Stardom, Peer-to-peer and the Socially Optimal Distribution of Music

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Abstract

Music industry is "facing the music" now. Big stakeholders try very hard to maintain their positions while other players see opportunities in the advent of peer-to-peer networks. Music, as a kind of representative information good, deserves its economic properties to be examined and made explicit. Using the familiar Hotelling (1929) model of product differentiation, I show that the current music distribution is inefficient and peer-to-peer file-sharing networks may be a solution. Further, I explain why big labels want to prevent the development of peer-to-peer networks and propose a market mechanism that improves the social welfare without endangering the artists' incentive to create music.

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1 Introduction

"No musicians are hurt in the writing of this paper" - The author.

The music industry is undergoing a profound change now. The penetration of CD burners, MP3 players, broadband and peer-to-peer (P2P) networks accelerated the writing of new rules. The issue is interesting because music enjoys many unique properties, and these properties have not been thoroughly addressed by economic theory. The advent of the Internet further complicates the problem; music, originally a kind of very representative information good, has its economies unleashed by the Internet.

The trade association representing the big labels, the Recording Industry Association of America (RIAA), has sued and driven Napster out of business. But there are many so called Napster Clones flourishing[1], they do not rely on a central server, they occupy less bandwidth, and collectively they attract even more users than Napster. Major music labels are also changing, they started to test online music distribution business models[2], but so far, they have attracted few consumers.

Although a Jupiter Media Metrix report expects online music sales to soar[3], RIAA's mid-year chart of 2002 shows a gloomy picture[4]. According to RIAA, the CD shipments dropped 7 percent in the first six months of 2002, this is on top of 2001's overall 5.3% drop[5].

After winning a lawsuit for $1 million with Integrated Information Systems for allowing its employees to access and distribute thousands of MP3 files over the corporate network, RIAA is warning major universities and big companies and urging them "to ensure that their networks are not being misused to infringe copyrighted works"[6]. But the warning is challenged by Electronic Privacy Information Center (EPIC), which points out significant privacy and free speech concerns[7]. A proposal in Congress to legalize hacking of peer-to-peer networks was put forward by California Rep. Howard Berman; once enacted, it will let owners of

[1] Morpheus, KaZaA, Freenet, BearShare, Grokster, eDonkey, Gnutella, etc.

[2] MusicNet, Pressplay and Rhapsody, for example.

[3] Stone, M., 2001, "Online Music Sales to Hit $6B by 2006 - Jupiter. (Industry Trend or Event)", Newsbytes News Network, July 23.

[4] http://www.riaa.com/pdf/2002midyrchart.pdf

[5] http://www.riaa.com/News_story.cfm?id=552

[6] http://www.pcworld.com/news/article/0,aid,106959,00.asp, Nov. 14, 2002.

[7] Mark, R., 2002, http://boston.internet.com/news/article.php/1498081, Nov 11.

copyrighted material hack into and disrupt peer-to-peer networks. The measure attracted instant criticism from consumer groups, academics and technologists[8].

Different from previous papers addressing the issues related to piracy, this paper aims to stand on the viewpoint of a social planner and analyze the welfare implications of P2P networks to the music industry. The rest of the paper is organized as follows: In section 2, we review the literature concerning copyright law and music distribution. We then lay out a model of traditional music distribution in section 3, and show why RIAA wanted to sue Napster, and why smaller labels and new artists welcomed P2P networks. In section 4, we propose a new way of leveraging the power of P2P networks and achieving a Pareto improvement for all parties.

2 Literature Review

One of the earliest attempts to look at the issue of economics of copyright is Hurt and Schuchman (1966). Frase (1966) notes that Hurt and Schuchman's suggestions of tax relief and direct payment may not be appropriate. Breyer (1970), in a framework similar to Hurt and Schuchman, improves the arguments by focusing on author's right to benefit from the work and suggests using some sort of social welfare model in this context. Pethig (1988) examines the historical changes in the information goods market. He shows in a Cournot-Nash game where pirates[9] can copy information goods, the result is reduced profits for the copyright owner, profit-sharing contracts with authors, and less production of information goods. A recent work by Yoon (2001) specifies the optimal level of copyright protection for an individual producer and the society as a whole. He shows that an increase in copyright protection may increase or decrease the social welfare loss due to underutilization, but it will always decrease the social welfare loss due to underproduction. Watt (2000) is a nice recent survey on the economics of copyright.

Each time when there was an advance in copying technology, there would be lobbying, proposals, oppositions from content providers, and almost always, the

[8] Bowman, L., 2002, "P2P Hacking Bill May Be Amended", News.com, November 10, 2002.

[9] These pirates are different from later pirates people are talking about. These are pirating companies, they pirate the goods and sell to other people, which is a typical case of pirating of books. Later papers are more and more focusing on individual pirates, especially when legal frameworks can deter pirating sellers, and the Internet infrastructure enable individuals pirating of softwares and music easily.

content producers suffered losses. This is true in the case of introduction of Xerox copier in 1959, in the case of Sony Beta VCR in 1974, and the digital audio tape (DAT) in the 1980s. There are several seminal papers starting to talk about the effects of copying and pirating (Novos and Waldman, 1984; Liebowitz, 1985; Johnson, 1985; and Besen and Kirby, 1989). When software piracy becomes prevalent, there are also many papers addressing this issue.

Novos and Waldman (1984) show that when consumers have different copying costs, there is no social welfare loss due to underutilization, and only tenuous social welfare loss due to underproduction. Liebowitz (1985) concerns exclusively on photocopying of journals. He shows that under indirect appropriability, the purchaser of the original good takes the value of copies into account when determining their willingness to pay for the original, hence, the producer of the original good can capture some of the copying profit by charging a higher price for the good than they could in the absence of copying. He concludes that under some conditions[10], producer returns can increase with piracy. Liebowitz's model is not suitable for software or music market because he assumes that pirate copies can only be made from originals. Johnson (1985) uses a spatial production differentiation model to analyze two models of copying differing in characteristics related to marginal cost and fixed cost, he concludes that an increase in copying has uncertain effects on the price the monopolist charges for his creative work, but the revenue would decrease; in the long run, social welfare will depend on the numbers of people switching from buying to copying and the elasticity of supply. The author suggests that whether someone is buying or copying is determined by his valuation, his unit wage rate as well as cost of copying. In the market, people are separated into 3 segments: those don't care (very low valuation), those pirate (higher valuation but lower copying cost), and those buy (highest valuation but higher copying cost). This segmentation brings elegant math results, but it can not be generalized to the current situation for analyzing music distribution, because in the real world people with low wage rate can not even afford a computer, they have no way to use CD burners to pirate music, and very rich people may as well enjoy a high cognitive surplus by pirating music online (to show "I can trick the system"). At least in the context of music distribution, the distinction line between buyers and pirates should not be one monetary but cognitive. Besen and Kirby (1989) analyze 3 models where copies and originals are imperfect substitutes and marginal cost of copying is constant but greater than the marginal cost of produc-

[10] The most important condition is that the producer can price discriminate between consumers who copy and not.

ing originals, where copies and originals are perfect substitutes, but the marginal cost of copying is increasing, and where copyright royalties are considered. They show that long run welfare would depend on how copying affects the number of works produced, so copying should be restricted in the case where consumer gains are not much larger than producer losses. This result is very interesting if applied to the music distribution industry, a welfare analysis of consumer gains in a world of free music will shed light on strategy and policy.

Takeyama (1994) points out that all these previous models fail to consider the possibility that consumption of illegal copies can generate surplus for consumers of originals. Building on the works by Katz and Shapiro (1985, 1986) and Farrell and Saloner (1985, 1986), She shows that demand network externalities can induce greater firm profits relative to the case where there is no copying, it can also lead to a Pareto improvement in social welfare. Her paper hints that illegal copying can function as a form of price discrimination among different classes of consumers. Conner and Rumelt (1991) and Shy and Thisse (1999) follows the same reasoning and conclude that piracy may potentially raise the producer's profits.

Takeyama (1997) extends her work to show piracy may raise the legal demand by enabling the producer to credibly commit to not reduce its price in the future. Similar to Takeyama's work, Duchêne and Waelbroeck (2001) conducts a welfare analysis, they show when network externalities satisfy some conditions, the losses generated by illegal copies can be compensated by the introduction of new products. Alexander (2002) is a recent review of the relationship between digital distribution and market structure in the music recording industry. He first gives a very brief history of the music recording industry, then introduces relevant digital technologies and recent law suites. He concludes that it is progressively more costly for the firms in the industry to counteract file sharing through legal mechanisms, and the major firms in the industry is likely to face significant difficulties in controlling the reproduction and distribution of their products. Belleflamme (2002) extends a model proposed by Mussa and Rosen (1978), he shows that when the copying technology involves a marginal cost and no fixed cost, producers act independently, when the copying technology involves a fixed cost and no marginal cost, pricing decisions are interdependent. Gayer and Shy (2002a, 2002b) show that it is not always a good strategy to impose a hardware tax to compensate software producers when the software must be used together with the hardware, and it is possible for producers of digital information goods to utilize the Internet, such as P2P systems, to enhance sales of their goods sold in store. Although the

authors want to model the broad case of both software and music pirating, the assumptions are not satisfied in software pirating. Many unique properties of music distribution can not be reflected by the assumptions either.

Chen and Png (2002) summarized the previous research on piracy and copyright enforcement into three themes: the impact of piracy on the legitimate producer's sales and profit; the impact of piracy on social welfare and the optimal government policy; and how the legitimate producer should respond to piracy both through conventional business strategy, specifically pricing, and instruments particularly directed at piracy. In their model the government must consider how the publisher adjusts price and detection to changes in fine, tax, and subsidy, the key result is that increases in detection affect welfare more negatively than price cuts, also, tax is welfare superior to a fine, and subsidy is optimal.

There are few empirical attempts in the literature on this topic. Although facing strong critiques regarding the methods, Holm (2001) applies a contingent valuation approach to study willingness-to-pay for originals when illegal copies are available. He shows that piracy is insensitive to price cuts, and majority of the subjects wanted to pay a non-negligible amount for the original. The results can be be used in the calculation of damages of piracy. Using international panel data for music CDs and cassettes, Hui, Png and Cui (2001) provide empirical evidence that the demand for both goods decreased with piracy.

In summary, few works are done to explicitly analyze the economics of music distribution. Papers discussing software pirating and copyright protection in general can be drawn upon, but can not be relied to address the problems of music industry. Especially, theoretical and empirical works related to the specifics of music distribution should be done to gain a better understanding and then to provide policy insights to solve the problems.

3 A Model of Music Distribution

In this section we consider the question of why P2P networks are welcomed by many users[11] as well as some artists, and why RIAA wanted to drive Napster out of business. The model shows that the current music industry is inefficient in terms of consumer welfare gained from music. P2P networks can probably address the

[11] 60 million in the heyday of Napster, probably more today using various file-sharing softwares.

problem, but in the long run, the overall social welfare is likely to decrease due to P2P's harmful effects on music producers.

3.1 The market

We collapse the hierarchy of music distribution market to two sets of players: the consumers and the firms. The firms represent the artists, the producers, the distributors and the retailers. Although each mentioned party has different profit margin and different competition environment, we see the firms in the model as residual claimants of the value chain.

Building on Hotelling (1929), we see the market as composed of two firms located at the two ends of the line [0,1] and a continuum of consumers uniformly distributed along the line. The density is normalized to 1. We can as well model the market as an infinite line with many firms or, following Salop (1979) and Johnson (1985), a unit circle with N firms, but they do not add insights to the issue. We can see our model as only analyzing a segment of the market where many firms compete, we are focusing on any two of them.

Firms are horizontally differentiated, reflecting diversity of creative works; a consumer's distance to the firms measures her taste, the nearer she is to a firm, the more she likes the work. Consumers differ only in tastes, and they will buy at most one work from the two firms. So the customers are categorized into two groups by their location, each firm will have its own market niche (unless the market is dominated by one firm). The layout of this model has two implications: 1. there can not be two firms located at one location, since no two artists are exactly same (actually, no two songs are exactly same); 2. with scaling, we can model the relationship between any two firms in our framework.

3.2 Assumptions

ASSUMPTION 1: Both firms charge the same price.
This is not surprising, because CDs have a very low price dispersion across titles. The price of music CDs only reflects the average production cost (of course, plus some premium for each of the participants in the value chain). A good musician gets better paid by selling more CDs, but he can not charge more money for each CD.

ASSUMPTION 2: Each firm has a unique value to all the consumers, designated by v, so firm 0 and firm 1 each has value v_0 and v_1, respectively.
I use this measure to model a baseline willingness-to-pay for all consumers, with v_0 or v_1 higher representing the music is more valuable for all consumers. One way to understand this is that every musician has some talent which is exogenously determined. This value is recognized by everyone, but due to transportation costs, some consumers will not buy from a musician even if she has a high talent[12].

ASSUMPTION 3: Consumers' perceptions toward goods are affected by advertising.

This models the combined effects of stardom and persuasive advertising. I use stardom to reflect consumer inertia, Bain (1956) argues that consumers tend to be loyal to pioneering brands, Shmalensee (1982) offers a model showing how a high-quality incumbent can earn supranormal profit by deterring the entry of even high-quality entrants. Due to extensive advertising, a consumer may have a wrong perception of the quality (talent in this case) of the good. This is the classical assumption in the literature of experience goods.

Suppose the advertising has a scaling effect on the value, we assume with advertising level a, consumers' perceived value is changed from v to $v \cdot a$, with $a > 1$. Of course, the firm incurs an advertising cost $C(a)$, we assume $\frac{dC(a)}{da} > 0$, and $\frac{d^2C(a)}{da^2} > 0$. For the purpose of illustration, we will let $C(a) = a^2 - 1$ in the rest of the paper. Further, we assume, without loss of generality, that firm 0 does not have a budget for advertising[13], and firm 1 has unlimited budget for advertising[14].

ASSUMPTION 4: Consumers' incur linear transportation cost t, $t > 0$.
This is a standard assumption in this context, we can relax it and consider quadratic cost functions, it will not qualitatively change the result from the model.

ASSUMPTION 5: The two firms cover the whole market.
This is also a standard assumption, if the two firms can not cover the whole market, then there are some consumers in the middle of the line will not be served , and the two firms each form a monopoly around it.

ASSUMPTION 6: We assume there are a proportion α of consumers have access

[12] An example is that I admit Britney Spears has talent in performance, but I may not like her type of songs.

[13] There is no qualitative change to the model if we assume firm 0 has a limited budget.

[14] Think firm 1 as a star supported by big labels, and firm 0 as a street performer.

to peer-to-peer networks and can use it to download music. Further, we assume among these people, a proportion of β will eventually buy the CD from their preferred artist.

This assumption is different from that of previous models by Johnson (1985), Gayer and Shy (2002) and some others. In their models, cost of making a copy is the determining force affecting people's decision to copy, so only poor people with low income and those with lower copying cost will copy. But in reality, the set of copiers should not be determined either by the income level (per unit wage rate in Johnson's model), or marginal cost of copying. First, the cost of copying is reduced to a very low level nowadays. The two major sources of costs are no longer barriers for most of the people who want to copy music: 1. Search cost is reduced because there are more and more songs available in P2P networks, and some of the P2P softwares can search other P2P networks for songs[15]; 2. With more and more people connected to broadband (the catch-phrase for broadband advertisement is usually "downloading music and games"). Second, really poor people who has high values toward music may not be able to afford a computer to download and burn music to CDs. In this regard, music piracy is totally different from software piracy. So the traditional way of modelling piracy can not be used in the context of music. Also, with a near zero cost of copying, even rich people can enjoy a positive surplus by copying; the disutility of time and energy one gets from pirating may not be lower than the unit wage rate, but he or she can enjoy a cognitive surplus[16]. I assume a uniform distribution of these innate copyright violators.

ASSUMPTION 7: When consumers use P2P networks, they will learn the true value of the firms.

This reflects the fact that music is a kind of experience good[17], once you hear it, you know if you like it or not.

[15] KaZaA allows users to search other file swapping networks such as Fileshare and Grokster, which are all based on FastTrak protocol. There are on average more than 3 million users connected by KaZaA at any time, sharing 600 million files with a total size of 4 million GB.

[16] In other words, it is exogenously determined that some people enjoy from copying, and the others not.

[17] as defined in Nelson (1970)

3.3 The model of stardom

Given the assumptions, we first show the case when P2P networks are not available.

Firm 0 has an empty strategy set in this case, it has no budget for advertising, its value v_0 is exogenously determined. It incurs a fixed cost F_0 in creating the work and a marginal cost of c_0 in distributing the work.

Firm 1 spends advertising fee a to enhance its popularity (or perceived value), this fee will shift the perceived value to be $a \cdot v_1$. Firm 1 also incurs a fixed cost F_1 in creating the work and a marginal cost of $c_1$in distributing the work[18].

The consumers are located on the line uniformly, a consumer at a distance of x to firm 0 is located at a distance $1-x$ from firm 1. A consumer's utility is given by the following utility functions: if she buys from firm 0, then $U_{x,0} = v_0 - p - t \cdot x$, if she buys from firm 1, then $U_{x,1} = v_1 - p - t \cdot (1-x)$. But since firm 1 can use advertising to shift consumers' perceived value, her expected utility is then $E(U_{x,1}|a) = a \cdot v_1 - p - t \cdot (1-x)$, before she buys the music.

Firm's profits are given by: $\pi_0 = (p-c_0) \cdot D_0 - F$ and $\pi_1 = (p-c_1) \cdot D_1 - a^2 - F$, where D_0 and D_1 are demands for good 0 and good 1.

CONDITION 1: (market coverage) In order to get the market covered as assumed in assumption 5, it must be

$$p \leq \frac{v_0 + v_1 - t}{2}; \tag{1}$$

Proof: For firm 0, the consumer who is indifferent between buying and not buying is located at $\bar{x}_0$, where $U_{\bar{x}_0} = v_0 - p - t \cdot \bar{x}_0 = 0$, so we have $\bar{x}_0 = \frac{v_0 - p}{t}$. Similarly, we have the location of an indifferent buyer for firm 1 at $\bar{x}_1 = \frac{p+t-v_1}{t}$. In order to cover the market, it must be $\bar{x}_1 \leq \bar{x}_0$, which gives the condition: $t \leq v_0 + v_1 - 2p$. ■

CONDITION 2: (natural blockade) Without advertising effects, firm 0 is naturally

[18] The fixed cost is related to the creative production of music, it is hard to measure in monetary terms, but our analysis is not affected, we treat it as sunk cost in the analysis. In this spirit, we can write $F = F_0 = F_1$. In order to make a non-negative profit, we require $p > c_i$ where $i = 0, 1$.

blockaded[19] from the market when

$$t \leq v_1 - v_0$$

Proof: It is equivalent to say that firm 1 has a higher value even at location $x = 0$. So we have condition $v_1 - p - t \cdot (1-0) \geq v_0 - p - t \cdot 0$, which can be simplified as $t \leq v_1 - v_0$.■

The case of condition 2 is not an interesting one, because the value of good 0 is so low that it is not worthwhile to supply it at all.

ASSUMPTION 8: We assume that a firm 0 is not naturally blockaded, in particular

$$t \geq v_1 - v_0 \tag{2}$$

Now we add the strategic variable a for firm 1, suppose firm 1 uses advertising to maximize its profit in this market.

PROPOSITION 1: Firm 1 will choose advertising level

$$a^* = \frac{(p - c_1) \cdot v_1}{4t} \tag{3}$$

and the firms' profits are

$$\pi_0 = \frac{pv_1^2(pc_1 + c_0 - p) + 4tv_0(p - c_0) + t^2(4p - 4c_0 - c_0c_1 - 8F)}{8t^2} \tag{4}$$

and

$$\pi_1 = \frac{(p - c_1)[v_1^2(p - c_1) - 8tv_0 + 8t^2] - 16(1 + F)t^2}{16t^2} \tag{5}$$

Proof: A consumer who is indifferent between the two firms is located at $A = D_0(a)$, where A is given by equating the utility functions; i.e.,

$$v_0 - p - t \cdot A = a \cdot v_1 - p - t \cdot (1 - A).$$

[19] In this case, firm 1 does not need to take any strategic action (no advertising is needed), firm 0 can not be profitable whether it chooses to enter the market or not. This happens when firm 0 is of very low value to the consumers.

The firm's respective demands are

$$D_0 = A = \frac{v_0 - a \cdot v_1 + t}{2t}$$

and

$$D_1 = 1 - A = \frac{a \cdot v_1 - v_0 + t}{2t}$$

Firm 1 faces the maximization problem of $\max_a \pi_1 = (p - c_1) \cdot D_1 - a^2 - 1 - F$. Taking first-order condition:

$$\frac{\partial \pi_1}{\partial a} = \frac{\partial [(p - c_1) \cdot \frac{a \cdot v_1 - v_0 + t}{2t} - a^2 - F]}{\partial a} = \frac{(p - c_1) \cdot v_1}{2t} - 2a = 0$$

and the second-order condition is satisfied. We then obtain the profit maximizing advertising level $a^* = \frac{(p - c_1) \cdot v_1}{4t}$, and the profits

$$\pi_0 = (p - c_0) \cdot D_0 - F = (p - c_0) \cdot \frac{v_0 - a \cdot v_1 + t}{2t} - F = \frac{(p - c_0)[v_0 - \frac{(p - c_1) \cdot v_1^2}{4t} + t]}{2t} - F$$

$$= \frac{4tpv_0 - p^2 v_1^2 + pc_1 v_1^2 + 4pt^2 - 4tc_0 v_0 + pc_0 v_1^2 - c_0 c_1 t^2 - 4c_0 t^2 - 8Ft^2}{8t^2}$$

$$= \frac{pv_1^2(pc_1 + c_0 - p) + 4tv_0(p - c_0) + t^2(4p - 4c_0 - c_0 c_1 - 8F)}{8t^2}$$

Similarly,

$$\pi_1 = (p - c_1) \cdot D_1 - a^2 - 1 - F = (p - c_1) \cdot \frac{a \cdot v_1 - v_0 + t}{2t} - a^2 - 1 - F$$

$$= \frac{8pt^2 - 8tpv_0 + p^2 v_1^2 - 2pc_1 v_1^2 - 8c_1 t^2 + 8tc_1 v_0 + c_1^2 v_1^2 - 16(1 + F)t^2}{16t^2}$$

$$= \frac{(p - c_1)[v_1^2(p - c_1) - 8tv_0 + 8t^2] - 16(1 + F)t^2}{16t^2} \blacksquare$$

Although we have assumed that firm 0 is not naturally blockaded from the market, there is a condition such that with advertising, firm 1 occupies the whole market, and drives firm 0 out of business.

PROPOSITION 2: Competing with a star, an entrant suffers under the following conditions:

1. firm 1's distribution cost is lower, or
2. the CDs' market price is higher, or
3. the transportation cost is lower (people are more willing to try something they don't like), or
4. firm 1 has a higher value (more popular), or
5. firm 0's value is lower.

Except for the last two reasons, all other reasons are unfairly disadvantageous to the new entrant. In particular, Firm 0 is forced out of business if

$$(p - c_1) \cdot v_1^2 \geq 4t^2 + 4tv_0 \tag{6}$$

Proof: Similar to the proof of Condition 2, we are looking for a condition where an $\bar{a}$ is large enough to drive firm 0 out of business

$$\bar{a} \cdot v_1 - p - t \cdot (1 - 0) = v_0 - p - t \cdot 0$$

which gives $\bar{a} \cdot v_1 - v_0 \Rightarrow \bar{a} = \frac{t+v_0}{v_1}$. If the profit maximizing advertising level a^* in (3) is greater than $\bar{a}$, then the firm won't bother to advertise more than $\bar{a}$, because firm 0 is already unable to make any sales now. So the condition is $\frac{(p-c_1)\cdot v_1}{4t} \geq \frac{t+v_0}{v_1}$, which is $(p - c_1) \cdot v_1^2 \geq 4t^2 + 4tv_0$. The conditions follow from simple comparative statics. ■

PROPOSITION 3: Advertising campaign distorts the demand and supply of music in favor of stars.
Proof: The demand for good 0 is $D_0(a) = \frac{v_0 - a \cdot v_1 + t}{2t}$, $\frac{\partial D_0(a)}{\partial a} = -\frac{v_1}{2t} < 0 \ \forall v_1 > 0$ and $t > 0$. So the more firm 1 advertise, the less good 0 is demanded. Indeed, in the extreme case, if condition 3 holds, firm 0 gets no demand at all. ■

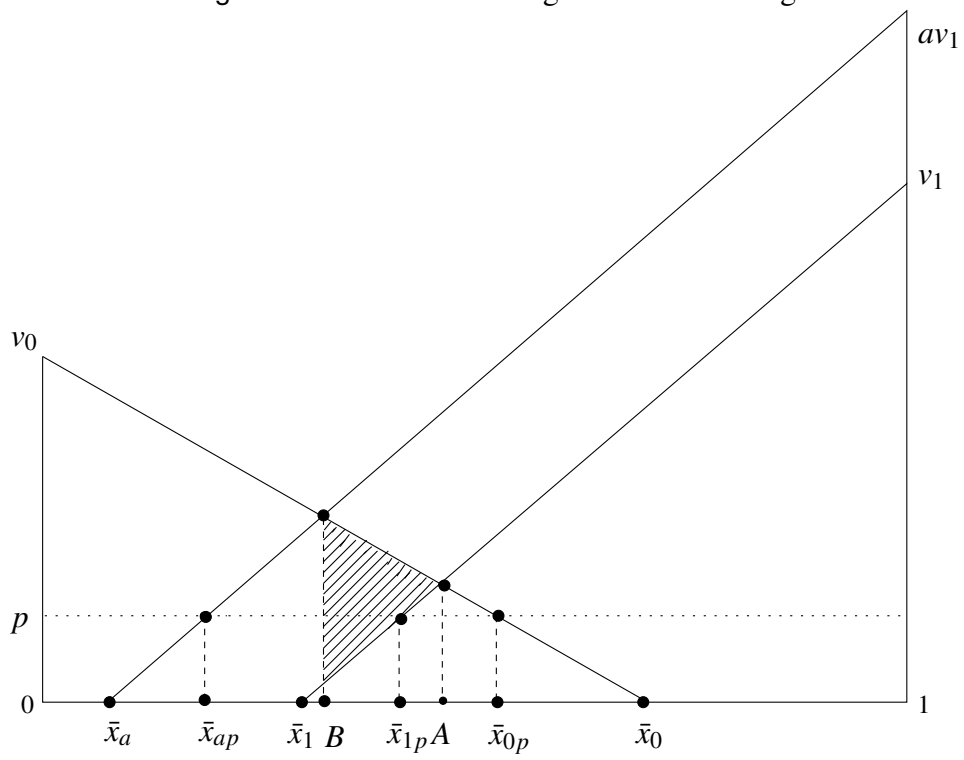
From equation (3), we see that although the star (firm 1) is not strategically deterring the entry of the entrant (firm 0)[20], it does reduce the demand for good 0. This is a source of social inefficiency, because there are some consumers who might have bought good 0 and enjoyed a higher surplus.

[20] The profit maximization level of advertising is not a response to the value of good 0, it is solely determined by good 1's value, distribution cost and transportation cost.

We now calculate the welfare loss induced by advertising. In Figure 1, due to the advertising and stardom effects, the demand of good 0 shifts from A to B, the indifferent buyer for good 1 moves from $\bar{x}_1$ to $\bar{x}_a$. The consumers located between $\bar{x}_1$ and A switch from buying good 0 to good 1, although they do not suffer a pure loss from purchasing from firm 1, they could have increased their utility by buying good 0. The consumers located between B and $\bar{x}_1$ also switch from buying good 0 to good 1, they end up suffering a loss from this switch.

Taking the first-best case as a benchmark, we can calculate the welfare loss resulted from advertising, which is the triangular shaded area in Figure 1.

Fig. 1: Social Welfare Change with Advertising



PROPOSITION 4: The consumer welfare loss resulted from advertising is

$$\Delta CS = -\frac{v_1^2 \cdot (a-1)^2}{4t} = -\frac{v_1^2 \cdot [v_1(p-c_1)-4t]^2}{64t^3} < 0$$

Proof: In order to calculate the consumer welfare loss, we need to find out the

values of A and B. From the proof of proposition 1, we can see

$$A = \frac{v_0 - v_1 + t}{2t}$$

and

$$B = \frac{v_0 - a \cdot v_1 + t}{2t}$$

the change in consumer surplus is simply the difference in utility, which is

$$\Delta CS = \int_B^A [v_1 - p - t \cdot (1-x)] - (v_0 - p - t \cdot x) dx$$

$$= \int_{\frac{v_0 - a \cdot v_1 + t}{2t}}^{\frac{v_0 - v_1 + t}{2t}} (v_1 - v_0 - t + 2tx) dx = -\frac{v_1^2 \cdot (a-1)^2}{4t}$$

Since $v_1^2 > 0$, $(a-1)^2 > 0$, and $t > 0$, $\Delta CS < 0$.

Also, $\frac{\partial \Delta CS}{\partial a} = -\frac{v_1^2 \cdot (a-1)}{2t}$, since $v_1^2 > 0$,and $a > 1$ (from assumption 3), we have $\frac{\partial \Delta CS}{\partial a} < 0$, so the more firm 1 advertises, the more consumers suffer from welfare loss. ■

3.4 The model of P2P market

We have shown that advertising campaign has negative effects on consumer welfare, this conclusion, however, is not very plausible due to the following reason. We are comparing the music industry structure with the first-best case where everyone has a correct prior for the talent of each firm. In reality, this can hardly be true, because before you buy the album, you can only estimate the value of each music CD, so the first-best outcome can never be reached. Since music is a kind of experience good, if a consumer can listen to the music and then decide whether to buy, the prior for the talent of a piece of music work will be more accurate. P2P networks offer such a way.

While it is a fact that P2P networks are used by some people to freely exchange MP3 files and copyrighted softwares, it is also a fact that P2P networks are not

used solely for that purpose. The computer science term for P2P networks is "distributed computing", and P2P has been proved useful in many exciting projects[21].

In our context, P2P helps to resolve the information asymmetry problem of music as "experience good". P2P networks bring great opportunities to less famous and new artists. These artists get exposure if people download their works, and if the β in assumption 6 is sufficiently high, they may be better off.

In particular, assuming when a consumer has access to a P2P network, she can download songs from both firms, and experience the songs. With a probability of β, she will purchase one of the two songs that gives her a higher real utility[22].

PROPOSITION 5: With P2P, firm 0 can be better off under some conditions, but firm 1 is losing for sure.
Proof: As shown in Figure 1, comparing with the stardom case, both firms will lose some sales (a proportion of α) due to the penetration of P2P, both firms will gain from the extra sales to the proportion of β "honest" consumers who buy albums after experiencing the songs with P2P. A firm's net gain can be defined as $netgain_i = gain_i - loss_i$,where $i = 0,1$. Specifically, the loss for firm 0 is $loss_0 = \alpha \cdot B \cdot (p - c_0)$, the gain for firm 0 is $gain_0 = \alpha \cdot \beta \cdot A \cdot (p - c_0)$. In order to be better off, firm 0 hopes to have gains bigger than losses, which is $\alpha \cdot \beta \cdot A \cdot (p - c_0) > \alpha \cdot B \cdot (p - c_0)$, so the proportion of "honest" consumers need to satisfy:

$$\beta \geq \frac{B}{A} = \frac{v_0 - a \cdot v_1 + t}{v_0 - v_{1+t}}$$

Similarly, for firm 1, we have the inequality $gain_1 > loss_1$:$\alpha \cdot \beta \cdot (1-A) \cdot (p - c_1) > \alpha \cdot (1 - B) \cdot (p - c_1)$, which is equivalent to:

$$\beta \geq \frac{1 - B}{1 - A} = \frac{a \cdot v_1 - v_0 + t}{v_1 - v_0 + t}$$

[21] For example, in a research project called Popular Power, P2P is used to improve influenza vaccine; in SETI@home, people use P2P to enhance the computing power to "Search for Extra-Terrestrial Intelligence"; some online content providers are experimenting ways to use P2P to broadcast a show to many people, the content stream can leverage the power of P2P among the viewers, so that the network bandwidth can be used better.

[22] According to an RIAA report done by Peter D. Hart Research Associates, about 14% of the surveyed consumers will buy the album when they hear a song they like by an unfamiliar artist. The same research shows that about 20% of surveyed consumers will download for free from file-sharing service. http://www.riaa.com, 2002 Mid-year Survey Presentation.

Since $B < A$, $\frac{1-B}{1-A} > 1$, so even if all people using P2P will buy the album he or she likes, firm 1 will still lose money as long as $B \neq A$, which is the case if firm 1 advertises in the market.

On the other hand, it is easier for firm 0 to gain with P2P, especially, when firm 0 is forced out of business. So if condition (6) holds, $B = 0$, even with only a very small proportion of "honest" consumers, firm 0 would be better off. ■

Proposition 5 explains why RIAA had to sue Napster, and free downloading indeed has a disruptive effect on the existing music industry structure.

PROPOSITION 6: Consumers are the winners of this transition. The more consumers use P2P or the higher the price of music CDs, the more consumers gain from P2P, specifically,

$$\Delta CW = \frac{\alpha}{4t} v_1^2 (a-1)^2 + (1-\beta)[(v_0 + v_1 - t)^2 + 4tp] \tag{7}$$

Proof: We first calculate the intersections' location in Figure 1: It is very easy to get, $\bar{x}_a = \frac{t-av_1}{t}$, $\bar{x}_{ap} = \frac{p+t-av_1}{t}$, $A = \frac{v_0-v_1+t}{2t}$, $B = \frac{v_0-av_1+t}{2t}$, $\bar{x}_1 = \frac{t-v_1}{t}$, $\bar{x}_{1p} = \frac{p+t-v_1}{t}$, $\bar{x}_0 = \frac{v_0}{t}$. In terms of consumer welfare, the $1-\alpha$ proportion of consumers who do not use P2P remain the same. For the α proportion of consumers who use P2P, we calculate the change in welfare in the following way:

First, we calculate the consumer surplus of the $(1-\beta)$ proportion of consumers who use P2P and do not pay at all:

$$CS_{1-\beta} = (1-\beta)[\int_0^{\bar{x}_0} (v_0 - tx)dx + \int_{\bar{x}_1}^1 (v_1 - t(1-x))dx]$$

Then we calculate the consumer surplus of the β proportion of consumers who use P2P and pay for the album:

$$CS_\beta = \beta[\int_0^A (v_0 - p - tx)dx + \int_A^1 (v_1 - p - t(1-x))dx]$$

Then we calculate the consumer surplus before the introduction of P2P:

$$CS_{old} = \int_0^B (v_0 - p - tx)dx + \int_B^1 (v_1 - p - t(1-x))dx$$

The total change in consumer welfare is then $\Delta CW = CS_{1-\beta} + CS_\beta - CS_{old}$, in particular,

$$\Delta CW = \alpha \cdot \{ (1-\beta)[\int_0^{\bar{x}_0}(v_0 - tx)dx + \int_{\bar{x}_1}^1 (v_1 - t(1-x))dx] + \beta[\int_0^A (v_0 - p - tx)dx + \int_A^1 (v_1 - p - t(1-x))dx] - [\int_0^B (v_0 - p - tx)dx + \int_B^1 (v_1 - p - t(1-x))dx]$$

$$= \alpha[(1-\beta)(\frac{v_0^2+v_1^2}{2t}) - \beta\frac{4pt - v_1^2 - 2tv_0 + t^2 - 2tv_1 + 2v_0v_1 - v_0^2}{4t} + \frac{4pt - 2v_0v_1 + t^2 - 2tv_1 - v_0^2 - 2av_1^2 - 2tv_0}{4t}]$$

$$= \frac{\alpha}{4t}(v_0^2 + 2v_1^2 - \beta v_0^2 - \beta v_1^2 - 4\beta pt + 2\beta v_0 t - \beta t^2 + 2t\beta v_1 - 2\beta v_0 v_1 + 4pt - 2tv_0 + t^2 - 2tv_1 + 2v_0v_1 + a^2v_1^2 - 2av_1^2)$$

$$= \frac{\alpha}{4t}[v_0^2(1-\beta) + v_1^2((a-1)^2 + 1 - \beta) + t^2(1-\beta) + 2v_0v_1(1-\beta) - 2t(v_1 + v_0 - 2p)(1-\beta)]$$

$$= \frac{\alpha}{4t}v_1^2(a-1)^2 + (1-\beta)[(v_0+v_1)^2 + t^2 - 2t(v_1 + v_0 - 2p)]$$

$$= \frac{\alpha}{4t}v_1^2(a-1)^2 + (1-\beta)[(v_0+v_1-t)^2 + 4tp]$$

We know all the terms in the equation are positive, so consumers enjoy a net gain. ■

Proposition 5 and proposition 6 reflect the *status quo* of music industry. Big labels can not bring in the previous level of profit, while smaller producers see P2P as a big opportunity for them to get known. The consumers are unambiguously better off no matter what proportion of them will purchase the album eventually. The overall social welfare change is yet to be examined.

From a social planner's point of view, we analyze the overall social welfare change in terms of the combined changes in firm 0, firm 1, and the consumers. In order to do this, we have to confine ourselves with a less dynamic time frame. In the long run, P2P networks will be more sophisticated, technology may advance to ensure copyright protection; the proportion of people using P2P networks will change; the proportion of "honest" P2P users will also change; big labels and smaller producers will take strategic actions to maximize their profits; legislative actions may be introduced[23]. What we do now is to compare the P2P model with the

[23] RIAA is trying to eliminate music sharing on P2P networks completely; Berman's proposal aims to get legal support for hacking P2P networks.

model of stardom, strategic and dynamic interactions between the stakeholders will be analyzed in the next section.

PROPOSITION 7: When P2P networks are used, the social welfare change is

$$\Delta SW = \frac{\alpha}{4t}[v_1^2(a-1)^2+(1-\beta)(v_1+v_0-t)^2+2t(c_1+c_0)(1-\beta)+2(c_0-c_1)(v_0-v_0\beta+v_1\beta-av_1)] \tag{8}$$

Proof: Denote the change in social welfare as ΔSW, we have $\Delta SW = \Delta\pi_0 + \Delta\pi_1 + \Delta CS$. From the proof of proposition 5 and proposition 6, we know

$$\Delta\pi_0 = \alpha\cdot\beta\cdot A\cdot(p-c_0)-\alpha\cdot B\cdot(p-c_0)$$
$$\Delta\pi_1 = \alpha\cdot\beta\cdot(1-A)\cdot(p-c_1)-\alpha\cdot(1-B)\cdot(p-c_1)$$

$$\Delta CW = \frac{\alpha}{4t}v_1^2(a-1)^2+(1-\beta)[(v_0+v_1-t)^2+4tp]$$

where $A = \frac{v_0-v_1+t}{2t}$ and $B = \frac{v_0-a\cdot v_1+t}{2t}$.

So we have

$\Delta SW = \alpha\cdot\beta\cdot A\cdot(p-c_0)-\alpha\cdot B\cdot(p-c_0)+\alpha\cdot\beta\cdot(1-A)\cdot(p-c_1)-\alpha\cdot(1-B)\cdot(p-c_1)+\frac{\alpha}{4t}v_1^2(a-1)^2+(1-\beta)[(v_0+v_1-t)^2+4tp]$

$= \frac{\alpha}{4t}[-2c_1v_0+2c_0v_0+2c_0t-2\beta c_0v_0+2ac_1v_1-2\beta c_1v_1+2\beta c_1v_0-2ac_0v_1-2\beta tc_1-2\beta tc_0+2\beta v_1c_0+2v_1^2-2v_0t+t^2-2tv_1+2v_0v_1+v_0^2-\beta v_0^2-\beta v_1^2-\beta t^2+a^2v_1^2-2\beta v_0v_1+2\beta tv_0+2\beta tv_1-2av_1^2+2tc_1]$

$= \frac{\alpha}{4t}[v_1^2(a-1)^2+(1-\beta)(v_1+v_0-t)^2+2t(c_1+c_0)(1-\beta)+2(c_0-c_1)(v_0-v_0\beta+v_1\beta-av_1)]$

■

Equation (8) is a very favorable message to the use of P2P networks. First, in reality, there is no evidence that the distribution costs incurred by stars and those by unknown artists are different, so the last term can be taken as zero. All the first several terms are positive, showing a social welfare gain for the society. If $\beta = 0$, when no P2P users pay for albums at all, the consumer will enjoy all the losses incurred to the firms, and the overall social welfare will also benefit from the saved distribution cost to the α proportion of P2P users. Even if $\beta = 1$, in which case, everyone using P2P are paying the albums (either willingly or forced by law), there is still a welfare gain of $\frac{\alpha}{4t}v_1^2(a-1)^2$, which corresponds to the consumer welfare gain from better choice.

4 A Win-win Market for All

In the short run, with P2P networks, the total social welfare has increased. All the losses from the firms are transferred to be benefits for consumers. For a social planner, it is wise not to ban P2P networks for now. P2P, like other technology advancements, proves to be beneficial to the society as a whole.

In the long run, however, if the proportion of "honest" consumers can not pay enough money to cover the fixed cost of creating music, musicians would no longer have incentives to produce as many and as good works, the overall social welfare will decrease as a result.

The solution is not to ban P2P at all as RIAA has been trying, but to leverage the power of this new technology and improve the market for all the participants. Banning P2P will result in an arms race between legal efforts from labels and the consumers who look for more freedom, Napster's shutdown and many other P2P file-sharing softwares' rising proves this.

As shown in section 3, P2P is in favor of unknown artists, stars are deprived of some previous privileges. I call this the "star's curse" in music industry. Although firm 1 is losing market, its true value is not discounted. Without the advantage from advertising, it can still earn a profit if its talent is high.

In this section, we try to address this issue by proposing a specific market structure. Since the usage of P2P by the consumers is inevitable, we design a market to leverage the power of P2P, so that the overall social welfare is improved.

I will only address the copyright infringement issues brought about by P2P; cases such as a street vendor selling pirate CDs or an offshore website offering FTP access to MP3 files will not be considered here, these problems are not new and they are easier to address with legislative measures.

Observation 1: Comparing with downloading from FTP sites, P2P makes a consumer better off by giving her a **wider choice** and potentially better **anonymity**. P2P also makes her a **source** providing the files for others to search and download in the future .

Anonymity may be the biggest reason for people to use P2P networks to download music. It is not always comfortable for people to ask friends for a copy of a CD, so downloading from a stranger's computer eliminates the feeling of guiltiness.

Observation 2: Connecting with a friend through P2P is not as harmful as connected to **strangers** through P2P in terms of copyright infringement.

Even before P2P file-sharing softwares are widely used, people could be connected by P2P through softwares like Laplink, PC-Anywhere, or even Microsoft HyperTerminal which is included in every version of MS Windows. People can transfer and share music files and copyrighted softwares long before the wide use of P2P file-sharing softwares, but file sharing has never posed a threat to the music industry as Napster and its clones do. The big difference is that now people can be connected to strangers.

Observation 3: It is technologically feasible to **monitor** the file transfers in P2P networks.

Napster lost its case because people rely on a central server to search for songs. But all P2P networks have some mechanisms to provide a menu of songs available. If built in the protocol to do a transfer accounting, we can have a very precise picture of what songs are exchanged, which artists are the most popular, who are the contributors and lurkers, when a song gets popular in its S-curve of diffusion, and how people are searching for songs.

Observation 4: There is no incentive for people to change the name of the songs in P2P network.

Since people will rely on a search of the song's name or the artist's name to locate a song, if a song's name or the artist's name is changed, it will not be easily found by others. If everyone changes the songs' names, the P2P network will not be useful at all to download songs.

Observation 5: Some network effects related to P2P:

1. Sarnoff's law: named after the pioneer of the broadcast industry, a broadcast network's value increases linearly with the number of participants.
2. Metcalfe's law: named after Bob Metcalfe, the inventor of Ethernet, the law says the value of a network grows in proportion to the square of the numbers of users.
3. Reed's law: named after David Reed, who proposed that group forming networks scales exponentially with network size in a 1999 article[24].

From n to n^2 to 2^n, P2P networks' incredible potential should provide us with some strategy in building a successful business model for music distribution.

[24] http://www.contextmag.com/archives/199903/digitalstrategyreedslaw.asp

Observation 6: P2P networks has a tremendous **advantage in saving** distribution cost, server hosting space, and bandwidth to the content distributors.

In the model in section 3, if a consumer chooses to download music from a P2P network, and if there is a mechanism to pay the artists in the P2P network, the firm actually can save the distribution cost and the marginal production cost for the CDs, CD cases, booklets, etc.

Observation 7: Like in the revolution of VCR to the movie industry, and radio to the music industry[25], P2P will **not substitute** the music industry completely.

There are only a proportion of people who want to use P2P networks, most people would still enjoy buying a CD and its well designed booklet with photos of artists and lyrics of songs.

Observation 8: It is feasible for an organization (ASCAP, BMI, or SESAC) to do the popularity accounting and collect royalties and distribute them to musicians and producers.

From these observations, we propose a market structure combining technological capabilities, legal enforcement and economic feasibilities that improve the overall social welfare without being harmful to the creative works of musicians.

In particular, consider a P2P network that is specialized for music distribution, people can use it just as they use Napster; but each time a user downloads a song, she should pay a small royalty fee to the P2P service provider. The P2P service provider can then split the fee into two parts: 1. some commission for the user who uploaded the song for this downloader; 2. the rest to be distributed by organizations such as ASCAP, BMI or SESAC to the copyright owners. The commission to the uploader gives incentives to share music in this network instead of other free file-sharing networks and at the same time rewards the uploader for distributing the music to more people and thus creating more value based on the music. The proportion to be distributed by ASCAP, BMI or SESAC will work in a similar way as royalties are distributed now.

There are several economic advantages in this system:

1. It gives incentives for uploaders to use this system instead of others because they are awarded for uploading. They can further use the credit to buy music from others, and their uploading and downloading will be legal.

[25] Both technologies contributed greatly to the development of the industries.

2. When uploaders shift to the proposed system, the provision of music in free file-sharing networks will decrease. If downloaders can not find the songs, they will move to the new network. There is no incentive for uploaders to provide the music in both networks because the free file-sharing market is cannibalizing his for-profit market.

3. The precision of popularity accounting will be greatly improved because the P2P networks can monitor each transaction.

4. It offers the copyright owner a better way to price discriminate or to implement vertical product differentiation schemes. Comparing with the original market where everyone is charged the same price, this can be a great opportunity for sellers. Traditional price discrimination such as "quantity discount" and "versioning" (in digital music context, different sampling frequency) can be used in P2P networks. These measures can compensate for the copyright owners' losses in the current free file-sharing systems.

5. Fake songs might be a problem in the system, a bad uploader may just upload files of noises disguised in the name of very popular songs. This can be easily addressed with a reputation system such as the one in eBay.com. More conveniently, each song can be given a digital fingerprint, so that it can be verified before download (MIT researchers have developed technology to extract fingerprint of audio which they call TunePrint, this TunePrint will not change if the mus ic file is sampled in different frequency, or compressed or translated into other formats[26]).

5 Conclusions

We have shown that before people can use P2P file-sharing networks, the distribution of music is inefficient. On one hand, the demand for music is distorted, on the other hand, some people who have lower valuations are deprived of the right to listen to the music. P2P networks help to provide a better information environment for music listeners to experience the music works; while smaller labels and unknown artists welcome the new technology, the big labels and stars suffer from the transition. The overall effects on social welfare is positive, but the it is harmful to the music industry if only a small proportion of P2P users buy albums.

[26] http://www.tuneprint.com

The paper also proposes a new market structure where everyone can benefit from P2P technology, and turn it to be a new driver of music industry development.

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