.*Business, Corpus* ID: 167912088.

[18] Gomes., R, Pavan., A. (2016). Many-to-many matching and price discrimination. Theoretical Economics. 11(3):1005–1052.

[19] Hagiu., A, Wright., J. (2019). The status of workers and platforms in the sharing economy. *Journal of Economics & Management Strategy*.

[20] Jay Pil Choi (2006).Broadcast competition and advertising with free entry: Subscription vs. free-to-air. *Information*

Economics and Policy, 18(2), 181-196.https://doi.org/10.1016/j.infoecopol.2005.12.002.

[21] Jeon, D-S; Kim, B-C;Menicucci, D. (2019).Second-Degree Price Discrimination by a Two-Sided Monopoly Platform. CEPR Discussion Paper No. DP11488, Available at SSRN: https://ssrn.com/abstract=2834825

[22] Kind, H-J; Köthenbürger, M;Schjelderup, G. (2009). Should Utility-Reducing Media Advertising be Taxed? *CESifo Working Paper* Series 2589, CESifo.

[23] Liebowitz Stan.,J.(2003). Will MP3 downloads Annihilate the Record Industry? The Evidence so Far. In Advances in the Study of Entrepreneurship, Innovation, and Economic Growth, edited by Gary Libecap, JAI Press. SSRN: https://ssrn.com/abstract=414162 or http://dx.doi.org/ 10.2139/ssrn.414162.

[24] Liebowitz Stan., J. (2006). File Sharing: Creative Destruction or Just Plain Destruction? *The Journal of Law & Economics*, Vol. 49, No. 1 (April 2006), pp. 1-28 (28 pages) Published By: The University of Chicago Press, DOI: 10.1086/503518. https://www.jstor.org/stable/10.1086/503518

[25] Liu,Q ; Serfes.,K. (2013). Price Discrimination in Two-Sided Markets.*journal of economics and management Strategy*, https://doi.org/10.1111/jems.12038.

[26] Lin., S (2020). Two-Sided Price Discrimination by Media Platforms. Marketing Science 39(2):317-338. https:// doi.org/10.1287/mksc.2019.1211.

[27] Molteni and Molteni (2003). Consumption Patterns, Digital Technology and Music Downloading, Long Range Planning 36(4):389-406, DOI: 10.1016/S0024-6301(03)00073-6.

[28] Nguyen., G, Dejean., S, Moreau., F. (2013). On the Complementarity between Online and Offline Music Consumption: The Case of Free Streaming (2013).Journal of Cultural Economics. DOI: 10.1007/s10824-013-9208-8. Project: Business model of digital economy.

[29] Nocke., V, Peitz., M, Stahl., K, (2007). Platform ownership". *Journal of the European Economic* Association 5 (6), 1130–1160.

[30] Oberholzer,F;Strumpf, K. (2007). The Effect of File Sharing on Record Sales An Empirical Analysis.*Journal of Political Economy*. 2007, vol. 115, no. 1, 2007, by The University of Chicago. All rights reserved. 0022-3808/2007/11501-0001$10.000.

[31] Peitz.,M;Waelbroeck.,P. (2004). The effect of internet piracy on music sales: cross-section evidence.*Review of Economic Research on Copyright Issues*, 2004, vol. 1(2), pp. 71-79.

[32] Peitz., M, Waelbroeck., P. (2005). An economist's guide to digital music. *CESifo Economic Studies* 51, 359 – 428.

[33] Peitz., M; Valletti.,T. (2008). Content and advertising in the media: Pay-tv versus free-to-air.*International Journal of Industrial Organization*. vol. 26, issue 4, 949-965.

[34] Belleflamme, P; Peitz, M. (2014). Digital Piracy: Theory. Springer Science + Business Media New York, DOI: 10.1007/978-1-4614-7883-6_13-1.

[35] Rochet., J-C; Tirole., J, (2003).Platform competition in two-sided markets. *Journal of the European Economic Association*, 1(4):990–1029.

[36] Reisinger (2012). Platform competition for advertisers and users in media markets. *International Journal of Industrial Organization*, 2012, vol. 30, issue 2, 243-252.

[37] Sinclair., G; Green.,T, (2015). Download or stream? Steal or buy? Developing a typology of today's music consumer". *Journal of Consumer Behaviour* 15(1). DOI: 10.1002/cb.1526.

[38] Thomas., Y, Lu (2013). Understanding Streaming and Copyright: A Comparison of the United States and European Regimes.*Journal of Business & Technology Law*, Volume 13, Issue 2.

[39] Weyl., E-G. (2010). A price theory of multi-sided platforms. *The American Economic Review* 100 (4), 1642–1672.

[40] Wlömert., I.; Papies., D. (2019).International heterogeneity in the associations of new business models and broadband Internet with music revenue and piracy. *International Journal of Research in Marketing*.Volume 36, Issue 3, September 2019, Pages 400-419, https://doi.org/10.1016/j.ijresmar.2019.01.007.

[41] Zentner, A (2006). Measuring the Effect of File Sharing on Music Purchases. *The Journal of Law & Economics*.Vol. 49, No. 1 (April 2006), pp. 63-90 (28 pages), Published By: The University of Chicago Press, DOI: 10.1086/501082, https://www.jstor.org/stable/10.1086/501082.

★★★