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File-Sharing, Sampling, and Music Distribution

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Abstract

The use of file-sharing technologies, so-called Peer-to-Peer (P2P) networks, to copy music files has become common since the arrival of Napster. P2P networks may actually improve the matching between products and buyers – we call this the matching effect. For a label the downside of P2P networks is that consumers receive a copy which, although it is an imperfect substitute to the original, may reduce their willingness-to-pay for the original – we call this the competition effect. We show that the matching effect may dominate so that a label's profits are higher with P2P networks than without. Furthermore, we show that the existence of P2P networks may alter the standard business model: sampling may replace costly marketing and promotion. This may allow labels to increase profits in spite of lower revenues.

Keywords: file-sharing, P2P, sampling, information transmission, piracy, music

JEL-Classification: L11, L82

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1. Introduction

Digital music files (mostly in MP3 format) have become widespread on the internet. File-sharing systems pioneered by Napster and for a while dominated by Kazaa have become popular among certain online communities and a target for legal prosecution by record companies. Industry representatives partly attribute the recent drop in music sales (in Dollars and in units) to a rise in online file-sharing, which, from the point of view of the record companies simply reads as piracy of copyrighted material. For instance, in the U.S. alone an estimated number of 60 million people have downloaded MP3 files (see Ipsos Reid, 2002). Since the vast majority of material on file-sharing systems is copyrighted material this means that almost the same number has downloaded copyrighted material. The music industry has reacted by warning consumers and filing court cases against copyright infringers as well as by implementing technological measures of protection. These actions are based on the belief that music downloads are causing a substantial damage to the music industry. Advocates of online file-sharing, however, believe that file-sharing should be free and unrestricted. One argument goes that downloaders use the downloaded files for sampling in order to make more informed purchasing decisions. Hence, the argument continues, the music industry may actually benefit from file-sharing networks.[1]

In this paper we analyze the role of sampling in music distribution. The argument of sampling fits well many types of music — individually acquired information is very important for music because of it is an experience good where horizontal product differentiation and taste heterogeneity are important. As the result of sampling, music labels may actually gain from

[1] This view is to some extent supported by survey data that show that a large share of internet users download files for sampling. A share of 69% of downloaders listen to new music and 31% to music by artists never heard before according to PEW internet tracking, July-August 2000. A share of 30% of respondents to an Ipsos survey of 2002 acknowledged that the genre that they typically listen to/purchase has changed since they started downloading (over a brief period of time), mainly because they were able to experiment with new genres and new artists; for more details see Peitz and Waelbroeck (2004b). Note that the recording industry has tried to use survey data to refute the argument that consumers spend more in the presence of P2P (see e.g. IFPI The Recording Industry in Numbers 2003).

P2P systems.[2]

Central to our analysis is the observation that there is a large variety of different titles and albums available. Therefore, we consider a multi-product environment in which the substitutability between products is explicitly taken into account. The positive effect of sampling on profit may be reflected on the revenue or the cost side, that is,

1. music labels may afford higher revenues in the presence of P2P or
2. music labels may be able to reduce their costs.

First, to the extent that sampling allows consumers to find their favorite music, the demand curve of consumers shifts outward and labels are able to achieve higher revenues. That is, MP3 downloads and music sales are complements and this leads to higher profits. Second, to the extent that sampling allows labels to save on marketing and promotion, their costs are decreased.

We first present a simple model which operates only on the demand side. We then present an extension of the model to allow for marketing and promotion by the labels, that is, labels may transmit information on product characteristics to consumers by marketing and promotion.[3]

Describing sampling only as a source of higher profits is a partial view as consumers have the option to download and listen to music without paying for it. Consumers have to decide

[2] Recent empirical analyses lead to ambiguous results. Some studies show a negative effect of downloads on music sales (see e.g. Peitz and Waelbroeck, 2004a, and Zentner, 2004), whereas others find a negligible or even slightly positive effect (see Oberholzer and Stumpf, 2004, and Boorstin, 2004). Liebowitz (2004) comes to the conclusion that the overall evidence supports the view that file-sharing has hurt music sales; our own analysis tends to support this view (see Peitz and Waelbroeck, 2004a,b). However, this finding does not invalidate our argument that the music industry may gain from file-sharing. First, current file-sharing systems are not well-designed for sampling purposes (see also the discussion section). Consequently, sampling has still the potential to be profit-improving. Second, even if music sales decrease in spite of sampling, this does not imply that profits fall since sampling may lead to significant cost savings on marketing and promotion, see below.

[3] The view that a firm can transmit information on product characteristics is also expressed in the industrial organization literature on informative advertising, see e.g. Rosen (1978) and Meurer and Stahl (1994).

whether they simply keep the download or whether they buy the song or album – this means that a download can be a substitute to the purchase of a song or album. This substitution may lead to a fall in the number of units sold or a lower price; the free download effectively becomes a competitor to the version which is sold. This competition effect counteracts the matching effect. Our question then is: in which situations does the matching effect dominate the competition effect?

To address this question we analyze a simple multi-product monopoly environment in which the original and the copy are imperfect substitutes. To keep the analysis simple, we consider a model with unit demand and full participation so that any increase in revenues stems from higher prices. We postulate that consumers make uninformed purchasing decisions in the absence of P2P. Information can only be revealed by sampling, for which a consumers incurs a fixed opportunity cost. Consequently, consumers sample all available songs or none. A consumer who likes a particular song or album has a much higher willingness to pay for the song or album for sale vis-a-vis the download, e.g. because she wants to possess the "original" which comes together with bundled items such as liner notes and other complementary material or because the free download has some defects (see Peitz and Waelbroeck, 2004b). By contrast, this added material has little value for a consumer who does not like the particular song or album.

If sampling leads to a better match between product and buyer his willingness to pay for the original increases. However, a consumer has also the option to listen to the download and not to buy the original. If the information acquired through sampling sufficiently increases the consumers' willingness-to-pay, then consumers are willing to pay a higher price with P2P even though free copies are available. Hence, P2P increases the labels' profits and the matching effect dominates the competition effect.

In the extension, sampling provides an alternative channel of information transmission, which allows labels to save on marketing and promotion. Here, the optimal business model in the music industry may change and a significant part of the marketing and promotion efforts may no longer

be needed with P2P.[4] We restrict our analysis to the extreme case in which sampling does not provide additional information compared to the setup with marketing and promotion by the labels. We find that for certain parameters P2P reduces the labels' revenues but at the same time increases profits. This result is consistent with the claim by the music industry that revenues have fallen. However, online file-sharing, if properly designed, has the potential to reduce the costs of marketing and promotion such that profits in the music industry actually increase. In effect, sampling, which is an information-pull technology, is a substitute to marketing and promotion, an information-push technology.

To summarize, in this paper the matching effect either leads to an outward shift of demand (section 3) or lower costs (section 4).

Related literature. There exists a growing theoretical literature on end-user copying (for a review see Peitz and Waelbroeck, 2003). However, most of the literature does not address sampling, or more generally copying as a means of information transmission. To the best of our knowledge the only papers that address sampling are Duchene and Waelbroeck (2003), Gopal, Bhattacharjee, and Sanders (2004), Takeyama (2003), and Zhang (2002).

Independent of our work, Gopal, Bhattacharjee, and Sanders (2004) show that for certain parameter constellations of their model a firm increases its revenues in the presence of P2P. In particular, some consumers with an intermediate interest in music first download and then buy the corresponding song or album if they like what they downloaded. These consumers would not buy if P2P were not available. A limitation of their analysis is that the price for the version that is for sale is not determined in the model but taken as a parameter. Also, they only consider a single-product environment.

Duchene and Waelbroeck (2004) analyze the effect of extended copyright protection on con-

[4] In the music industry, these marketing and promotion costs constitute an important part of the average cost of a CD. According to the RIAA, promotion costs are "perhaps the most expensive part of the music business today" (see www.riaa.org). Chuck Philips ("Record Label Chorus: High Risk, Low Margin", L.A. Times, May 31, 2001) reports that "marketing costs can run from $3 per hit CD to more than $10 for failed projects".

sumer surplus. For this they consider a single-product firm that decides how much costly technological protection to implement in different legal enforcement regimes.[5] In this framework, they show that increasing copyright protection has both a direct effect on copiers but also an indirect effect on buyers as technological protection and prices increase with legal protection, unambiguously reducing consumer surplus. Zhang (2002) argues that sticking to the traditional distribution technology is wasteful from a social point of view when P2P technologies are available. He considers an asymmetric environment in which a star performer can distort demand in its favor using the traditional distribution channel. Niche performers can partly compensate this disadvantage by using P2P that gives them the opportunity to expose a share of consumers to their music, increasing consumers' willingness-to-pay. Takeyama (2003) analyzes how copies that provide information on the quality of a product can be used to solve an adverse selection problem in a two-period durable good monopoly.[6]

Our contribution to this literature is to show in particular that copying improves the match between the purchased product and the tastes of a particular consumer, an aspect which can make consumer sampling beneficial to a (multi-product) label. Also, sampling may lead to a cost reduction for the label.

Our plan of the paper is as follows. In section 2, we present the model. In section 3 we analyze the effect of sampling as a means to reveal information to consumers and show that labels may benefit from this. In section 4 we extend the analysis to allow labels to reveal that

[5] Technological protection increases the consumers' disutility of a copy but at the same reduces the fair use value of the original product (although they assume that the first effect dominates the second). A strengthening of legal protection reduces the surplus of copiers through the increase in the expected penalty if caught copying.

[6] In particular, if a consumer copies the product in the first period, she learns its quality and can decide whether to purchase in the second period. However, there are some consumers, call them captive consumers, who never copy. Takeyama shows that there exists a pooling equilibrium in which the monopolist intertemporally price-discriminates, selling to the captive consumers in the first period and charging the price equal to the difference in valuation between the original and the copy to the other consumers in the second period. Takeyama then makes the availability or non-availability of copies part of the firm's strategy. She shows that the absence of copies (in other words, the enforcement of copyright) is a (cheap) signal for low quality.

information themselves, albeit at a cost. In this case labels may benefit from sampling although their revenues are reduced. Section 5 concludes.

2. The model

We consider the problem of a multi-product monopolist. We focus on the matching effect according to which sampling allows consumers to pick their favorite music. In an extension (section 4), we introduce the firm's efforts to provide information to consumers through marketing and promotion and compare such a situation of traditional marketing and promotion to the situation in which free downloads are available on a P2P distribution technology.

Products in the market. Suppose that a firm offers N products. For the sake of simplicity, we do not distinguish here between a single track and the album which contains this track.[7] We use the simple structure of the Salop circle: products are equidistantly located on a circle of unit length. Product i is located at l_i on the circle and the distance between two neighboring products is $1/N$. This particular structure makes the analytical problem easy to solve.[8]

The firm. In our model a single firm sells all products, that is, we analyze the strategic choices of a monopoly. The firm (or label) maximizes its profit π with respect to the prices of the products it sells. Because products are located equidistantly, the profit-maximizing firm will always charge the same price p across products.[9] The firm incurs zero marginal costs of

[7] An interesting issue is whether consumers desire unbundling. This is achieved by the downloading of individual songs in contrast to the purchase of an album which is a bundle of goods. In this paper we abstract from the unbundling issue.

[8] Other models (such as the multinomial logit) may be chosen alternatively. In particular, the one-dimensional spatial structure is merely assumed for convenience.

[9] In reality, we observe uniform prices. This means that: (i) labels mostly do not use prices as a discrimination device at least for new titles and albums within their repertoire and (ii) big labels do not follow different pricing strategies. With respect to (i), our analysis focuses on a (locally) symmetric environment. Clearly, in the real world there are winners and losers in the market for CDs and the market is asymmetric. However, since list prices are rather uniform across albums these asymmetries are not reflected in the pricing decision. With respect to (ii), we abstract from strategic interaction between labels. To the extent that the big labels collude in prices, it

production. In the case of CDs and other physical media this means that we consider the price net of any marginal costs of production. Since the number of products is given we do not need to consider any fixed costs. Hence, in this setting the profit is equal to revenues.

Consumer behavior. Consumers are uniformly distributed on the circle and have an ideal variety ω. They buy one product if at all. Consumers initially do not know the location of the N products. If consumers do not have downloaded they do not have any information and therefore can only buy at random. Consumers who have downloaded a product perfectly learn the location of that product on the circle. Hence, if consumers download all products the maximal distance between a consumer and the product he likes most is $1/(2N)$.

Consumers follow a two-stage decision process

- Stage 1: Download yes/no, denoted by $d = 1$ for downloading and $d = 0$ for not downloading. After downloading consumers learn the location of each downloaded product.
- Stage 2: Buy one unit yes/no, denoted by $b = 1$ for buying and $b = 0$ for not buying.

At stage 1 our model has the feature that every consumer either downloads to the extent that they learn the location of the product which is closest to his consumer's ideal point or that he does not download at all. For this, we assume that a consumer incurs an opportunity cost s for downloading all products and that this opportunity costs is independent of the number of downloads. In other words, there is a fixed cost of downloading and a zero marginal cost. With this simplifying assumption, we do not need to analyze consumer search and the resulting optimal size of the sample. Hence, the consumer selects the most attractive product available, which we assume to give a positive utility net of the download cost, i.e. $r > s$, to the consumer.

If the consumer has sampled all relevant products and selected the one closest to her ideal location, then he decides whether to buy one or zero unit of this product. Note that for simplicity

does not really matter for the analysis in section 3 whether we consider a single label, as in this paper, or several labels, as observed in reality. Indeed, the music industry has a history of alleged price collusion. For example, in 2003 the music industry reached an out-of-court settlement in the US on charges of price collusion.

we assume that a consumer who samples music only derives utility from up to one song or album. This allows us to stay within the unit-demand framework.[10]

We denote a consumer's actions as (b, d). Here the decision at stage 2 may depend on the information gathered at stage 1. The utility a consumer receives then depends on his actions (b, d), his ideal variety ω, and the price p, which is charged uniformly for all products.

Product differentiation among downloaded files. Suppose that a product is located at l. Then choosing this product gives the consumers a gross surplus equal to $r - \tau|\omega - l|$, where r is the surplus of a product located at the ideal location and τ is the "transport cost" parameter. Parameter τ measures the degree of substitutability between product: if τ is large then products are strongly differentiated and therefore are bad substitutes for one another.

A consumer's utility when he does not buy. A consumer's utility who neither buy nor downloads is normalized to zero, $v(0, 0) = 0$. A consumer who downloads and consumes a product located at l has utility $v(0, 1) = r - \tau|\omega - l| - s$. Clearly, for $r > s$ there are locations l such that a consumer prefers $(0, 1)$ to $(0, 0)$.

The added value of originals. If a consumer purchases the original product he obtains an added benefit $g(|\omega - l|) \geq 0$ which depends on the extent the product fits its taste. This added benefit reflects the value of the original over the copy (such as additional songs unavailable on P2P networks, lyrics, booklet, pictures, song information, feel-good factor to have indirectly paid the artist, ...). We assume that $g' < 0$ that is the less a product fits the taste of a consumer the less the added benefit. The underlying motivation for this assumption is that original cover with lyrics and other bundled services are very valuable for somebody's favorite band or album, whereas they have little or no value if the music is not appreciated. Similarly, possible defects

[10] We would like to comment on our unit-demand framework. In reality, some consumers who sample music buy their most preferred music but keep listening to some of the downloads without obtaining the corresponding originals. This additional utility from sampling may at least partly compensate for the sampling cost.

Although a model in which consumers derive utility from more than one product is certainly of interest, it is less tractable than the present model with unit demand. In such an extended model sampling may lead to an increase (or decrease) of the number of products purchased by a single consumer.

of the copy matter little if the music is not appreciated. An important feature of the function g is that consumers who make better informed choices are willing to pay a higher premium for the original.

To simplify computations, we take the linear form $g(|\omega - l|) = \gamma(1/2 - |\omega - l|)$. This gives the added benefit of $\gamma/2$ for an original at the ideal location and zero added benefit for a product at maximal distance 1/2. Taking other functional forms would give the same qualitative results.

A consumers utility when he buys. If a consumer buys the original at location l and price p he obtains utility

$$v(1,0) = r + \gamma(1/2 - |\omega - l|) - \tau|\omega - l| - p$$

If he downloads and purchases the original version of a product he obtains

$$v(1,1) = r + \gamma(1/2 - |\omega - l|) - \tau|\omega - l| - p - s$$

Clearly, for a given product $v(1,0) > v(1,1)$. A consumer is only willing to pay the opportunity cost of downloading s if he expects to be able to buy a product better suited to his tastes. Note also that for a given product l, the utility gain from buying is $\gamma(1/2 - |\omega - l|) - p$.

To summarize, a consumer's utility can be written as

$$v(b,d) = \max\{b,d\}r + b\gamma(1/2 - |\omega - l|) - \max\{b,d\}\tau|\omega - l| - bp - ds.$$

3. Sampling and the label's revenues

To highlight the basic trade-off between availability and non-availability of P2P we analyze the simple model presented in the previous section and elaborate on the trade-off between the *competition* and the *matching effect*. In our simple setting, P2P is the only way to transmit information about the characteristics of a particular album to consumers. While this is an extreme assumption it allows us to clearly state our main point that P2P increases the information available to consumers and that this may benefit firms.

The competition effect. A consumer has to decide whether or not to buy the original. His outside option is not to buy in the market. Then if P2P increases the expected utility to buyers P2P increases the value of the outside option, which is not to buy any product. Here the download becomes a competitor to the original and we refer to this as the competition effect. The competition effect tends to reduce the firm's profit.

With P2P consumers learn the location of all products and only consider the one which is closest to his ideal location. Downloading is ex post rational for all consumers if it is for the marginal consumers. A consumer is a marginal consumer if he is indifferent between the preferred album to its left and to its right on the circle, i.e. $|\omega - l_i| = 1/(2N)$ for those albums. If a marginal consumer only downloads but does not buy his utility is

$$\hat{v}(0,1) = r - \tau\frac{1}{2N} - s$$

If he does not download his expected utility is $u(0,0) = v(0,0) = 0$. We say that there is a *competition effect* if $\hat{v}(0,1) > u(0,0) = v(0,0) = 0$ which is equivalent to

$$s < r - \tau\frac{1}{2N}. \tag{3.1}$$

The matching effect. There is a countervailing effect: downloading enables a consumer to buy the music he likes. In this sense, P2P leads to a better match between consumer and purchased product, which increases his willingness-to-pay.

Without P2P consumers cannot distinguish ex ante between the different albums and buy at random. The expected distance to the ideal variety is $E|\omega - l| = 2\int_0^{\frac{1}{2}} l dl = \frac{1}{4}$. Their expected utility is therefore

$$\begin{aligned} u(1,0) &= Ev(1,0) = r + \gamma/2 - \gamma/4 - \tau/4 - p \\ &= r + (\gamma - \tau)/4 - p. \end{aligned}$$

With P2P consumers who download learn the location of the products. The utility of a marginal consumer is then

$$\hat{v}(1,1) = r + \gamma\left(\frac{1}{2} - \frac{1}{2N}\right) - \tau\frac{1}{2N} - p - s.$$

We say that there is a *matching effect* if $\hat{v}(1,1) > u(1,0)$. This is equivalent to

$$s \leq \frac{\gamma + \tau}{2}\left(\frac{1}{2} - \frac{1}{N}\right). \tag{3.2}$$

For this condition to hold, the opportunity cost of sampling has to be sufficiently low. The matching effect tends to allow the monopolist to charge a higher price and still cater to all consumers.

Clearly, for the sampling cost sufficiently low both the matching and the competition effect are present: it becomes worthwhile to download for any given purchasing decision. Combining (3.1) and (3.2) we obtain

$$s \leq \min\left\{\frac{\gamma + \tau}{2}\left(\frac{1}{2} - \frac{1}{N}\right), r - \frac{\tau}{2N}\right\}. \tag{3.3}$$

As N large this condition becomes approximately $s < \min\{(\gamma + \tau)/4, r\}$.

We are interested in the analysis of situations in which both the matching and the competition effect are present. To do so, we have to bear in mind that the purchasing decision is endogenous. We next explore the monopolist's behavior for a given download decision and then endogenize all decision variables.

Prices and profits without P2P. Since all consumers are identical ex ante (because they do not know where products are located) the monopolist's profit is

$$\pi(p; d = 0) = \begin{cases} p & \text{if } p \leq r + (\gamma - \tau)/4 \\ 0 & \text{if } p > r + (\gamma - \tau)/4 \end{cases}$$

The monopolist then sets its price so as to extract the full surplus from consumers and $u(1,0) = u(0,0)$. We therefore have the following result.

Lemma 1. *Given $d = 0$, the profit-maximizing firm sets $p^0 = r + (\gamma - \tau)/4$ and makes profit*

$$\pi^{0*} \equiv \pi^0(p^0; d = 0) = r + (\gamma - \tau)/4. \tag{3.4}$$

All consumers buy.

Prices and profits if all consumers download. Consider the other extreme scenario in which all consumers use P2P, download all products, and consider buying their favorite product. Consumers now make their decision in a full information environment. If all consumers buy the product then the maximal distance between the location of the product and the ideal location of any consumer is $1/(2N)$. Suppose that it is optimal for the monopolist to serve all consumers. If a marginal consumer downloads but does not buy his utility is $\hat{v}(0,1)$. Alternatively, he may decide to buy one of the two preferred albums after downloading. This gives utility $\hat{v}(1,1)$. After downloading, a marginal consumer is weakly better off buying if $\hat{v}(1,1) \geq \hat{v}(0,1)$ which is equivalent to

$$p \leq \gamma \left(\frac{1}{2} - \frac{1}{2N} \right) \tag{3.5}$$

If this inequality is satisfied the action $(1,1)$ gives a larger utility than $(0,1)$ also to inframarginal consumers. Hence, given sampling, i.e. $d = 1$, if inequality (3.5) holds, all consumers buy, i.e. $b = 1$.

To see that a multi-product monopolist does indeed want to serve the whole market, note that in order to obtain demand x for a particular album the participation constraint $v(1,1) \geq v(0,1)$ has to be satisfied for all consumers in a neighborhood $x/2$ of that album. Profit for that single album takes the form $(\gamma/2)x(1-x)$. Consequently, profit-maximizing demand for that album is $x = 1/2$. This implies that for $N \geq 2$ the monopolist will cover the whole market. We summarize with the following lemma.

Lemma 2. *Given $d = 1$ the profit-maximizing firm sets $p^1 = \gamma \left(\frac{1}{2} - \frac{1}{2N} \right)$ and makes profit*

$$\pi^{1*} \equiv \pi(p^1; d = 1) = \gamma \left(\frac{1}{2} - \frac{1}{2N} \right). \tag{3.6}$$

All consumers buy.

The profitability of P2P. We can now compare profits. Since all consumers buy one unit profits with P2P are greater than without P2P if $p^1 \geq p^0$, provided that condition (3.3) is

satisfied. This is equivalent to

$$r \leq \frac{\gamma}{4}\left(1 - \frac{2}{N}\right) + \frac{\tau}{4}. \tag{3.7}$$

Proposition 1. *Suppose that the matching and the competition effect are present, i.e. condition (3.3) is satisfied. The introduction of P2P leads to an increase in prices from p^0 to p^1 and in profit from π^{0*} to π^{1*} if condition (3.7) is satisfied.*

Proof. Consider first the case that no P2P is available. Condition (3.3) implies that price p^0 is the profit-maximizing price and π^{0*} the corresponding profit (see Lemma 1). Consider now the case that P2P is available. Then, p^1 solves $\hat{v}(1,1) = \hat{v}(0,1)$ (see Lemma 2). That is, if consumers download it is worthwhile for all of them to buy the version for sale at the second stage of their decision process. Condition (3.7) implies that $p^1 \geq p^0$. For $p^1 \geq p^0$ we have that $u(1,0) \leq u(0,0) = 0$. Finally note that condition (3.3) implies that $\hat{v}(0,1) \geq u(0,0)$ – this is the competition effect. To summarize these findings, $\hat{v}(1,1) = \hat{v}(0,1) \geq u(0,0) = 0 \geq u(1,0)$. Hence at the first stage, consumers decide to download. Since condition (3.7) is satisfied, P2P leads to higher prices and profit. **Q.E.D.**

As stated in Proposition 1 the introduction of P2P leads to an increase in prices and profit if condition (3.7) is satisfied. How does this condition relate to the matching and competition effect? The size of the matching effect can be measured by $\hat{v}(1,1) - u(1,0)$ and the size of the competition effect by $\hat{v}(0,1) - u(0,0)$. The matching effect dominates the competition effect if $\hat{v}(1,1) - u(1,0) > \hat{v}(0,1) - u(0,0)$. Proposition 1 has the following implication:

Corollary 1. *The introduction of P2P leads to an increase in prices and profit if the matching effect dominates the competition effect.*

Proof. The condition that the matching effect dominates the competition effect can be rewritten as $\hat{v}(1,1) - \hat{v}(0,1) > u(1,0) - u(0,0)$. In the absence of P2P the firm sets $p = p^0$. At this point $u(1,0) = u(0,0) = 0$. Hence, the inequality from above becomes $\hat{v}(1,1) - \hat{v}(0,1) > 0$

at $p = p^0$. With P2P the firm can therefore increase its price and still sell to all consumers at a higher price. This leads to higher profits. **Q.E.D.**

For P2P to be beneficial it is necessary for the label to be a multi-product firm. Namely, $N > 2$ is a necessary condition so that inequality (3.7) can be satisfied. This can be explained by the disadvantage to reveal information for a single product offered by the label. With P2P (so that information is revealed) the added value for the marginal consumer determines the price whereas without P2P consumers have to take expectations so that the *average* added value determines the price — with a single product the average added value is greater than the added value at the margin. If the label offers more than two products sampling allows consumers to pick a product which comes quite close to their ideal location and the value from information is larger the larger N. By contrast, without sampling an increase in the number of albums does not lead to better choices on average. This captures the multi-product aspect of sampling; an aspect which is absent in other work (see our literature review in the introduction). Our result thus highlights the role of labels offering a large number of products under P2P: it provides consumers the possibility to make more informed choices. Consequently, the larger the number of products the more likely that condition (3.7) is satisfied. For N large, we must have approximately $r < (\gamma + \tau)/4$.

We also observe that a higher transportation cost and a higher value of the original (for $N > 2$), which is measured by γ, tend to make P2P more attractive for the firm. This is explained by the advantage of P2P: consumers obtain the product which better fits their tastes.

Numerical example. A numerical example may be helpful for illustration. Suppose that $s = 1/2$, $r = 3/4$, and $\gamma = \tau = 2$. First note that condition (3.3) is satisfied for $N \geq 4$. Also condition (3.7) is satisfied if $N \geq 4$. Independent of N we have without P2P that $p^0 = \pi^{0*} = 3/4$. We have with P2P that $p^1 = \pi^{1*} = 1 - (1/N)$.

Welfare. If P2P leads to higher profit (i.e. if the conditions of Proposition 1 hold), we have an unambiguous welfare result. Welfare necessarily increases because without P2P consumers obtain zero net surplus whereas with P2P inframarginal consumers obtain a strictly positive net

surplus. (Marginal consumers still obtain zero net surplus in this latter case.) Therefore we have the following welfare result: if the conditions of Proposition 1 hold, introducing P2P leads to a Pareto-improvement, that is, the firm and all consumers are better off.

Music genre. Our model can be applied to music in general or to music of a specific genre. With respect to the first interpretation if a consumer finds out about new genres thanks to file-sharing then this simply means that in the absence of file-sharing he is restricted to consume music which he is used to and that provides a rather bad match to his tastes. The discovery of a new genre that he prefers then leads to a better match. With respect to the second interpretation, file-sharing may lead to additional demand if consumers learn about genres of music they did not know before and they like, provided that they do not substitute one genre of music by another. Following the second interpretation there is a demand-increasing effect of P2P which is not included in our model. If we took this additional effect into account our result would be reinforced.

Downloads and loyal music buyers. Proposition 1 was derived under the assumption that all consumers download. A straightforward extension is to consider a population mix in which a share λ of the population never downloads. We call consumer belonging to this group loyal music buyers because they do not consider substituting purchased versions for downloaded files. If these consumers are informed about the different albums (perfect precision) then, if λ is not too large, the label's maximization problem has the solution that both groups buy the original. The price is determined by the incentive constraint of the downloaders. If loyal music buyers are less informed about the albums then, for certain parameter values, the price is determined by the participation constraint of the loyal music buyers. Even if loyal music buyers have the same ex ante information as downloaders profits may be higher with P2P (a necessary condition is that λ is not too large). However, in this case loyal music buyers do not buy at all when P2P networks are available.

4. Sampling and cost reduction

In the previous sections we have assumed that sampling is the only means for consumers to gather information. This can be criticized on two grounds. First, as a matter of fact labels spend large amounts of resources on marketing and promotion. This can be seen as an attempt to inform consumers. Our model did not allow for the possibility that labels spend on marketing and promotion. Second, there is some empirical support for the claim that file-sharing negatively affects revenues (see footnote 2). However, such finding does not invalidate our previous result that revenues increase because current file-sharing systems are not well-designed for sampling purposes. Nevertheless, it seems to us useful to point out that the matching effect can also operate on the cost side of the label and that higher profits with P2P are compatible with lower revenues.

In this extension we show that sampling may lead to higher profit even if revenues are decreased. Revenues are lower if labels have to lower their prices to make downloaders buy the original compared to a situation in which downloads are not available. However, since labels save on marketing and promotion they may enjoy higher profits.

We make our argument in a slightly extended model. We stick to the monopoly set-up.[11] In our basic model, consumers only received information about the location of products through downloading. In this extension, the label decides whether to fully inform all consumers about the location of its products through marketing and promotion. It can do so by spending a cost c.[12] For simplicity and consistent with our specification of sampling costs, this cost does not

[11] To be directly applicable to a multi-label context, firms not only must collude over price, in addition, they must jointly do the marketing and promotion of their products. Otherwise, provided that they choose to inform consumers, their aggregate expenditure for marketing and promotion is likely to exceed those under monopoly. This reinforces our result about the profitability of P2P.

[12] This is clearly an extreme assumption. A major problem for labels is to transmit information and because of high costs it may refrain from transmitting the full information. In a follow-up paper (Peitz and Waelbroeck, 2004c) we use a related model and elaborate on the information transmission through marketing and promotion. In that model, a label often decides to only partially inform consumers. In this case the following result can be

depend on N. To summarize, we analyze a market in which the firm first sets the price and decides whether to inform consumers itself, second consumers decide whether to download and third whether to buy.

Prices and profit without P2P. From Lemma 1 we know that the firm makes profit $r+(\gamma-\tau)/4$ if it does not use marketing and promotion. Otherwise, assuming that the firm maximizes its profits by selling to all consumers it sets its price equal to $r+(\gamma/2)(1-1/N)-\tau/(2N)$. In this latter case its profit is $r+(\gamma/2)(1-1/N)-\tau/(2N)-c$. It is profit-maximizing for the firm to use marketing and promotion if $c<\frac{\gamma+\tau}{2}\left(\frac{1}{2}-\frac{1}{N}\right)$. Clearly, marketing and promotion can only increase profit if $N>2$.

Prices and profit with P2P. If consumers are informed via marketing and promotion they can simply download their favorite song (given our assumption that downloading only has a fixed opportunity cost for consumers, they incur this cost also when downloading a single file). If consumer ω buys the product he has utility $v(1,0)$, if he downloads he has $v(0,1)$. Hence, the firm that uses marketing and promotion (and sells to all consumers) has to set the price such that $v(1,0)\geq v(0,1)$ for all values of $|\omega-l|$ with $|\omega-l|\leq 1/(2N)$. This is equivalent to $p\leq s+\gamma\left(\frac{1}{2}-\frac{1}{2N}\right)$. Alternatively, if consumers are not informed via marketing and promotion, Lemma 2 applies and the firm sets $p=\gamma\left(\frac{1}{2}-\frac{1}{2N}\right)$. Hence, not to use marketing and promotion is profitable if and only if $c>s$. In this case it is more costly to transmit information via marketing and promotion than to let consumers sample.

The profitability of P2P. As shown above, if $s<c<\frac{\gamma+\tau}{2}\left(\frac{1}{2}-\frac{1}{N}\right)$ the introduction of P2P leads to sampling instead of marketing and promotion. Then the firm has a higher profit if $\gamma\left(\frac{1}{2}-\frac{1}{2N}\right)>r+\gamma\left(\frac{1}{2}-\frac{1}{2N}\right)-\frac{\tau}{2N}-c$ which is equivalent to $c>r-\tau/(2N)$. Hence, if the value of a copy r is low compared to the cost of transmitting information through marketing and promotion, the firm benefits from P2P. However, provided that the competition effect is present

shown: The introduction of P2P leads to (i) higher profit but (ii) lower revenues, (iii) a replacement of marketing and promotion by sampling, and (iv) better informed consumers. Our result documented in Proposition 1 shares features (i) and (iv). In this section our result documented below shares features (i)-(iii) but not (iv).

so that $r - \frac{\tau}{2N} > 0$, prices and revenues are lower with P2P. To summarize, if $c > r - \tau/(2N) > 0$ profit increases with P2P but prices and revenues decrease.

5. Discussion and conclusion

We have analyzed the impact of sampling on profits. We placed our analysis in the context of the music industry where music used to be bought on CDs but has recently become available in the easily transportable MP3-format on file-sharing networks. If consumers download and listen to music to find out which music they like to buy, we referred to as sampling. This improves the matching between products and buyers and tends to make downloads complements for CDs – this has been called the matching effect. On the other hand the fact that downloads can be consumed without buying the corresponding CD tends to make downloads substitutes for CDs – this has been called the competition effect.

The main question is whether music labels necessarily suffer from downloading on file-sharing networks. In our basic model profits increase for a certain set of parameters because the price of CDs increases after the introduction of file-sharing networks and consumers make more informed purchases after the introduction of P2P. In an extended model we show that profits can increase even though the price of CDs falls. Here, the fall in revenues triggered by the presence of P2P is more than offset by the reduction of costs for marketing and promotion.

Furthermore, if promotion and advertising costs are significant at the margin or even prohibitive as in our main analysis, less information is transmitted in a traditional distribution system than under the use of P2P. This is an admittedly simplifying picture: even a P2P network that works with advanced search tools such as cross recommendations and individual recommendations based on past downloads is unlikely to provide full information (see below). However, we do believe that customized information available through P2P networks is likely to generate better recommendations than "blind" marketing and promotion.[13] We would therefore

[13] Even in a world in which information is acquired via P2P, marketing and promotion still plays a role. In particular, targeted online advertising seems a way to combine information-push and information-pull technologies.

argue that our model is a bit simplistic but a useful starting point for further research. Below we discuss a number of modifications and extensions of our model.

The cost of downloads to consumers. Our model can be easily extended to account for the case of positive opportunity costs of sampling an additional file. If consumers have a positive and sufficiently high opportunity cost of sampling additional songs they do not sample all songs. Indeed, in reality consumers only sample a subset of available songs. However, if this sample is sufficiently large and if consumers can be guided in their sampling towards their favorite music the qualitative features of our main result still hold. In the opposite extreme, if the opportunity cost of downloading an additional file is large for all users even for a small sample, consumers would hardly sample at all and P2P would not be a threat to standard business models. On an intermediate range, consumers engage in some search but fall short of finding their best match. A formal analysis with a directed search model seems promising to us.

Market coverage. In our simple model we assumed that the market is always covered. For a different set of parameters the market is not fully covered with P2P so that some consumers do not buy originals at all. Even in this case P2P may be profit-increasing because a label's markup can be drastically improved and this may overcompensate the loss in units sold. This means that in our model, both price and quantity sold may decrease after the introduction of P2P but profits nevertheless increase because labels save on the cost of marketing and promotion.

Variable individual demand. Several surveys have asked whether P2P has increased or decreased the number of purchases for a given period (see e.g. Peitz and Waelbroeck, 2004b). To formally address this question, our model with unit-demand would need to be modified to include variable individual demand or at least partial participation. In such a model the matching effect, which in general increases the marginal willingness to pay, leads to an outward shift of the individual demand function. On the contrary, the competition effect leads to an inward shift of the individual demand function. With respect to revenues and costs the same economic mechanisms as in our simple model seem to be at work.

New business models, consumer information, and directed search. The music industry seems

to have recognized that the only alternative to P2P networks on which copyrighted material is exchanged for free is the online sale of music in MP3 or other (better) compressed formats. Then as consumers pay a price for these downloads, downloading becomes a positive source of revenue in itself.[14] Selling downloads requires the music industry to strike a balance between the consumers' interest in unrestricted use and compatibility and the industries' interest in avoiding the transfer to other consumers.

Of particular importance is the question to which extent these new business model allow sampling and more generally information transmission. They have the potential to reduce informational inefficiencies of the traditional distribution system by promoting and recommending new products online and targeting only consumers who have the highest likelihood to purchase (either a download or music in a traditional format such as a CD). Using smart software to track past purchases and streaming and to recommend new music based on purchases of consumers with similar taste would allow record companies to save on the large costs of marketing and promotion by transferring part of the cost of information transmission to consumers who are better informed about their own tastes (and may to some extent even enjoy sampling).[15] This may lead to directed search by consumers so that the associated sampling cost is much lower than with current file-sharing systems, which, with the existing software, are not very helpful in guiding the consumer to his favorite music. However, for directed search to work consumers must be allowed to "experience" the product. Currently, intermediaries who provide pay-per-download services typically provide some information to consumers which may facilitate search but free listening is severely restricted (30 seconds listening to a song cannot substitute listening to the full song).[16]

[14] Recent experiences with iTunes in the US and OD2 in Europe suggest that finally there may exist viable business models to sell downloads to consumers. In particular, iTunes, which was launched in mid 2003, claims to have sold more than 150 Mio. downloads by November 2004.

[15] Clearly targeted marketing and promotion can also reduce costs. However, even in this case record companies still have to pass information to a heterogeneous group of consumers.

[16] An exception is the digital-right-management solution recently adopted by Kazaa which allows consumers to

Star and niche performers. It is a salient feature of the music industry that there are some star performers and many other artists whose albums sell on a much smaller scale. Perhaps the main reason is that some music appeals to many listeners whereas other music to few. Such asymmetry can be introduced into our Salop model. Two specifications come into mind: (a) the present setting with an additional "quality" dimension (consumers then learn about the horizontal characteristic and quality through sampling); (b) the present setting with the modification that products are not equidistantly spaced on the circle. In the absence of P2P, labels only promote acts with a sufficiently large drawing. Sampling then can lead to more successful "small acts" because high fixed costs of promotion can be avoided — this may lead to more music variety.[17] Further explorations along these lines are certainly of interest and we plan to continue our research in this direction.

Music variety. In this paper we treated the number of products, i.e., albums or titles, as given. The lobby of the music industry has painted the horror picture of a world without music as online piracy takes over and rips artists and record companies of their sources of revenues. This is clearly a caricature as musicians have other sources of revenues such as live concerts and do not only respond to monetary incentives.[18] Moreover, P2P networks allow new artists to enter the market with lower distribution and marketing costs.

The less drastic statement that the definition and enforcement of property rights affects the "production" of music certainly cannot be dismissed. Hence, it would be of interest to analyze how P2P affects the variety (and quality) of music. Since variety of artistic expression is often seen as a public good in itself, research in this direction would contribute to the public policy

listen to a song for free for a certain number of times before purchase.

[17] This would also be the case if marketing and promotion were successful in targeting the relevant consumer segment. However, labels are apparently not able to devise such a fine-tuned targeting technology.

[18] As Gayer and Shy (2004) have shown in a model with network effects, music labels and artists are likely to have conflicting interest over the availability of free downloads. The reason is that a larger number of downloads tends to increase the popularity of the artist. This in turn gives higher revenues to the artist (but typically not to the label) through live concerts.

debate. Such an analysis would certainly be value-added but would in our opinion benefit from a more elaborate model in which artists are an additional group of players in the market.

Sampling of other digital goods. We have placed the analysis of sampling within the music industry. Repeated use and the discovery of product characteristics are also key feature of other industries such as software and video games. In these industries it is a standard practice to distribute demos and free trial versions which allow consumers to sample. Consumers are expected to buy the product if they want to continue using them after some period. Hence, in these industries firms have already partly recognized the importance of sampling and adjusted their business strategies.

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