# Cooperative solutions to unauthorized download of copyrighted creations

Eitan Altman*, Sulan Wong†, Julio Rojas-Mora‡, Alireza Aram§
*Maestro Group, INRIA Sophia-Antipolis, France
Email: eitan.altman@sophia.inria.fr
†Fac. of Law, University of A Coruña, Spain
Email: swong@udc.es
‡Fac. of Economic and Business Sciences, University of Barcelona, Spain
Email: jrojasmo7@alumnes.ub.edu
§Finance Dept., Wharton School of the University of Pennsylvania, USA
Email: aaram@wharton.upenn.edu

***Abstract*—A large part of the Internet traffic is due to P2P file sharing, and most of it is associated with unauthorized sharing of copyrighted music and films. In several countries, a direct confrontation has emerged as a strategy to deal with this demand. In contrast, in some other countries it has been recognized that this huge demand may have also positive externalities on the economy and could even result in increasing legal purchase of music and films. The first contribution of this paper is the study of some benefits that free access to the Internet can bring to content providers. We study in particular the sampling externalities of free Internet access using a Bayesian framework. We then formulate a non-cooperative hierarchical game to model the interaction between users and content providers. We also present a study on the perspectives of cooperation between service providers and content providers that could result in transforming a large part of non-authorized P2P downloads to legal ones.**

## I. Introduction

Fast evolution of the P2P technology in last years has increased the wide spread access to popular culture (music and films). It has promoted file sharing at the expense of free riding. This evolution created a major conflict between internautes and the content production industry (CPI). While a legal battle is being held in courts and in the legislation area, the conflict also finds its echoes in scientific analysis of experimental data and of the economy of P2P networks. In particular, some publications conclude that the music and film industry gains from P2P where as other conclude the contrary. The gains can be attributed to a sampling effect: by downloading music, a customer can get more information that may increase its willingness to purchase a hard copy of the CD. On the other hand, the availability of free copies for download considerably decreases the demand for costly electronic copies sold by the companies and may constitute for many users a satisfactory alternative to the original CD thus decreasing again the incomes of the content providers industry[1].

At the same time, the traffic that corresponds to non-authorized download of copyrighted music and films on the Internet has been increasing and has become a major source of income to service providers. The interaction between this demand and the CPI can evolve on a confrontation basis where the CPI try to destroy it with the help of the legal system and the service providers (who may not profit from such a move). The CPI may on the other hand seek for strategies that allow both Internet Service Providers (ISPs) and CPI to benefit of this huge demand. Many attempts have been made in the past to propose sharing of the potential benefits that this demand can create. We are in particular inspired with the attempt of Virgin to create a legal P2P network together with Universal that would offer their customers with unlimited access to their products [36].

We shall analyze in this paper several aspects of illegal downloads that can create benefits to the CPI.

We provide in the next section an overview of the economic aspects of sampling and of legal measures against unauthorized downloads. We then introduce an economic model and compute the expected income of the CPI taking into account the impact of their actions on the availability of the files at the P2P networks, on the demand for sampling of the file and for purchasing it. Them, we present a cooperative model for the industry and the ISPs based on the concept of the Shapley value. Finally, some final remarks on the problem are exposed.

## II. Sampling

Experience goods [25] identify assets that need to be consumed before knowing their satisfaction level. Consumers make an initial selection based on information from indirect sources and will continue testing until the cost of a new trial exceeds the expected growth in satisfaction.

[1]According to the 2009 IFPI [17], by 2008 its 3.7 billion dollars digital music business model had, on an international level, a 25% estimated growth. The RIAA [30] reported that sales of digital music have grown in 2008 by 30%, which represents 1.6 billion dollars, and constituted 32% (shipments) of the total market value and 2.7 billion dollars in total sales. The market for physical recorded music have fallen 28% to 5.8 billion dollars.

Cultural contents can be seen as the quintessential experience good, one that creates a multibillion-dollar global industry, one that is based on a myriad of genres and countless artists. Consumers are faced with the difficult task of using their limited budgets to acquire some of these contents, without fully knowing how fulfilling they are.

Nelson [25] states that consumers will be willing to pay for the information needed to get a completely fulfilling experience from the acquired goods. This payment should be, of course, smaller than the cost of the average number of trials before buying the fulfilling good.

Sampling is then, the process of trying different brands of the same kind of good until the consumer feels that a new trial will not generate a significant increase in his satisfaction. In our particular context, sampling is carried out by P2P users who share files with cultural contents, to get a more informed opinion on subjects, authors and genres they search for. As presented in [1], sampling can also be seen as a branching process in the sense that each sampled content can generate many new samples on many different genres or authors. Thus, sampling can act as a promotional or marketing tool for both mainstream and obscure cultural contents.

### A. Theoretical models and statistical surveys on sampling

Liebowitz [22] supports Nelson's idea of a more informed consumer arises due to the sampling effect that P2P networks allow. This consumer, he also says, is not going to increase his purchasing level due to his newly acquired knowledge. In fact, he believes that file sharing has the main responsibility in the fall of music sales in physical format. [21], [23].

One could argue then, like Nelson stated, that a more informed consumer will be willing to pay more for products that are matched to their tastes. Peitz and Waelbroeck [28] created a model in which increased prices don't affect sales negatively, as consumers use P2P networks for sampling before buying. Even with lower prices, they say, file sharing can help the CPI as a promotional tool which will perform better than "blind" advertisement and will curb marketing and distribution costs, which in turn will increase revenues.

For Sandulli [13], nonetheless, price is one of the main motivators that consumers argue, make them download music instead of buying CD's. Andersen and Frenz [2] also see this behavior in Canadian P2P users, as the binary variable for "album too expensive" used in their survey, has a negative correlation with album sales. On the other hand, they also found that heavy P2P use have a positive correlation with album sales, when file sharers adduce that they want to sample before buying or that they cannot find the album elsewhere.

Despite this evidence, a survey on United States college students by Rob and Waldfogel [31], sets the impact of file sharing close to 9%. Another study [42], this time using data from the European Consumer Technographics survey, concludes that file sharing reduces the probability of buying music by 30%, and music sales by 7.8%.

Blackburn [6] and Gopal *et al.* [15] concur that popular artists are the ones that have more to lose from file sharing, as they monopolize sales. But for the performers who receive little or no promotion, those who make up the vast majority of the industry, sampling through P2P networks can increase their popularity. The drop in sales from the popular group, however, is not offset by the increased sales from the obscure group, and this accounts for the global drop in sales observed on surveys.

Nevertheless, Anderson [3] presents the business model developed at Amazon.com, which is based on the same principle of selling not only popular things, but a broad array of many different products which will be bought in smaller quantities. The aggregated sales of these less popular items, as they belong to a heavy tail distribution, can amount for a big portion of the revenues: "give people unlimited choice and make it easy for them to find what they want, and you discover that demand keeps on going into niches that were never even considered before". In music, Anderson explains while quoting Nielsen SoundScan, online sales of new material accounts for one third of the total sales, while old material accounts for the other two thirds.

### B. The discussion of sampling in American jurisprudence

From the close to 30,000 individual file sharers that since 2003 the RIAA has threatened with lawsuits [9], there have been two cases that reached the civil courts, where the defendants's attorney used the sampling argument as part of the strategy.

On the first one, the original centralized P2P file sharing service, Napster, was brought to court by the CPI [34] for allegedly helping its users infringe copyrights. For Napster, its users were only sampling the immense catalog the CPI offered, thus ensuring that their purchases were better suited to their tastes. This behavior, Napster argued, is similar to fair use and thus exempts Napster's users of direct liability, and Napster of contributory and vicarious liability. Nonetheless, the Court concluded that sampling is commercial in nature, leaving Napster's users out of the fair use doctrine. Moreover, the Court concluded, the sampling can not be carried out without the express permission of the producers of phonograms, which issue licenses for that purpose. Therefore, Napster was held liable for the infringements committed by its users.

The second case took place five years later and this time it was not a company but a user of file-sharing networks who faced a civil trial brought by the CPI. Cecilia Gonzalez [35] agreed that 30 files found in her computer, had been downloaded through P2P networks. But her argument was that they had been obtained only as a direct source of information prior to purchasing some of them. The Court applied the doctrine of both Napster and Grokster cases, to declare Gonzalez liable for copyright infringement. As we just saw, the Napster case left clear, at least in U.S. courts, that the sampling can not be equated with the fair use doctrine, defusing this allegation. Moreover, in the Grokster case it was discussed with empirical arguments that downloading music files throughout the Internet is a close substitute for purchased music.

## III. Public goods

In the economical literature [32] a public good is defined as a good that is non-rivaled and non-excludable. Non-rivaled because the consumption of the good by one user will not leave less of the resource for the remaining users. Non-excludable because the consumption of the good doesn't exclude other users from simultaneously consuming it. In this sense, the good is public not because it is produced by a public entity, but because its consumption is publicly available.

Cultural contents share this characteristics, meaning they can be seen as public goods. But the Legislator has created, with copyrights, artificial means to limit access to them. The reproduction of cultural contents has been the main monopoly on which the CPI has based its revenue. If everybody could copy cultural contents without paying compensations to the CPI, the industry and the authors would be put between a rock and a hard place.

But that's exactly what P2P file sharing networks have allowed and, as we have seen in section II-A, there is no consensus on the effect of file sharing. Even in the worst case scenarios, the negative effect has been measured in close to 10%.

Because legal prosecution has failed in the United States[2] due not only to the inability to bring to justice all offenders, or a significant number of them, but also due to the poor image of the industry that within the group of younger consumers this strategy has created, we believe that a consensus solution must be implemented.

### A. The free rider problem

Olson [26] thought that people is moved to help a common interest only if the group is small or they are forced to it. Otherwise, they only act by their individual interests, even if that impairs the common goal. This selfish individual, the free rider, will not be encouraged enough to contribute, in a voluntary way, to the provision of the common good once it has been produced, as he cannot be excluded from reaping the benefits. At the heart of every collective action model, Ostrom [27] says, lies the problem of the free rider.

In the file sharing context, P2P users as seen as free riders by the CPI, as they get to keep music they like without paying for it. Thus, economic compensation can be equated to some sort of provisioning of the public good, as authors, performers and the CPI contribute with cultural contents, but users of P2P networks have no other way to do it.

[2]The United States has been the most active and vocal country in the pursuit of file sharing, but the RIAA has recently stated that it is going to drop the abandon mass lawsuits [24]. Nonetheless, in countries like France the legislative initiative is aimed to get laws with even stringer punishments for copyright infringements through Internet, like the failed HADOPI Act project (which was rejected by the Constitutional Council, and has been modified and reintroduced in the parliament to include criminal as well as administrative penalties) [14]. In New Zealand there has been a reintroduction of their version of the graduated response law, with changes that resemble those made to the HADOPI Act [29].

### B. Provision of the public good

The reproduction of copyrighted cultural contents "in any manner or form" [38, Art. 9.1] is an exclusive right granted to authors, performers and producers of cultural contents, as well as broadcasting organizations [38][41][40][39][10]. This means that to reproduce a work protected by copyright laws, the authorization from rightholders should be obtained. However, this right may have some exceptions in "special cases", provided that the reproduction does not conflict with the "normal exploitation" of the work or that the exemption causes "unreasonable prejudice" to the copyright holders interests [38, Art. 9.2] [41, Art. 13] [39, Art. 10][40]. Within the framework of the European Union and with the aim of harmonizing the rules on copyright in the Member States, a common scheme of legal limitations or exceptions regarding the reproduction of cultural contents is incorporated in the directive 29/2001/CE [10], allowing the development and smooth functioning of the cultural industries. Thus, we find in the European economic context the enforceability of a "fair compensation" [10, Art. 5b] to those, that for private use, reproduce copyrighted works[3].

Two schemes of compensation can be seen in different legislations throughout the world:

*1) The private copying levy on recordable media, reproduction equipment and Internet access:* The private copy levy is a compensation mechanism that is established on analog and digital devices that allow unauthorized copying of cultural contents. The basis of this tax is supported on the idea of uncontrolled future events that the use of such equipment may trigger in the economic exploitation of cultural works[4].

The levy may depend on the ability to copy that the device allows [19]. The distribution of revenue collected may depend on a law or on a contract subject to the supervision of a public authority[5].

The indiscriminate way by which the levy is usually applied, has been the key rebuttal argument by consumer associations [4] [33], since in many cases who acquires the cultural content, doesn't intend to copy or, actually, makes copies, and the consumer who buys blank media doesn't do it with the intent to copy copyrighted works.

The possibility of applying this levy on the Internet connections is a solution to the file sharing issue that has not been entirely abandoned in the public debate. We believe that the European Legislator [10, Recital 35] wanted to avoid that consumers incur a double payment the levy, and hence it is established only as an exception to the exclusive right of reproduction that, on their works, the rightholders have[6].

[3]In the European Union, United Kingdom, Cyprus, Ireland, Luxembourg and Malta do not provide compensation for private copying in their legislations.

[4]The damage claimed by the CPI is based on the idea that every single or CD not sold is due to the acquisition of a copy. However, it is not clear that anyone who is not allowed to get a copy of an cultural content is going to replace it by buying the original.

[5]To know more on the distribution mechanism see [8, pp. 3–5]

[6]The ADSL connection is but a mere connection, not a reproduction equipment, thus it cannot lead to any private copy levy [18]

The establishment of a levy on the connection may also lead Internet users to assume that they have acquired a legitimate right of reproduction, rather than an obligation to compensate, on the works they have access through Internet.

*2) Blanket license:* In France, in the National Assembly debates on the DADVSI Act[7], an amendment to the Intellectual Property Code which promoted the creation of an Optional Blanket License (OBL), to legalize noncommercial file-sharing of cultural contents protected by copyright and compensate their rightholders.

This OBL[8] was essentially an authorization granted by the authors to Internet users to access their work in an unlimited way, in exchange for a flat fee[9] paid as compensation. This compensation would have been collected by the ISPs and collectively managed.

The proposal didn't find support on the CPI and was eventually rejected by the French parliament as it will benefit neither the creators nor the consumers because: 1) the ISPs would have been forced to implement surveillance measures on the network[10]; 2) the license would have increased the subscription price of Internet access[11]; 3) it did not allow the respect of the chronology of the media[12]; 4) there wasn't a viable proposition for the distribution of revenue collected[13].

However, a group of parliament members are reluctant to abandon the idea that, in France, the internauts can opt for a blanket license: nine identical proposals for a blanket license have been discussed in the parliamentary debate of July 2009[14] about the *"protection pénale de la propriété littéraire et artistique sur Internet"*[15], and again, they have been rejected by the majority using, basically, the same arguments used to reject the OBL proposed in the DADVSI Act [16].

A similar proposal has been raised by the Electronic Frontier Foundation (EFF) as a legitimating mechanism of socially accepted Internet behaviors [37]. The Songwriters Association of Canada (SAC) promotes a "proposal for the monetization of the file sharing of music from the songwriter and recording artists of Canada",i.e., a blanket license for file sharing. For this license, the rightholders ask for the reform of the Copyright Act, in which the recognition of a new reproduction right[17], to obtain compensation for the reproduction of their works through file sharing, will be consecrated. Although the license for the file-sharing is proposed on an optional basis, the fee will only be exempted if the Internet user agrees to not perform file-sharing and, if he catched doing it, he agrees to pay a predetermined compensation in damages.

These proposals have several common elements:

1) Existence of a collecting society for the distribution of the revenue.
2) The ISPs will act as fee collecting entities.
3) Monthly payment of the license fee.
4) Voluntary participation of creators, rightholders and Internet users.
5) Legalize the exchange of cultural contents on the Internet.

In the Isle of Man, there is a discussion to create a compulsory blanket license to Internet connections that will cover it's population, allowing users to download as much music as they want[18].

Noank[19] is a commercial application that, based on his proposal for a global license as an alternative compensation mechanism [11], Harvard professor William Fisher has launched in Hong Kong. In it, the control, collection and pricing strategies are managed centrally, using a client that can search for and download the contents. Rights holders, by placing their works in Noank, pick one of two types of licenses. In the first scheme, reproduction and distribution rights, as well as those that allow the creation of derivative works, are licensed. In the second scheme,this last right is not licensed. The difference between the two schemes leads to a reduction in licensing fees to the assigned work for the owners who choose the latter.

Notwithstanding, there are voices like that of Birmingham

[7]Loi sur le Droit d'Auteur et les Droits Voisins dans la Société de l'Information (Loi Nº 2006-961 du 1er Août), through which the EU directive 2001/29/CE [10] was transposed into French law.

[8]Supported by more than 14,000 authors, performers, producers, designers, photographers and consumers of the L'Alliance "Public-Artistes" (http://www.lalliance.org/pages/1_1.html)

[9]Between 5 to 7 Euros per month.

[10]The OBL posed a *Tragedy of the commons* [16], as the lack of control mechanisms gives no incentive to pay the license.

[11]If no surveillance measures are implemented, the license should be compulsory, so the increase in the price of the subscription service is automatic.

[12]The chronology of the media is a protectionist measure designed to ensure the economic development of the domestic film industry versus the foreign one. The aim of the measure is to establish a schedule -after the premiere in cinemas- for dissemination of film in other media. Mandatory minimum periods have to be completed before moving films from cinemas to home video (DVD, Blu-ray disc), and from it to television broadcasts. In France, an agreement has been recently signed to adjust the chronology of the media (http://www.cnc.fr/Site/Template/A2.aspx?SELECTID=28&ID=29&TextId=267&Dsecteur=0&Dtexte=0&Dpublication=0&ret=1&t=3). By contrast, in European countries like UK, Spain, Denmark, Italy, Serbia and Lithuania, there are no laws that guarantee the chronology [20].

[13]The fact that the blanket license involved a distribution of income based on a representative sample of works downloaded through the P2P networks with no correlation with the market reality, was questioned.

[14]See http://www.assemblee-nationale.fr/13/dossiers/protection_penale_proplitt.asp

[15]The discussion about this new project in the French parliament has been generated by the Constitutional Council's decision [7] that rejected the HADOPI Act, on the basis that the suspension of the Internet service goes against the principles and values enshrined in the Declaration of the Rights of Man and of the Citizen.

[16]In http://www.assemblee-nationale.fr/13/cri/2008-2009-extra/20091027.asp

[17]More than a new right of reproduction, what they ask for is the specification of a particular way of reproduction of works subject to copyright rules.

[18]http://arstechnica.com/media/news/2009/01/isle-of-man-gets-unlimited-music-downloads-with-blanket-fee.ars

[19]See http://www.noankmedia.com/howitworks.html.

City University Andrew Dubber, who opposes this kind of licensing scheme arguing that it will only solve the cash flow of the major recording labels and that ISPs shouldn't be a police force and revenue collecting agency of the CPI[20].

A different kind of blanket license business model has been launched in China by Google [5], which is sharing advertisement revenues with its associates (the four biggest recording labels plus many smaller ones) to offer unlimited free downloads from a catalog above one million songs. The objective of this strategy is, from Google's side, to gain market share against Baidu, the biggest search engine in China. From the CPI side, it is clear that the move will help it increase the pyrrhic revenues obtained from the Chinese music market (estimated in close to US$ 90 million). There are reports [12] that Google is using China as a testing bench to perfect the model and expand it to other countries.

## IV. Sampling effect

A consumer $Z$ considers acquiring an item $r$. The consumer values the item according to some private criteria that may differ from one consumer to another. Suppose that a consumer $Z$ has a set $J$ of possible types. The classification between types represents preferences of the consumer. We assume that the type $J(Z,r)$ of item $r$ according to consumer $Z$ is not known to $Z$ and that it has a prior probability distribution $\theta(Z,r;\cdot)$ over its value:

$$P(J(Z,r)=j)=\theta(Z,r;j). \tag{1}$$

The utility for $Z$ of acquiring $r$, if it is of type $j$, is given by:

$$\begin{cases} v(j,Z)-q(r) & \text{if he purchases } r \\ w(j,Z)-p(r,Z) & \text{if he downloads } r, \end{cases} \tag{2}$$

where $q(r)$ is the cost of item $r$ and $p(r,Z)$ is the perceived cost for the user $Z$ to download the file, including the Internet service cost, and the cost of the license to download, if it is allowed, or the perception of the risk, if it downloading is not allowed. We shall assume that $v(j,Z)\geq w(j,Z)$,e.g., the value of a CD is higher than that of an MP3 version of the CD. (In addition, one could include in $v$ some monetary cost per sampling or some risk taken in illegal sampling.) When clear from the context, we shall omit $Z$ from the notation.

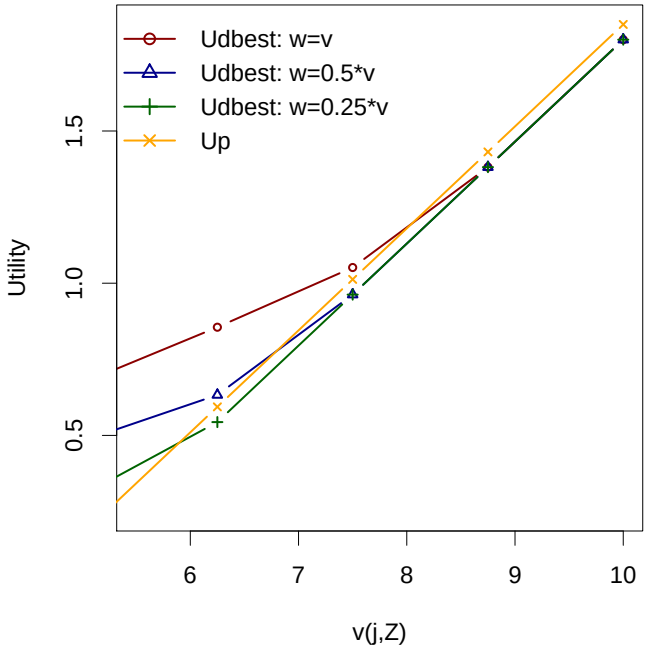
Consumer $Z$ has to decide between outright purchasing $r$ or downloading it first and then decide to buy or not to buy it. If $Z$ cannot download $r$ then we assume that he purchases $r$ only if $U(Z,r;p)\geq 0$ (see (3)). In other words we also consider the option of not downloading and not purchasing.

The expected utility for $Z$ of purchasing $r$ without sampling is:

$$U(Z,r;p)=\sum_j \theta(Z,r;j)\,(v(j)-q(r)) \tag{3}$$

[20]http://www.musicthinktank.com/blog/the-blanket-license-debate.html

Fig. 1. Numerical example for the utility of the consumer using $\theta(Z,r;j)$ constant for all $r$, but changing $v(j,Z)$.




To calculate the expected utility for the sampling case, we first order $j$ such that $v(j,Z)-q(r)-w(j,Z)$ is increasing in $j$.

Let $\xi(Z)=\min\{j\in N : v(j,Z)-q(r)>w(j,Z)\}$, the customer would purchase an item $r$ if $j\geq\xi(Z)$. If $\xi(Z)=\emptyset$, the we will make $\xi(Z)=\infty$.

The expected utility for Z in first sampling and then taking the best decision is:

$$\begin{aligned} U(Z,r;d-best) \quad := \quad & \sum_{j\geq\xi(Z)} \theta(Z,r;j)\,(v(j,Z)-q(r)) \\ & + \sum_{j<\xi(Z)} \theta(Z,r;j)w(j,Z) \\ & -p(r,Z) \end{aligned}$$

Let:

$$u(Z,r):=\max(U(Z,r;d-best),U(Z,r;p),0) \tag{4}$$

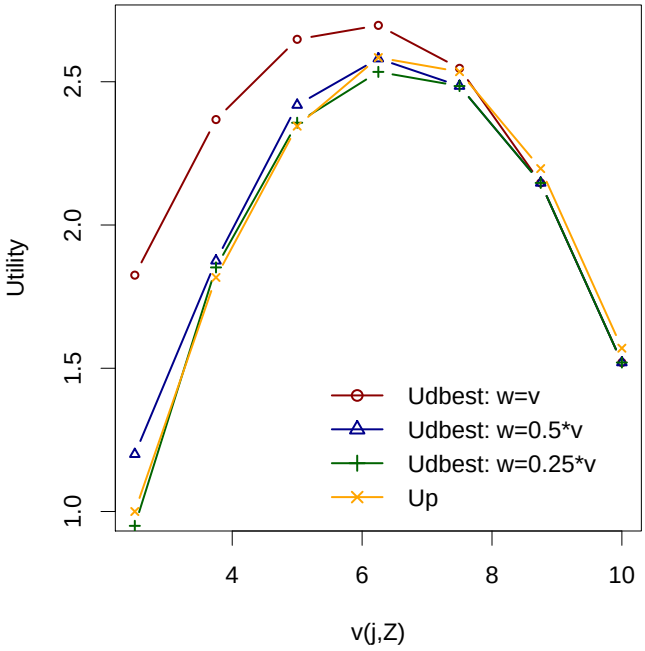
We thus have the following behavior of the consumer.

*Theorem 4.1:* The consumer chooses to not buy if $u=0$, otherwise, he purchases without sampling if $U(Z,r;d-best)<U(Z,r;p)$, and it samples and then decides optimally how to proceed if $U(Z,r;d-best)>U(Z,r;p)$.

### A. Numerical example

On figure IV-A we can see a numerical example using the same value of $\theta(Z,r;j)$ for different levels $v(j,Z)$. In it, the value of downloading, w(j,Z), is taken as a proportion of the value of purchasing. As we can see, the most closely resembles the downloaded item the original one, the more difficult it is

Fig. 2. Numerical example for the utility of the consumer using $\theta(Z, r; j)$ dependant on $v(j, Z)$.




to justify outright buying it, being a better option to sample first and then take the decision.

This same behavior is observed on figure IV-A, in which we used $\theta(Z, r; j)$ dependant on $v(j, Z)$, such that bigger values of $v(j, Z)$ will be associated to smaller values $\theta(Z, r; j)$, modelling that users give more value to items that are more difficult to please them.

## V. CPI's Revenues and the Benefit of Sampling

We assume that the revenue of the CPI from selling an item $r$ is $q(r)$. According to $\theta$, the expected gain $G$ of the CPI if sampling is available (for free) is: $G(Z, r) = \sum_{j \geq \xi(Z)} \theta(Z, r; j) q(r)$ and is otherwise $q(r)$ provided that $U(Z, r; p) \geq 0$.

Sampling has an added value to the CPI if $V(Z, r) > 0$, where:

$$V(Z, r) = G(Z, r) - q(r) \mathbb{1}_{U(Z,r;p)>0}. \quad (5)$$

Let $d(r)$ be the demand for item $r$, $\mathcal{K}$ be the set of consumer types and $\pi(k)$ be the probability that a customer is of type $k$, then the global added value over all items $r$ created by type $k$ customers is

$$V(Z, k) = \sum_r d(r) V(Z, r) \pi(k) \quad (6)$$

We make the following observations.

- If $\sum_{k \in \mathcal{K}} U(Z) > 0$ then the CPI will profit from the existence of free legal P2P networks that allow sampling.
- It might further benefit by offering a "legal P2P" on its own site as this service may allow to improve and facilitate marketing. Further income can be created by subscription fees that may be quite acceptable to a large number of consumers.

Define $\mathcal{K}_s \subset \mathcal{K}$ to be the subset of consumers for which $V(Z, r) > 0$,

- Offering a "legal P2P" access to this set of customers creates an added value to the CPI of $\sum V(Z, k)\pi(k)$. This could be substantially larger than the added value obtained if free access to P2P is available to all consumers.
- Differentiating between customers types requires the "legal P2P" to be controlled, and maintained by the CPIs. This comes at some extra costs $C$. If $C$ is large then it may be more profitable to authorize the use of todays file sharing networks already deployed on the Internet. They can then be viewed as "public goods".

The class $\mathcal{K}_{fr} = \mathcal{K} - \mathcal{K}_s$ of consumers generate losses to the CPI if free sampling is available for all. In this context, they can be seen as free riders.

## VI. Impact of Cooperation on Revenues

In this section, we study cooperation between content providers (CPs) and ISPs and investigate its potential benefits for both sides. In particular, we focus on the scenario where there are 1 ISP and 2 CPs. In doing so, we first present a mathematical model to describe the impact of the preventive measures taken by the CPs, against P2P networks, on individual revenues. Next, we consider the scenario where CPs and the ISP form a coalition, i.e., agree to cooperate and divide their aggregate payoffs among each other. Specifically, we consider the well known *Shapley value* as the sharing rule. Finally, we show that such cooperation mechanism is indeed beneficial to each individual, provided that a certain set of conditions are met. Furthermore, we show that under this cooperation mechanism, the CPs' actions decided in a complete selfish manner, form a globally optimal Nash equilibrium.

Consider a scenario with 1 ISP and 2 content providers, $\text{CP}_1$ and $\text{CP}_2$. Each content provider decides how much money it is going to spend on preventive measures against illegal downloading in P2P networks. Let $L_i$ denote the amount $\text{CP}_i$ spends on this. $\{L_1, L_2\}$ will then constitute the set of decision variables in our game model. The levels of $L_1, L_2$ will consequently determine the individual payoffs of the ISP and content providers.

Denote by $R_i$ the corresponding payoff of $\text{CP}_i$, which is determined by the level of sales of contents provided by $\text{CP}_i$. Note that this can include sales of hard copies, as well as digital ones. Here, we consider a linear model for $R_i$s as follows.

$$R_i = c_i - e_1^i L_1 - e_2^i L_2 \quad (7)$$

where $c_i$s and $e_j^i$s are all exogenous constant parameters, which could depend on a variety of factors, such as the popularity of the content, the price, etc. Notice that we allow

the possibility of $R_i$ depending on both $L_1, L_2$, justified by the sampling effect, as was described in sections III and IV.

The payoff of the ISP, on the other hand, is mainly determined by the demand for bandwidth in the market. A portion of this demand is promoted by the copy righted material (for instance, the contents provided by $CP_1$ and $CP_2$) shared in P2P networks. As a consequence of this, a portion of ISP's payoff can be related to the content providers. In light of this fact, we denote by $D_i$ the portion of ISP's payoff that is, in some way, related to $CP_i$. This payoff, depending on how effective CPs' measures against illegal downloading are, might then be affected by $L_1, L_2$. Similar to (7), we assume $D_i$s are linear functions of $L_1, L_2$ as the following.

$$D_i = a_i - b_1^i L_1 - b_2^i L_2, \tag{8}$$

where $a_i$s and $b_j^i$s are again exogenous constants. Note that we did not make any assumptions on the sign of these constant parameters. From here on, we can assume without loss of generality that $D_1$ and $D_2$ constitute the total payoff of the ISP, as other incomes are not affected by whether there is cooperation between the ISP and CPs.

We can now proceed to introduce the game model. Let $\mathcal{N} = \{ISP, CP_1, CP_2\}$ denote the set of players in the game. A nonempty subset of players $\mathcal{S} \subseteq \mathcal{N}$ who agree to cooperate and share their payoffs is called a *coalition* of players. We assume that in case the ISP is not cooperating with $CP_i$, $CP_i$ sets $L_i = \bar{L}_i$, a constant level which is decided a priori. However, when $CP_i$ and ISP are in a coalition, $L_i$ can be set to other values, which potentially improves their aggregate payoff. We denote by $v(.)$ the *worth function*, which measures the aggregate payoff attained by each coalition. In defining the worth of a coalition $\mathcal{S}$, $v(\mathcal{S})$, we assume that no players outside of $\mathcal{S}$ form any coalition[21]. As a consequence, in order to derive the worth of some coalition $\mathcal{S}$, we set $L_i = \bar{L}_i$ if either $CP_i$ or the ISP are not in $\mathcal{S}$. With this, the worth of each coalition of players is well defined. For example, the worth values of the 2 coalitions, $\{ISP\}$ and $\{ISP, CP_1\}$ equal

$$\begin{aligned} v(\{ISP\}) &= (a_1 + a_2) - \bar{L}_1(b_1^1 + b_1^2) \\ &\quad -\bar{L}_2(b_2^1 + b_2^2) \\ v(\{ISP, CP_1\}) &= (a_1 + a_2 + c_1) - L_1(b_1^1 + b_1^2 + e_1^1 \\ &\quad +1) - \bar{L}_2(b_2^1 + b_2^2 + e_2^1) \end{aligned}$$

Using the worth function $v(.)$, we can now measure the contribution of a player two a coalition of players as the following.

*Definition 6.1:* The marginal contribution of a player $i$ to a coalition $\mathcal{S} \subseteq \mathcal{N} \backslash i$ is defined as $\Delta_i(\mathcal{S}) = v(\mathcal{S} \cup i) - v(\mathcal{S})$.

Now the stage is set to present the definition of *Shapley value*, the well known solution concept in cooperative games proposed by Lloyd Shapley.

[21]We made this assumption so as to achieve a coalitional game in characteristic form.

*Definition 6.2:* The Shapley value $\varphi$ is defined by

$$\varphi_i(v) = \sum_{\mathcal{S} \subseteq \mathcal{N} \backslash i} \frac{|\mathcal{S}|!(|\mathcal{N}| - |\mathcal{S}| - 1)!}{|\mathcal{N}|!} \Delta_i(\mathcal{S}). \tag{9}$$

Now, suppose all players agree to cooperate and form the coalition $\mathcal{N}$, and divide their aggregate payoff according to the Shapley value. The content providers, anticipating this cooperation, ex ante set the values of $L_i$s so as to maximize their individual shares. Note that this part of the game is played noncooperatively.

We can now proceed to state the propositions. We will use the following set of assumptions.

$I$)

1) For any coalition $\mathcal{S}$ of players containing the ISP, the aggregate payoff of the coalition is decreasing in $L_i$, for all $i : CP_i \in \mathcal{S}$. In other words, when a content provider and the ISP agree to cooperate, it is overall optimal to spend less money on preventive measures against P2P networks. It is easy to verify that this condition reduces to the follwing set of inequalities.

$$\begin{cases} b_i^1 + b_i^2 + e_i^i + 1 > 0 \\ b_i^1 + b_i^2 + e_i^2 + e_i^1 + 1 > 0 \end{cases} \tag{10}$$

2) A content provider's revenue is negatively affected by the money the other content provider spends on preventing measures. More precisely, $e_j^i > 0,\ i \neq j$. This condition could be interpreted as the following: The customers who sample the contents of one content provider are in general promoted to try the contents of the others.

*Proposition 6.1:* If condition 1 is satisfied, the we have.

1) The noncooperative game in which content providers select $L_i$s has a unique Nash equilibrium, at which, $L_i = 0,\ i = 1, 2$.
2) This equilibrium is globally optimal.

*Proof:* Using definition 6.2, the Shapley value of $CP_1$ can be written as

$$\begin{aligned} &\frac{1}{3}\Delta_1(\emptyset) + \frac{1}{6}\Delta_1(\{CP_2\}) + \frac{1}{6}\Delta_1(\{ISP\}) \\ &\qquad + \frac{1}{3}\Delta_1(\{ISP, CP_2\}). \end{aligned} \tag{11}$$

It is straightforward to verify that the first 2 terms in (11) are constants independent of $L_i$s. We have for the other 2

$$\begin{aligned}\Delta_1(\{ISP\}) =& v(\{ISP, CP_1\}) - v(\{ISP\}) \\ =& (a_1 + a_2 + c_1) - L_1(b_1^1 + b_1^2 + e_1^1 + 1) \\ & - \bar{L}_2(b_2^1 + b_2^2 + e_2^1) - (a_1 + a_2) \\ & + \bar{L}_1(b_1^1 + b_1^2) + \bar{L}_2(b_2^1 + b_2^2) \\ =& c_1 + \bar{L}_1(b_1^1 + b_1^2) \\ & - \bar{L}_2 e_2^1 - L_1(b_1^1 + b_1^2 + e_1^1 + 1),\end{aligned} \tag{12}$$

and similarly,

$$\begin{aligned}\Delta_1(\{ISP, CP_2\})) =& c_1 + \bar{L}_1(b_1^1 + b_1^2 + e_1^2) - L_1(b_1^1 + \\ & b_1^2 + e_1^2 + e_1^1 + 1) - L_2 e_2^1.\end{aligned} \tag{13}$$

Using 1, it is clear that both (12) and (13), and hence $\varphi_{CP_1}(v)$, are linearly decreasing in $L_1$. A similar condition holds for $\varphi_{CP_2}(v)$. Then it is clear that the game of selecting $L_i$s has a unique equilibrium at which $L_1 = L_2 = 0$.

Now consider the aggregate payoff of coalition of all players, $v(\mathcal{N})$, which equals

$$\begin{aligned}v(\mathcal{N}) =& (a_1 + a_2 + c_1 + c_2) - L_1(b_1^1 + b_1^2 + e_1^2 + e_1^1 \\ & + 1) - L_2(b_2^1 + b_2^2 + e_2^1 + e_2^2 + 1).\end{aligned}$$

Once again, condition 1 ensures that $v(\mathcal{N})$ is decreasing in $L_1$ and $L_2$. Thus the equilibrium maximizes the aggregate payoff and the second claim follows. ∎

Proposition 6.1 guarantees that the decision of each content provider, in the scenario where there is cooperation with the ISP, ensures a globally optimal outcome. This, however, does not guarantee the very formation of cooperation among players. The reason is that these players are all selfish entities who seek their own benefit through cooperation. Therefore, a player will only cooperate if he perceive it is profitable to do so. For instance, a content provider is very unlikely to consent to our cooperation scheme, if his Shapley value falls below his individual payoff in no cooperation scenario. Cooperative game theory provides a more general condition for the success of a cooperation strategy, known as the *stability* of the payoff profile.

*Definition 6.3:* The Shapley value is said to form a stable payoff profile if for all coalitions $\mathcal{S} \subseteq \mathcal{N}$, $e(\mathcal{S}, v) \triangleq v(\mathcal{S}) - \sum_{i \in \mathcal{N}} \varphi_i(v) \leq 0$. In words, this condition requires that no set of players can profit by splitting from coalition $\mathcal{N}$, and form their own one. $e(\mathcal{S}, v)$ is called the **excess** of $\mathcal{S}$.

The following proposition provides a condition for the Shapley value to form a stable payoff profile.

*Proposition 6.2:* If in addition to 1, condition 2 also holds, then at the equilibrium, the payoffs of individuals given by the Shapley value form a stable payoff profile.

As an immediate consequence of proposition 6.2, this scheme provides players with incentives to participate in cooperation.

*Proof:* At the equilibrium, $L_1 = L_2 = 0$ and the Shapley value will be

$$\begin{aligned}\phi_{CP_1} &= c_1 - \frac{1}{2}\bar{L}_1(-b_1^1 - b_1^2 + e_1^1 - \frac{2}{3}e_1^2 + 1) \\ &\quad -\frac{1}{2}\bar{L}_2 e_2^1, \\ \phi_{CP_2} &= c_2 - \frac{1}{2}\bar{L}_1 e_1^2 - \frac{1}{2}\bar{L}_2(-b_2^1 - b_2^2 + e_2^2 - \frac{2}{3}e_2^1 \\ &\quad +1), \\ \phi_{ISP} &= (a_1 + a_2) - \frac{1}{2}\bar{L}_1(b_1^1 + b_1^2 - e_1^1 - \frac{1}{3}e_1^2 - 1) \\ &\quad -\frac{1}{2}\bar{L}_2(b_2^1 + b_2^2 - e_2^2 - \frac{1}{3}e_2^1 - 1).\end{aligned}$$

We need to show that $e(\mathcal{S}, v) \leq 0$ for all coalitions $\mathcal{S}$. We demonstrate this for only two the coalitions, $\{CP_1\}, \{ISP, CP_1\}$. The rest follows similarly.

$$\begin{aligned}e(\{CP_1\}, v) &= \varphi_{CP_1}(v) - v(\{CP_1\}) \\ &= -\frac{1}{2}\bar{L}_1(b_1^1 + b_1^2 + e_1^1 + \frac{2}{3}e_1^2 + 1) \\ &\quad -\frac{1}{2}\bar{L}_2 e_2^1\end{aligned}$$

The two terms are negative by conditions 1 and 2, respectively. Thus $e(\{CP_1\}, v) \leq 0$. Similarly,

$$\begin{aligned}e(\{ISP, CP_1\}, v) &= -\frac{1}{2}\bar{L}_1 e_1^2 - \frac{1}{2}\bar{L}_2(b_2^1 + b_2^2 \\ &\quad +\frac{4}{3}e_2^1 + e_2^2 + 1).\end{aligned}$$

While the first term is negative by 1, the second term is negative by the combination of both 1 and 2. Hence, $e(\{ISP, CP_1\}, v) \leq 0$. The procedure is similar for other coalitions. ∎

## VII. Conclusions

We have reviewed the different problems that governments, copyright holders and ISPs face when the internautes make file-sharing of copyrighted contents. The copyright holders have tried, unsuccesfully, to curtail this behavior with judiciary iniciatives. This strategy has proved expensive, not only in monetary terms, but also in image lost with younger consumers who are accustomed to freely share files. Now, the copyright holders are trying to use the bottleneck that the ISPs present to the users, so control and filtering measures can be taken. This aggresive behavior seems to contradict what our models present, where cooperation can be seen as a better revenue generating strategy to all parties involved.

By letting users sample, they can have a clear choice on what they would like to buy later. There are cryings from the copyright holders' side, explaining that this strategy really conceals a tragedy of the commons, as the users will not be

compeled to buy if they can obtain the product for free. As we can show in this paper, the value a user gives to an item is what really motivates his buying habits. By making the option presented by the industry a much better alternative than the one that is downloaded, the user will choose buying over downloading.

There is also the option of a blanket license, that if adequately negotiated, can generate revenue for the copyright holders and remove the everlasting threat of legal action to the users.

We expect this kind of works help all the parties involved be aware of the problems each one is facing and how cooperative solutions are the best deal for all of them.

## REFERENCES


[1] Eitan Altman, Sulan Wong, and Julio Rojas-Mora. P2P business and legal models for increasing accessibility to popular culture. In *Proceedings of the International Conference on Digital Business (DIGIBIZ 2009)*, 2009.

[2] Birgitte Andersen and Marion Frenz. The Impact of Music Downloads and P2P File-Sharing on the Purchase of Music: A Study for Industry Canada. Industry Canada, 2007. http://www.ic.gc.ca/eic/site/ippd-dppi.nsf/eng/h_ip01456.html.

[3] Chris Anderson. *The long tail: why the future of business is selling less of more*. Hyperion e-books, 2008.

[4] Asociación de Internautas. La Asociación de Internautas recurre el canon digital ante la Audiencia Nacional, 2008. http://www.internautas.org/html/5076.html.

[5] David Barboza. Google Offers Links to Free Music Downloads in China . The Wall Street Journal, March 30, 2009. http://www.nytimes.com/2009/03/31/technology/companies/31music.html?fta=y.

[6] David Blackburn. On-line piracy and recorded music sales. Working paper, December 2004. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.117.2922&rep=rep1&type=pdf.

[7] Conseil Constitutuionnel. Décision Nro. 2009-580 DC du 10 juin (Loi favorisant la diffusion et la protection de la création sur internet), 2009.

[8] Directorate General for the Internal Market and Services. Stakeholder consultation on copyright levies in a converging world. European Commission.

[9] Electronic Frontier Foundation. RIAA v The People: Five years later, 2008.

[10] European Parliament and Council of the European Union. Directive 2001/29/EC on the harmonisation of certain aspects of copyright and related rights in the information society. Official Journal of the European Communities L167/10, Volume 44, 22 June, 2001. http://eur-lex.europa.eu/JOIndex.do?year=2001&serie=L&textfield2=167&Submit=Search&_submit=Search&ihmlang=en.

[11] William Fisher. *Promises to Keep: Techonology, Law, and the Future of Entertainment*. Stanford University Press, 2004.

[12] Owen Fletcher. Google May Take Music Downloads Beyond China. PC World, June 1, 2009. http://www.pcworld.com/businesscenter/article/165832/google_may_take_music_downloads_beyond_china.html.

[13] Sandulli Francesco D. CD music purchase behaviour of P2P users. *Tecnovation*, 27:325–334, 2007.

[14] French Republic. Propriété intellectuelle : protection pénale de la propriété littéraire et artistique sur internet. National Assembly, July 9, 2009. http://www.assemblee-nationale.fr/13/dossiers/protection_penale_proplitt.asp.

[15] Ram D. Gopal, Sudip Bhattacharjee, and G. Lawrence Sanders. Do Artists Benefit from Online Music Sharing? *Journal of Business*, 79(3):1503–1533, 2006.

[16] Garrett Hardin. The tragedy of commons. *Science*, 162(3859):1243–1248, December 1968.

[17] IFPI. Digital Music Report 2009. Technical report, IFPI, 2009.

[18] Kingdom of Spain. Ley 23/2006, de 7 de julio, por la que se modifica el texto refundido de la Ley de Propiedad Intelectual, aprobado por el Real Decreto Legislativo 1/1996, de 12 de abril. Boletín Oficial del Estado, No 162, 8 de Julio, 2006.

[19] Kingdom of Spain. Orden pre/1743/2008, de 18 de junio, por la que se establece la relación de equipos, aparatos y soportes materiales sujetos al pago de la compensación equitativa por copia privada, las cantidades aplicables a cada uno de ellos y la distribución entre las diferentes modalidades de reproducción. Boletín Oficial del Estado Nro. 148, 2008.

[20] Martin Kuhr. La chronoloie des médias en pleine évolution: Enjeux et défis. Iris Plus: Observations juridiques de L'observatoire Europeen de l'audiovisuel, 2008.

[21] Stan J. Liebowitz. Will MP3 downloads annihilate the record industry? The evidence so far. *Intellectual property and Entrepreneurship*, 15:229–260, 2004.

[22] Stan J. Liebowitz. Economists Examine File-Sharing and Music Sales. In Gerhard Illing and Martin Peitz, editors, *Industrial Organization and Digital Economy*. MIT Press, 2006.

[23] Stan J. Liebowitz. Testing File-Sharing's Impact by Examining Record Sales in Cities. *SSRN eLibrary*, 2006.

[24] Sarah Mcbride and Ethan Smith. Music industry to abandon mass suits. The Wall Street Journal, December 19, 2008. http://online.wsj.com/article/SB122966038836021137.html.

[25] Phillip Nelson. Information and Consumer Behavior. *The Journal of Political Economy*, 78(2):311–329, 1970.

[26] Mancur Olson, Jr. *The logic of collective action: public goods and the theory of groups*. Harvard University Press, Cambridge, 1965.

[27] Elinor Ostrom. *Governing the commons: the evolution of institutions for collective action*. Cambridge University Press, New York, 1990.

[28] Martin Peitz and Patrick Waelbroeck. File-Sharing, Sampling and Music Distribution. *SSRN eLibrary*, Diciembre 2004.

[29] Realm of New Zealand. Section 92a review policy proposal document. Ministry of Economic Developement, July 14, 2009. http://www.med.govt.nz/templates/MultipageDocumentTOC____41169.aspx.

[30] RIAA. 2008 Year-End Shipment Statistics, 2008.

[31] Rafael Rob and Joel Waldfogel. Piracy on the high C's: Music downloding, sales displacement, and social welfare in a sample of college students. *Journal of Law and Economics*, XLIX, April 2006.

[32] Paul A. Samuelson. The pure theory of public expenditure. *The Review of Economics and Statistics*, 36(4):387–389, November 1954.

[33] Todos contra el canon. Derecho de petición presentado al Presidente del Congreso de los Diputados, Mayo 2009. http://www.todoscontraelcanon.es/index2.php?body=article&id_article=238.

[34] United States Court of Appeals for the Ninth Circuit. A&M Records, Inc., et al. v. Napster, Inc. Nr. 00-16401, 2000.

[35] United States Court of Appeals for the Seventh Circuit. BMG Music, et al., vs Cecilia Gonzalez. No 05-1314, 2005.

[36] Virgin Media. Virgin Media and Universal Music to Launch World's First Unlimited Music Download Subscription Service. Virgin Media, June 15, 2009. http://pressoffice.virginmedia.com/phoenix.zhtml?c=205406&p=irol-newsArticle&ID=1298879&highlight=.

[37] Fred von Lohmann. A better way forward: Voluntary collective licensing of music file sharing. Technical report, Electronic Frontier Foundation, 2008.

[38] World Intellectual Property Organization (WIPO). Berne Convention for the Protection of Literary and Artistic Works, 1886, Revised. http://www.wipo.int/treaties/en/ip/berne/trtdocs_wo001.html.

[39] World Intellectual Property Organization (WIPO). Copyright Treaty, 1996.

[40] World Intellectual Property Organization (WIPO). Performances and Phonograms Treaty (WPPT), 1996. http://www.wipo.int/treaties/en/ip/wppt/trtdocs_wo034.html.

[41] World Trade Organization. Trade-Related Aspects of Intellectual Property Rights (TRIPS), 1995. http://www.wto.org/english/docs_e/legal_e/legal_e.htm.

[42] Alejandro Zentner. Measuring the Effect of File Sharing on Music Purchases. *The Journal of Law and Economics*, 49, Abril 2006.