Selling digital music
business models for public goods

Hougaard, Jens Leth; Tvede, Mich

Publication date:
2009

Document version
Publisher's PDF, also known as Version of record

Citation for published version (APA):
Hougaard, J. L., & Tvede, M. (2009). *Selling digital music: business models for public goods*. Department of Economics, University of Copenhagen.

Discussion Papers
Department of Economics
University of Copenhagen

No. 09-19

Selling Digital Music: Business Models for Public Goods

Jens Leth Hougaard
Mich Tvede

Øster Farimagsgade 5, Building 26, DK-1353 Copenhagen K., Denmark
Tel.: +45 35 32 30 01 – Fax: +45 35 32 30 00
http://www.econ.ku.dk

ISSN: 1601-2461 (online)

Selling digital music: business models for public goods*

Jens Leth Hougaard[†] **Mich Tvede**[‡]

Abstract

This paper considers the market for digital music. We claim that the combination of the MP3 format and peer-to-peer networks has made music non-excludable and this feature is essential for the understanding of the economics of the music market. We study optimal business models for selling non-excludable goods and show that despite promising theoretical results, adding just a slight uncertainty about the number of customers has significant negative implications for profitability. Indeed, as the average number of customers tends to infinity the average payment per customer converges to zero. Therefore, the music industry should concentrate on alternative ways of creating profit such as selling access to listeners, concerts, merchandise, ringtones etc.

Keywords: Digital music, Experience good, Public good, Music industry, Piracy

JEL-classification: D2, D4.

*We would like to thank an anonymous referee for many helpful and constructive comments.

[†]Department of Food and Resource Economics, University of Copenhagen, Rolighedsvej 25, DK-1958 Frederiksberg C, Denmark. E-mail: jlh@foi.dk

[‡]Department of Economics, University of Copenhagen, Studiestraede 6, DK-1455 Copenhagen K, Denmark. E-mail: mich.tvede@econ.ku.dk

1 Introduction

One of the major new features of the digital economy is the introduction of information goods in digitalized form like digital music and movies, e-books etc. It has long been known that information goods exhibit special features compared to standard commodities. For instance they are experienced goods in the sense that the value of the good only can be assessed while or after being used. Clearly this feature has an impact on the suitable business model as witnessed by the availability of free samples for music, trial versions of computer games, trailers for movies etc. On top of this, another significant feature has appeared recently: due to digitalization and distribution via peer-to-peer (P2P) networks, information goods are nowadays (to a varying degree) characterized by non-excludability making them public goods in effect.

The digitalization of music has had a profound impact on the music industry as witnessed by the many conflicts between the music industry, artists and consumers as well as the changes in business models: some artists like 'Arctic Monkeys' have launched themselves using Myspace letting people have free access to downloads; some artists like 'Madonna' sign with concert-promoters rather than record companies; the structure of the market is changing from CD sales in physical stores to Web-based music stores like iTunes Store (selling more than 3 billion downloads since it was launched in 2003); consumers have witnessed a significant decline in music prices (CD's were sold for approx. 20 dollars some years ago and now an entire album can be bought on iTunes for 10 dollars and on MPSparks for 2 dollars) etc. These effects and many more have been documented in various papers, e.g. Pfahl [16], DeFigueiredo [7], Peitz & Waelbroeck [13], Oberholzer-Gee & Strumpf [12], Bhattacharjee et al. [2] and Hong & Kim [9].

We focus on business models for private suppliers selling public goods to individual customers, who are free to choose whether to buy or not, discarding centralized public financing using for instance Clark-taxes. According to economic folklore the revenue from selling public goods to customers is limited because of free-riding. However, economic theory suggests that using more complicated selling mechanisms non-excludability does not limit revenues, in fact it is possible to first-order price discriminate - see Bagnoli & Lipman [1] and Cremer & McLean [6]. A basic assumption in these models is that the number of customers is known by the suppliers, but for the music market where the number of copies sold can be extremely large this assumption is questionable. Therefore, we make a minor modification introducing uncertainty about the number of customers and show that then the revenue obtained by any mechanism is very limited.

To be more specific we use a framework with a monopolist selling a non-excludable good to customers where the monopolist may use other business models than selling individual units of the good. We consider different scenarios with respect to information of the customers and the monopolist. In general every customer is assumed to know her own willingness to pay. However, taking into account that music is an experience good, the willingness to pay should be reinterpreted as expected willingness to pay, where the expectations may be influenced by free samples, reviews, earlier work by the artist, recommendations from friends etc. In our analysis the knowledge of the monopolist (and the customers) about the willingness to pay of (other) customers ranges from complete information, where the willingness to pay of every customer is known by everybody, to incomplete information, where only the probability distribution on willingness to pay is known.

As a main result we find that adding even a small uncertainty about the number of customers has dramatic implications. Indeed, we show that the average profit per customer converges to zero for a monopolist selling individual units to customers indicating a rather limited potential for the traditional business model of the music industry. Therefore, we conclude that the profits of the music industry from selling individual copies of music files or CD's will continue to decline. Hence, the music industry seems to be left with two options. An 'open source' strategy where music files are distributed freely or at a very low price and intellectual property rights are waived. This strategy should create maximum attention for artists, who in turn may sell concert tickets, ringtones and other sorts of merchandise. An 'eyeball' strategy where the music industry and artists sell access to listeners and fans to third party businesses.

The paper is organized as follows: In Section 2 we provide a further discussion of the economic features of the music market. In Section 3 we study the optimal selling mechanism using an aggregate price under various informational assumptions. In Section 4 we then study an optimal Bayesian mechanism using individual payments and demonstrate that a small uncertainty about the number of customers has dramatic negative consequences with respect to profitability. Finally, Section 5 contains our concluding discussion about the future structure of the music market.

2 Economic features of digital music

Two recent events have drastically changed the music industry: The first event was the invention of the MP3 format by a group of German engineers. In 1995 the MP3 format became the official format for digitalized audio. The second event took place in 1999 when the filesharing service Napster was launched. In effect, the combination of a convenient digital format and a highly efficient mean of distributing files at insignificant costs gave back music its natural public good characteristic.

The first systematic sounds made by man could either please or displease surrounding agents without affecting the utility derived by others. Music is therefore inherently a good with a strong element of non-excludability. This characteristic can be limited. For instance, in case of a concert the physical surroundings can make it possible to exclude non-paying agents. But the most important event in terms of making music excludable was Thomas Edison's invention of sound recording and later the phonograph (1877-78), which made it possible to 'store' and sell music to individual consumers on a large scale. The result of this radical change was the birth of the music industry. The growth and profitability of that industry was (and is) heavily supported by copyright laws, which in effect made the music industry monopolists with an unusually high degree of control over their products as argued e.g. in Boldrine & Levine [3].

Today, many things have changed on the market for music, but we shall argue that the key element related to an understanding of economic aspects of the market development is the fact that music has regained its public good characteristic through digitalization and the invention of P2P networks like Napster, Gnutella, KaZaA, Freenet, YouTube, Pirate Bay etc.

Now, previous attempts by economists to understand and model the market for digital products (including music) has primarily been related to models used in industrial organization, see e.g. the surveys in Peitz & Waelbroeck [13], [14]. One strand of the literature has focused on piracy due to the apparently direct relevance. Loosely speaking these models focus either on quality differences (e.g. Novos & Waldman [11]) or network externalities (e.g. Conner & Rumelt [4], Takeyama [17]). Another strand of the literature has focused on the experience good aspect arguing that the Internet facilitates marketing of digital music increasing consumers' willingness to pay and decreasing promotion costs (e.g. Peitz & Waelbroeck [15] and Duchêne, Peitz & Waelbroeck [8]).

In case of piracy models with positive network externalities, unauthorized copying may end up being attractive both in terms of producers profits and in terms of welfare. The argument is easy to follow in case of software where cheap and easy access of copies drastically increases the number of customers and thereby increases the value of the software for each customer. However, in the particular case of music, network externalities seem to play a much more modest role. Clearly there are elements of bandwagon effects in music consumption in the sense that everybody wants to play music that everybody wants to hear (a sort of peer-group effect) but the feedback on consumer value is much less evident than in case of software where it is common to swap files and there is a certain element of switching cost involved with being forced to change software.

Piracy models with product differentiation (quality differences) are difficult to relate to the music market since there is low correlation between production costs and product quality. Often bootleg or live versions outshine more expensive studio productions. However, there is another aspect of the quality differences relating to the case of digital music. On the one hand the quality of WAV-files (CD) offer a better sound quality than MP3-files and other formats often are converted WAV-files. On the other hand, MP3-files offer a better quality in terms of portability compared to WAV-files (using, for instance, an iPod one's entire music library can be carried around). Therefore, the evaluation of the quality differences between the two formats is far from evident.

In case of models focusing on experience goods the argument runs roughly as follows (see [15]): a monopolist is selling a number of different goods and every customer buys at most one unit of one of the goods; without samples the customers' willingness to pay for any of the goods is the expected reservation price; with samples the customers' willingness to pay for any of the goods is the difference between the true reservation price for the good and the reservation price for the sample; depending on the parameters of the model, the difference between the true reservation price for the good and the reservation price for the sample might be higher than the expected reservation price, and; consequently the monopolist might increase the profit by providing free samples.

The argument in models focusing on experience goods rests on the assumption that music is a private good. However, as explained above, whenever WAV-files are available, so are MP3-files in good quality via P2P-networks. Therefore, the willingness to pay for WAV-files is the difference between the reservation prices for WAV-files and MP3-files and not between WAV-files and samples. As indicated by the widespread use of P2P networks and the many conflicts between the music industry, artists and consumers, the difference between reservation prices for WAV-files and MP3-files is probably rather small. Hence the profit obtained by selling individual units of an experience good characterized by non-excludability should be expected to be very limited

As explained in the introduction we intend to consider a broader range of business models than selling individual units as in the piracy models and experience goods models: While enlarging the set of business models we restrict attention to non-excludable goods.

3 Selling digital music using an aggregate price

We consider a scenario where a profit maximizing music publisher sets an aggregate price for making the music available on the Web and a set of customers submit voluntary bids: If the sum of the bids exceeds the aggregate price then the music is provided and customers pay their bids. Otherwise the music is not provided and nobody pays.

It is assumed that the music can be made available at zero cost (only to increase transparency and without loss of generality). All customers (in the following assumed to be 2) are endowed with individual initial wealth w and an individual utility function u. The utility function is continuous and increasing in wealth and availability of the music increases utility. For each customer the willingness to pay is given by a number v that equals the utility of getting the music having wealth $w-v$ and the utility of not getting it having wealth w. Assume that the willingness to pay is be interpreted as the expected willingness to pay based on free samples, reviews, recommendations from friends, earlier work by the artist etc. as usual when customers evaluate experience goods. Since music has the characteristic of a public good (once provided consumption cannot be excluded) the publisher cannot hope to sell more than one copy on a usual market.

3.1 A dynamic game with voluntary contributions

Rather than selling individual copies, the publisher can use an alternative selling mechanism in order to maximize profits: Consider a "dynamic game" where, at stage 1, the publisher announces a price π for making the music available. At stage 2, customers submit their bids σ specifying how much they are willing to contribute. If the sum of the bids exceeds the announced price the music is made available and customers pay their bids to the publisher, otherwise everything remains at status quo. For a start assume that there is complete information.

Using the principle of backward induction we first analyze customer behavior. On the one hand, suppose that the total willingness to pay is smaller than the announced price, then "no production" is the only outcome that cannot be blocked by any group of customers. Therefore, we remain at status quo. On the other hand suppose that the total willingness to pay exceeds the announced price, then "production" is the only outcome that cannot be blocked by any group of customers. However, there are many supporting strategy profiles, i.e., all profiles where each individual contribution is less than or equal to the willingness to pay and they add up to the announced total price: No customer will benefit from contributing more since production is already ensured and no one will benefit from contributing less since this would imply that the music is not made available.

Given this behavior among the customers, it is clear that the profit maximizing strategy of the publisher is to announce a price equal to the total willingness to pay, which is known under complete information.[1]

Equilibria in the above game, i.e., the described strategies of both the customers and the publisher, are *efficient* in the sense that the music is produced and made available if and only if the total willingness to pay is positive. Moreover, the publisher captures all gains of exchange. Consequently, a monopolist with complete information selling an information good is able to

[1]Technically speaking, this equilibrium is the unique subgame perfect strong Nash equilibrium of the game.

first-order price discriminate despite the fact that non-excludability is an important characteristic of information goods. In other words, within the framework of the model, selling music does not constitute a problem with respect to profitability and efficiency - it only calls for a different selling mechanism. Note, further that even if the publisher could impose excludability it would not be profitable since a fixed price for all customers would reduce the profit. However, the assumption of complete information is obviously unrealistic as we shall now discuss.

At first glance it appears to be somewhat surprising that the publisher is able to first-order price discriminate in the presence of non-excludability since public goods give incentives to free ride. Hence, the problem of free riding is caused by the fact that no customer is pivotal. That is, no customer finds that their contribution determines whether the music is provided or not so it is an optimizing strategy to avoid contributing. Full information enables the publisher to set a price that makes every customer pivotal and thus solves the problem of free riding. Now, with incomplete information free riding reappears as will be demonstrated in Section 3.2. In particular it can be noted that the market ought to be designed in such a way that the probability for each customer of being pivotal is made as large as possible.

The simple voluntary contribution mechanism used in stage 2 of the above game replicates the mechanism in Bagnoli & Lipman [1], where it is analyzed with respect to stability and welfare.

3.2 Informational assumptions

In practice the publisher as well as customers will never have complete information in the above sense. Since music is an experience good, the publishers themselves are in principle able to influence the customers' willingness to pay through their release of product information. For example, if willingness to pay is likely to be high, the publisher has an interest in feeding information to customers. Reversely, if willingness to pay is likely to be low, the publisher has an interest in withholding information.

However this information strategy itself reveals the expectations of the publisher. Combined with the fact that a lot of independent information inevitable will be available in form of samples on YouTube, reviews etc. this suggests that there is very limited scope for strategic use of information. Therefore, we assume that customers know their own expected willingness to pay. But, even if customers know their own willingness to pay, the informational problem is twofold since: 1. for a given price π the customers may not know the total willingness to pay and thereby be uncertain about the other customers' contributions, and; 2. the publisher may not know the total willingness to pay (even in case it is common knowledge among the customers) and hence may have problems in determining the price π such that the profit is maximized.

If the latter problem occurs, various forms of marketing research such as consumer surveys, observational research etc. may prove useful in obtaining an estimate of the total willingness to pay. To the extent that the estimates are precise the mechanism described above is still reliable although it is inefficient in the sense that there is a chance for a total willingness to pay that is below the announced price (and above the costs of production). In short, there may be a trade off between efficiency and profitability that is absent in the complete information scenario.

In order to illustrate the consequences of incomplete information among risk neutral customers we consider the following example: Assume that there are two customers with two possible levels of willingness to pay, v and v^* where $0 < v < v^*$. Assume that the probabilities for each of the four possible states is given by the following matrix where $\alpha + 2\beta + \gamma = 1$.

	v	v^*
v	α	β
v^*	β	γ

This prior distribution is common knowledge among all agents and individual customers know their own willingness to pay.

3.3 One-sided complete information

First, we consider a scenario where both customers know their own as well as the other customer's willingness to pay. The publisher on the other hand only knows the prior distribution - this is supposed to capture situations where the publisher is less in touch with market trends than the customers themselves. Now, the publisher's problem is to set a price that maximizes expected profit. In short, he has three options; $2v, v + v^*$ or $2v^*$. If the publisher sets a price equal to $2v$, this also becomes the expected profit since both customers will contribute v with probability 1. If the price is set at $2v^*$, the expected profit is equal to $2\gamma v^*$ since there is only a probability of γ for the case where both customers have a willingness to pay that equals v^*. Finally, if the price is set at $v + v^*$, the expected profit is $(1 - \alpha)(v + v^*)$ since the only case where the good is not provided is where both customers have a willingness to pay that equals v. Hence, the optimizing strategy for the publisher is to set the price

$$\pi = \begin{cases} 2v & \text{for } v \geq \max\{\gamma, \frac{1-\alpha}{1+\alpha}\}v^* \\ \\ v + v^* & \text{for } (\frac{2\gamma}{1-\alpha} - 1)v^* \leq v \leq \frac{1-\alpha}{1+\alpha}v^* \\ \\ 2v^* & \text{for } v \leq \min\{\gamma, \frac{2\gamma}{1-\alpha} - 1\}v^*. \end{cases}$$

Note that, depending on the parameters there may be two or three price regions. In case of two regions the price is either $2v$ or $2v^*$ and in case of three regions the price may also be $v + v^*$ (as implicitly assumed in Figure 1).

If the difference $v^* - v$ is sufficiently small then the publisher chooses the smallest price, $2v$, ensuring efficiency with a limited loss of profit compared to the complete information scenario. On the contrary, if the difference is sufficiently large the price should be $2v^*$ which results in inefficiency because with probability $1 - \gamma$ the good is not sold even though the price ensures maximal expected profit (see also Figure 1). To sum up; *the expected profit in the one-sided complete information scenario is strictly smaller than the expected profit in the complete information scenario.*

3.4 Incomplete information

Secondly, consider a scenario where both customers only know their own willingness to pay and all three agents know the prior distribution - this captures situations where both the publisher and the customers are equally uninformed. As before there are two obvious candidates for a price; $2v$ and $2v^*$ with expected profit $2v$ and $2\gamma v^*$, respectively. However, contrary to the first scenario the third price is now set between $2v$ and $v + v^*$ because if the price is $v + v^*$ then the expected utility of truth-telling for v^*-types is zero while it may be strictly positive in case of lying (as there is a probability of $\gamma/(\beta + \gamma)$ that the other customer is a v^*-type yielding expected utility $(\gamma/(\beta+\gamma))(v^* - v) \geq 0$ of lying) - thus giving customers of v^*-type incentives to free ride. Given a price $v \leq \bar{\pi} \leq v + v^*$ there is an equilibrium in the stage 2 game $(\sigma, \sigma^*) = (v, \bar{\pi} - v)$ with $v^* - \sigma^* \geq (\gamma/(\beta + \gamma))(v^* - v)$ which implies that the publisher shall set the price

$$\bar{\pi} = \frac{2\gamma}{1-\alpha+\gamma} 2v + \frac{1-\alpha-\gamma}{1-\alpha+\gamma}(v + v^*).$$

Given the price $\bar{\pi}$ the publisher's expected profit is $(1 - \alpha)\bar{\pi}$.

Thus, the optimizing strategy for the publisher is now to set the price

$$\pi = \begin{cases} 2v & \text{for } v \geq \max\{\gamma, \dfrac{(1-\alpha-\gamma)(1-\alpha)}{(1-\alpha-\gamma)(1+\alpha)+4\alpha\gamma}\}v^* \\ \\ \bar{\pi} & \text{for } (\dfrac{(3(1-\alpha)+\gamma)2\gamma}{((1-\alpha)+3\gamma)(1-\alpha)} - 1)v^* \leq v \leq \dfrac{(1-\alpha-\gamma)(1-\alpha)}{(1-\alpha-\gamma)(1+\alpha)+4\alpha\gamma}v^* \\ \\ 2v^* & \text{for } v \leq \min\{\gamma, \dfrac{(3(1-\alpha)+\gamma)2\gamma}{((1-\alpha)+3\gamma)(1-\alpha)} - 1\}v^*. \end{cases}$$

Since, it is easy to show that

$$\frac{(1-\alpha-\gamma)(1-\alpha)}{(1-\alpha-\gamma)(1+\alpha)+4\alpha\gamma} \leq \frac{1-\alpha}{1+\alpha},$$

$$\frac{(3(1-\alpha)+\gamma)2\gamma}{((1-\alpha)+3\gamma)(1-\alpha)}-1 \geq \frac{2\gamma}{1-\alpha}-1,$$

we observe that incomplete information among the customers results in a weakly decreasing lower bound for the low price, $2v$, and a weakly increasing upper bound for the high price, $2v^*$, compared to the one-sided complete information scenario where the customers had complete information about the other customers willingness to pay. Hence, the following two observations can be made:

Observation 1. *If the publisher chooses the price $2v$ or the price $2v^*$ in the one-sided complete information scenario this remains the optimal price in the incomplete information scenario as well.*

Observation 2. *If the publisher chooses the price $\bar{\pi}$ in the incomplete information scenario then he chooses the price $v+v^*$ in the one-sided complete information scenario.*

Figure 1 compares the price schemes of the one-sided complete and incomplete information scenarios in case all three price regions are possible for both scenarios.

To sum up; *the expected profit in the incomplete information scenario is weakly smaller than the expected profit in the one-sided complete information scenario.*

Finally, it is hardly surprising that the problem of free riding introduced by incomplete information seems to become worse with an increasing number of customers as each customer has a smaller chance of being pivotal. Hence loosely speaking; the more the scenario deviates from one-sided complete in-

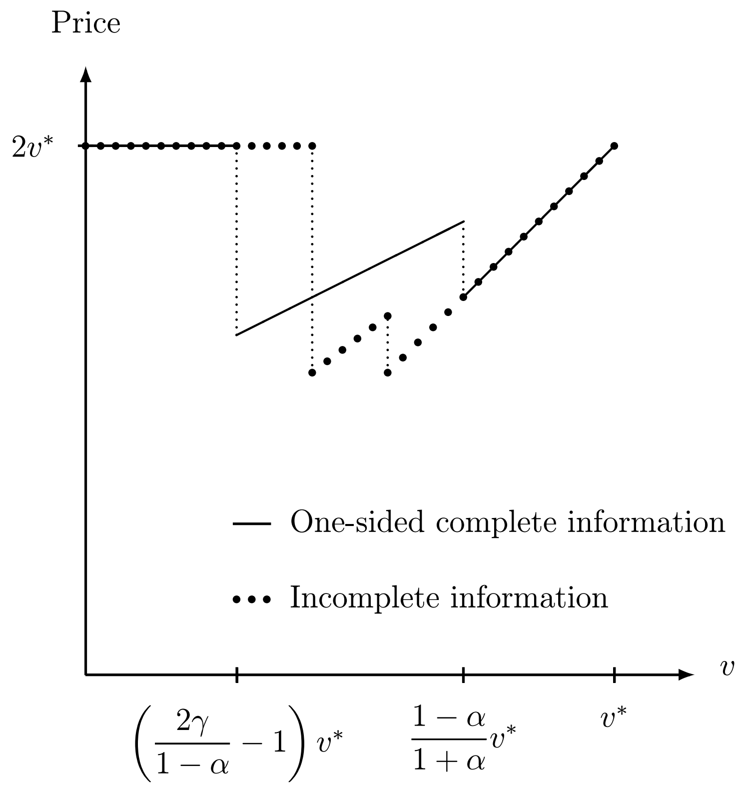

Figure 1: *Price as function of v for* $\frac{1-\alpha}{1+\alpha} \geq \gamma$.

formation the more it becomes important for succesful use of the mechanism that the number of customers is limited.

3.5 Information and profit

In conclusion, weakening the informational requirements the mechanism still works but expected profits may now be reduced (even considerably) as the publisher is no longer guaranteed to sell his product. In fact, the following theorem is a direct consequence of the above analysis:

Observation 3. *Let $\Pi_C(v, v^*)$, $\Pi_P(v, v^*)$ and $\Pi_I(v, v^*)$ be the expected profit in the complete, one-sided complete and incomplete information sce-*

nario, respectively. Then

$$\Pi_C(v, v^*) \ > \ \Pi_P(v, v^*) \ \geq \ \Pi_I(v, v^*).$$

In other words, decreasing information leads to decreasing expected profits. It is clear that the publisher is always better off knowing the willingness to pay among the customers. However, such information is relative costly to obtain as it involves data mining procedures, consumer surveys etc. What seems more interesting though is that *any action taken by the publisher that may increase the information among the customers will tend to increase his profitability.* This conclusion is in line with the findings in Crémer & McLean [5] concerning allocation mechanisms under asymmetric information.

Perhaps more importantly this conclusion is in line with the actual behavior of record companies as they induce the formation of fan-societies via the Web as well as software companies supporting the formation of customer-groups etc. – all in order to increase communication (and thereby information) between customers with respect to their "types". The Web itself seems to facilitate such actions since it involves very limited costs for individuals to meet and exchange information in cyber space.

Finally, more sophisticated mechanisms can be developed using a Bayesian approach as done for private goods in Crémer & McLean [6] and extended to public goods below.

4 Selling digital music using a Bayesian mechanism

We now consider a mechanism where the publisher chooses a pricing scheme and customers, knowing this scheme, choose their bids. Formally, the publisher and the customers know the distribution of willingness to pay, but customers further know their own willingness to pay (i.e., as in the case of incomplete information).

The selling mechanism used by the publisher has three stages: Firstly, the publisher announces how payments and the release of the music depend on the customers' bids. Secondly, the customers submit their bids. Thirdly, customers' payments and whether the music is released or not are determined by the publisher according to the announced mechanism. The selling mechanism shall mimic a market in the sense that customers should be able to ensure that they pay nothing (voluntary participation). Therefore, the set of possible bids of the customers consists of their valuation of the music and non-participation.

4.1 A Cremer-McLean mechanism for public goods

Recall the example of the previous sections. When customers have two possible valuations v and v^*, their set of possible bids is $S = \{v, v^*, n\}$ where n corresponds to non-participation. The payment is a map $p : S \times S \to \mathbb{R}$ where $p(s_1, s_2)$ is the payment of a customer submitting the bid s_1 (and $p(s_2, s_1)$ is the payment of the customer submitting the bid s_2). Moreover, $p(n, s_2) = 0$ as the customer submitting the bid n pays nothing. Whether the music is released or not is described by a map $r : S \times S \to \{0, 1\}$, where $r(s_1, s_2) = 0$ corresponds to the music not being released and $r(s_1, s_2) = 1$ corresponds to the music being released.

The problem of the publisher is to maximize the expected profit given that customers tell the truth about their willingness to pay, i.e the problem of the publisher becomes,

$$\max_{p,r} \quad 2(\alpha p(v,v) + \beta(p(v,v^*) + p(v^*,v)) + \gamma p(v^*,v^*))$$

$$\text{s.t.} \quad \begin{cases} \alpha r(v,v)(v - p(v,v)) + \beta r(v,v^*)(v - p(v,v^*)) \\ \qquad \geq \; \alpha r(v^*,v)(v - p(v^*,v)) + \beta r(v^*,v^*)(v - p(v^*,v^*)) \\ \\ \alpha r(v,v)(v - p(v,v)) + \beta r(v,v^*)(v - p(v,v^*)) \\ \qquad \geq \; \alpha r(n,v)(v - p(n,v)) + \beta r(n,v^*)(v - p(n,v^*)) \\ \\ \beta r(v^*,v)(v^* - p(v^*,v)) + \gamma r(v^*,v^*)(v^* - p(v^*,v^*)) \\ \qquad \geq \; \beta r(v,v)(v^* - p(v,v)) + \gamma r(v,v^*)(v^* - p(v,v^*)) \\ \\ \beta r(v^*,v)(v^* - p(v^*,v)) + \gamma r(v^*,v^*)(v^* - p(v^*,v^*)) \\ \qquad \geq \; \beta r(n,v)(v^* - p(n,v)) + \gamma r(n,v^*)(v^* - p(n,v^*)) \\ \\ p(n,v) \; = \; p(n,v^*) \; = \; p(n,n) = 0 \end{cases}$$

Suppose that each customer learns about the distribution of the willingness to pay of the other customer by learning his own willingness to pay. According to Bayes rule, if one customer knows that his own willingness to pay is v then the conditional probability of the willingness to pay of the other customer being v as well, is $\alpha/(\alpha+\beta)$. Likewise, if one customer knows that his own willingness to pay is v^* then the conditional probability of the willingness to pay of the other customer being v, is $\beta/(\beta+\gamma)$. Therefore, learning the type of one customer contains information about the type of the other customer if and only if $\alpha/(\alpha+\beta) \neq \beta/(\beta+\gamma)$ or equivalently $\alpha\gamma - \beta^2 \neq 0$, which is assumed to be satisfied in the following.

A solution to the problem of the publisher is a selling mechanism where the payments are

$$p(v,v) = \frac{\gamma(\alpha+\beta)v - \beta(\beta+\gamma)v^*}{\alpha\gamma-\beta^2}$$

$$p(v,v^*) = -\frac{\beta(\alpha+\beta)v - \alpha(\beta+\gamma)v^*}{\alpha\gamma-\beta^2}$$

$$p(v^*,v) = \frac{\gamma(\alpha+\beta)v - \beta(\beta+\gamma)v^*}{\alpha\gamma-\beta^2}$$

$$p(v^*,v^*) = \frac{\beta(\alpha+\beta)v - \alpha(\beta+\gamma)v^*}{\alpha\gamma-\beta^2}$$

and $p(n,v) = p(n,v^*) = p(n,n) = 0$ and the release is $r(v,v) = r(v,v^*) = r(v^*,v) = r(v^*,v^*) = 1$ and $r(n,v) = r(v,n) = r(n,v^*) = r(v^*,n) = r(n,n) = 0$.

Telling the truth is a Nash equilibrium for the customers and the expected profit for the publisher at the Nash equilibrium is $2(\alpha v + \beta(v+v^*) + \gamma v^*)$, so the publisher captures all gains of trade. Consequently there exists a business model such that a monopolist with incomplete information who is selling an information good is able to first-order discriminate.

As discussed in Mailath & Postlewaite [10], and obvious from the payment scheme calculated above, the payments may become arbitrarily large (both positive and negative). This aspect alone may limit the practical scope of such a mechanism. However, even considered as a theoretical result it seems of somewhat limited relevance because minor deviations from the set up changes the conclusion dramatically as will be seen below.

4.2 Uncertainty about the number of customers

Suppose that there are N potential customers, who are randomly transformed into actual customers, who are able to bid, and absent customers. In our model a customer, who is absent bids n, while actual customers are able to submit any possible bid including n. A straight forward interpretation is that all potential customers are actual customers but their bids may get lost due to server breakdowns, technical problems, accidents etc. An alternative interpretation is that customers may have negative expected willingness to pay since participation may be costly in terms of time and the expected value of the product may be close to zero (this is all the more likely in case of music because in general willingness to pay must be lower for experience goods as it requires an effort to make the actual evaluation). Consequently, it may not be worth it for the publisher to provide incentives for these customers, so the publisher wants them to be absent.

Intuitively, it is no longer possible to obtain full extraction: On the one hand, if the publishers only release the good in case all customers submit bids different from n (implying that all potential customers are transformed into actual customers), then there is a possibility that the music is not released and nothing is paid. On the other hand, if the publisher accepts to release the good even though he receives some bids equal to n, then actual customers might speculate in bidding n and thereby free ride. Moreover, we show that the ratio between profit and the total willingness to pay converge to zero as the number of potential users tends to infinity leaving little room for profits.

A selling mechanism is a $(N+1)$-tuple $((p_j)_{j=1}^N, r)$ where $p_j : \{v, n\}^N \to \mathbb{R}$ is the payment of potential customer j and $r : \{v, n\}^N \to \{0, 1\}$ is the release decision.

Assume for simplicity that all actual customers have valuation v, i.e., there is no uncertainty about the valuation. Moreover assume that a potential customer is transformed into an actual customer with probability $1-\varepsilon$ where $0 < \varepsilon < 1$.

Theorem 1. *Let $\sigma(N)$ be the maximal payment per customer. Then*

$$\lim_{N\to\infty} \sigma(N) \;\leq\; v\sqrt{\frac{1-\varepsilon}{\varepsilon}\,\frac{1}{2\pi N}}.$$

The proof is provided in the Appendix.

Theorem 1 states that if the number of potential customers tends to infinity, then the maximal average payment per customer converges to zero as fast as one over the squareroot of the number of customers converges to zero. Note, however, that this is not at odds with the maximal total payment being increasing in the number of potential customers. Indeed if the number of potential customers tends to infinity, then the maximal total payment tends to infinity as fast as the squareroot of the number of customers tends to infinity.

Consider the following example: Assume that customers have a willingness to pay 1 dollar ($v = 1$) for a given music file. Let the probability of being non-present be equal to one per mille ($\varepsilon = 0.001$). Then the upper bound of the maximal payment per customer is 13 cents for $10,000$ potential customers, 1.3 cents for $1,000,000$ potential customers and 0.13 cents for $100,000,000$ potential customers. For comparison we may note that Michael Jackson's 'Thriller' has sold around $100,000,000$ copies.

4.3 Mechanism design and profitability

The mechanism approach may seem somewhat theoretical when it comes to formulating a business model for the music industry. However, the intention was to demonstrate that no business model selling directly to customers (including models where the publisher does not sell individual copies) is profitable.

In particular, we have shown that introducing uncertainty about the number of actual customers (which may seem a small practical detail) significantly invalidates the Cremer-McLean result of full extraction because free riding reintroduces itself as a serious problem. Indeed, the calculations above show that, on average, if one potential customer per thousand is absent when bidding, then the obtained revenue is equivalent to only thirteen per thousand customers are paying their true willingness to pay in case of one million potential customers.

5 Concluding discussion

Many attempts to find ‘solutions’ to free riding problems, like selling music in the presence of P2P networks, have been made. Below we provide a taxonomy of such attempts:

- *Mechanism design.* In this case the producer designs a selling mechanism trying to reduce free riding. For example, the author Stephen King launched a novel called ‘The Plant’ exclusively on the Web using the following procedure: Two installments were offered to anyone who registered. These installments could be downloaded for free but the customers were invited to pay 1 dollar each to King for the privilege. It was stated that if 75 percent of those who downloaded also paid he would continue to offer new installments until the novel was complete.

- *The Disney model.* In this case the producer is fighting fiercely for their legal rights against piracy as Disney has done for decades.

- *The game consol model.* In this case the producers focus on technological protection of their rights making it difficult for the consumer to copy their products.

- *Bundling with private good.* In this case the non-excludable information good is bundled with a (more or less) excludable good in order to reduce free riding.

- *The eyeball model.* In this case the producer is turning the primary product, the non-excludable information good, into a secondary product generating profit from selling access to its customers rather than only selling the good itself.

- *Open source.* In this case the producer makes the product freely available often with the result that the product becomes a documentation of their skills and quality, which in turn may prove to be profitable in other ways.

As our analysis suggests, mechanism design is not a solution for the music industry.

When P2P networks were introduced the immediate answer from the music industry was to fight hard for their legal rights claiming that downloading music was harmful for society, because in the long run it would prevent the making of music itself, and should be considered as theft. Obviously, both these claims are wrong considering the non-excludable character of music. But more interestingly, it seems that the strategy of fighting hard for legal rights will prove wrong, too, in the long run (if not already).

Indeed, an immediate look at P2P networks reveals that downloading is a widespread phenomenon and just about anything continue to be available for free. Moreover, online sales at very low prices is available, apparently under legal conditions as e.g. on the Russian site MP3Sparks.com where albums typically cost around 2 dollars. This indicates that showcase lawsuits as used by the Recording Industry Association of America (RIAA) have a rather limited effect - if not being directly harmful for the image of an industry declaring war against their own customers. Therefore, it appears that using the 'Disney model' to maintain music as an excludable good is futile given the current technological conditions.

Another attempt to maintain excludability of music has been to use copy protection directly on CD's and legally bought MP3 files as in the 'game console model'. Copy protection of CD's proved to be a real nuisance for the customers since all sorts of problems occurred during the legal use of the CD's and thereby lowered the value of the CD itself. Furthermore, the protection was inadequate as it did not prevent copying in effect. Moreover, DRM on MP3 files prevents the buyer from making more than a certain limited amount of copies of the legally bought file - again limiting the value of the file itself. There seems to be a movement towards abandoning this strategy (for example, iTunes store is now selling all music from EMI's catalogue DRM-free and will work towards being entirely DRM-free within a year) and there are many sites not using DRM (like emusic, MP3Sparks etc.) and software, which de-DRM files, is freely available on the Web. The 'game console model' is consequently not working either.

Yet another attempt of the recording industry is to bundle music with some private good. For example, Bon Jovi issued a CD where the buyer got rights to buy concert tickets before other consumers. The Cardigans issued a CD giving the buyer a possibility of entering a web site with extra material, etc. However, given the non-excludable character of music, customers still have limited willingness to pay for music and, therefore, what is paid for is, in fact, only the private good. Yet it cannot be ruled out that CDs can be branded such that they become attractive by themselves as has been the case with bottled water etc., but facts remain that CD sales have dropped dramatically.

Consequently, this leaves the future business model of the music industry to be some kind of combination of the 'eyeball model' and the 'open source model' according to our taxonomy.

As such we argue that the future market form for music will consist of online stores like those existing now but with considerably lower prices and lower profitability. As in open source it may prove worthwhile to give up ones legal rights in order to encourage fan participation and build up reputation (especially because music is an experience good). This reputation can subsequently be used to generate various sorts of profit coming from direct voluntary payments from fans, sales of merchandize and concerts or as in the eyeball model selling access to fans and listeners to other companies. The latest trend appears to be that even major artists like Madonna switch away from record companies to contracts directly with concert promoters because as Madonna commented '*the paradigm in the music business has shifted and as an artist and a business woman, I have to move with that shift*'.

References

[1] Bagnoli M. & B.L. Lipman (1989): Provision of public goods: Fully implementing the core through private contributions, *Review of Economic Studies*, **56**, 583-601.

[2] Bhattacharjee, S., R.D. Gopal, K. Lertwachara, J.R. Marsden & R. Telang (2007), The effect of digital sharing technologies on music markets: a survival analysis of albums on ranking charts, *Management Science*, 53, 1359-1374.

[3] Boldrine, M. & D. Levine (2002), The case against intellectual property, *American Economic Review*, 92, 209-212.

[4] Conner, K.R. & R.P. Rumelt (1991), Software piracy - an analysis of protection strategies, *Management Science*, 37, 125-139.

[5] Crémer J. & R.P. McLean (1985): Optimal selling strategies under uncertainty for a discriminating monopolist when demands are interdependent, *Econometrica*, **53**, 345-361.

[6] Crémer J. & R.P. McLean (1988): Full extraction of the surplus in Bayesian and dominant strategy auctions, *Econometrica*, **56**, 1247-1257.

[7] DeFigueiredo, D. (2003), Unleashing the power of digital goods: enabling new business models for the music industry, unpublished manuscript.

[8] Duchêne, A. M. Peitz & P. Waelbroeck (2005), Marketing digital mucic: can DRM help?, working paper EC-05-02, Telecom Paris.

[9] Hong, J.-S. & J.-C. Kim, Competition with clone: and analysis of the role of illegal copy, *Netnomics*, 9, 87-94.

[10] Mailath, G.J. & A. Postlewaite (1990), Asymmetric information bargaining problems with many agents, *Review of Economic Studies*, 57, 351-367.

[11] Novos, I.E. & M. Waldman (1984), The effects of increased copyright protection: an analytic approach, *Journal of Political Economy*, 92, 236-246.

[12] Oberholzer-Gee, F. & K. Strumpf (2007), The effect of file sharing on record sales an empirical analysis, *Journal of Political Economy*, 115, 1-42.

[13] Peitz, M. & P. Waelbroeck (2005), An economists guide to digital music, *CESIFO*, 51 (2-3), 359-428.

[14] Peitz, M. & P. Waelbroeck (2006a), Piracy of digital products: A critical review of the theoretical literature, *Information Economics and Policy*, 18, 449-476.

[15] Peitz, M. & P. Waelbroeck (2006b), Why the music industry may gain from free downloading - the role of sampling, *International Journal of Industrial Organization*, 24, 907-913.

[16] Pfahl, M. (2001): Giving away music to make money: Independent musicians on the Internet; http://firstmonday.org/issues/issue6_8/pfahl/index.html.

[17] Takeyama, L.N. (1994), The welfare implications of unauthorized reproduction of intellectual property in the presence of demand network externalities, *The Journal of Industrial Economics*, 42, 155-166.

6 Appendix: Proof of Theorem 2

The set of states is $\Sigma = \{v, n\}^N$. For $\sigma = (\sigma_1, \ldots, \sigma_N)$ if $\sigma_j = v$ then potential customer j is transformed into an actual customer and if $\sigma_j = n$ then potential customer j is transformed into a customer who is absent. The set of strategy profiles is $S = \{v, n\}^N$. For $s = (s_1, \ldots, s_N)$ if $s_j = v$ then customer j is using the strategy v implying that customer j is an actual customer and if $s_j = n$ then customer j is using the strategy n implying that customer j is either a customer who is absent or an actual customer pretending to be a customer who is absent.

Let $\mu(s)$ be the probability that the strategy profile is s given that every potential customer tells the truth. For a strategy profile s where $N-K$ potential customers are transformed into actual customers and K potential customers are transformed into customers who are absent the probability $\mu(s)$ is $\varepsilon^K(1-\varepsilon)^{N-K}$. Let $\mu(s|t_j = n)$ be the probability that the strategy profile is s given that customer j uses the strategy n. For a strategy profile where the number of n's is K and the number of v's is $N-K$ the probability $\mu(s|t_j = n)$ is $\varepsilon^{K-1}(1-\varepsilon)^{N-K}$ for $s_j = n$ and 0 for $s_j = v$.

The problem of the publisher is

$$\max_{((p_j)_{j=1}^N, r)} \quad \sum_s \mu(s) \sum_j p_j(s)$$

$$\text{s.t.} \quad \begin{cases} \displaystyle\sum_s \mu(s)(r(s)v - p_j(s)) \\ \qquad \displaystyle\geq \sum_s \mu(s|t_j = n)(r(s)v - p_j(s)) \text{ for all } j \\ p_j(s) = 0 \text{ for all } s \text{ with } s_j = n \text{ and all } j \end{cases}$$

Let:

$$b(K; N, \varepsilon) = \begin{pmatrix} N \\ K \end{pmatrix} \varepsilon^K (1-\varepsilon)^{N-K}$$

$$B(M; N, \varepsilon) = \sum_{K \leq M} b(K; N, \varepsilon).$$

Suppose that $\mathrm{I}(a) \in \mathbb{Z}$ is the integer part of $a \in \mathbb{R}$, i.e., $a \leq \mathrm{I}(a) < a+1$, and let (p,r) be a mechanism that maximizes surplus then:

$$\begin{aligned}
N\sigma(N) &= \textstyle\sum_s \mu(s) \sum_j p_j(s) \\
&\leq \textstyle\sum_s r(s) \sum_i (\mu(s) - \mu(s|t_j = n)) \\
&= N(B(\mathrm{I}(\varepsilon N); N, \varepsilon) - B(\mathrm{I}(\varepsilon N) - 1; N-1, \varepsilon)) \\
&= (1-\varepsilon) N b(\mathrm{I}(\varepsilon N); N-1, \varepsilon) \\
&= (N - \mathrm{I}(\varepsilon N)) b(\mathrm{I}(\varepsilon N); N, \varepsilon)
\end{aligned}$$

where the first equality follows from the definition of $\sigma(N)$, the second equality follows from straight forward calculations and the last two equalities follow from Feller (1968) and straight forward calculations. Finally;

$$\lim_{N\to\infty} \sqrt{N} b(\mathrm{I}(\varepsilon N); N-1, \varepsilon) = \frac{1}{\sqrt{2\pi\varepsilon(1-\varepsilon)}}$$

according to Stirling's formula.

Q.E.D.