# FILE SHARING, COPYRIGHT, DIGITAL RIGHTS MANAGEMENT AND THE OPTIMAL PRODUCTION OF MUSIC

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**Abstract**

Much economic, political, judicial and legal attention has been showered on the significant changes currently in train within the music production and distribution business forced by the use of the Internet for both file sharing (of unauthorized copyrighted material) and more recently online (legal) music distribution. The strong demand for music coupled with the low cost of distributing illegal copies via peer-to-peer (P2P) systems is unraveling the business model by which music has traditionally been created, developed and distributed. Application of traditional copyright law has been ineffective in stopping the loss of business in the traditional channels. Producers have implemented forms of Digital Rights Management (DRM) in an attempt to protect their property via (technologically self-enforcing) contracts. Past DRM efforts have alienated customers, resulted in defective products, and in some cases laughably easy to defeat by "hackers." Producers assert that if the problem isn't solved somehow, music production will be sharply curtailed. The cost of "free" music via P2P will be less music and less choice, an outcome that all seem to agree is bad. In this paper, I attempt to answer the question whether or not a reduction in music choice is in fact bad. I model the music industry as a Hotelling-Salop differentiated products market, and using results from Bhaskar and To (2005) I show that significant overproduction can occur. The worst hypothesized loss due to file sharing tends to reduce this overproduction but not eliminate it. Applying successful DRM simply returns the market to overproduction. Taking account of potential externalities (using rough preliminary estimates of same) of creative material suggests that overproduction of music still occurs if customers' preferences are relatively flat in the neighborhood of their favorite music, in which case file sharing reduces this excess entry and DRM increases it. If preferences are relatively sharp in this neighborhood, underproduction will occur, in which case DRM may be socially as well as privately useful, if as emerging trends suggest it can be made relatively costless to legitimate customers.

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# TABLE OF CONTENTS

## 1. *Introduction*

The music business is in turmoil today; the traditional business model of the industry is being undermined by file sharing of their copyrighted material over the Internet using peer-to-peer (P2P) systems. The recording industry claims that file sharing has led to substantial losses in their traditional market of CD sales and has attempted to stem this loss by both legal and technological means. They claim that if performing, producing and distributing music becomes less profitable due to P2P file sharing, then less music will be produced.[1]

Enforcement of copyright has been ineffective against this threat, and the industry has begun to use software locks embedded in their products to prevent or limit copying. The initial deployment of this Digital Rights Management (DRM) went very badly for producers and customers alike. More recent evidence from the market, however, suggests that the latest forms of DRM are gaining substantial customer acceptance, although still not without problems.

In most industries, widespread theft of a product would be a police enforcement and industry issue, and not generate the public and scholarly controversy associated with file sharing. However, if P2P is a genuine threat to the profits of artists and producers, it is really is likely that less music will be performed, produced and distributed, which we presume to be a net social loss. Ultimately, the controversy is about the appropriate level of music production. Economic studies have focused on the extent to which file sharing has impacted CD sales, and thus industry profits. Other studies have focused on the extent to which DRM can recoup such sales without imposing substantial costs on customers.

In this paper, I model the music market as a *differentiated products market*, reconciling the obvious abundance of music in the market with copyright's grant of monopoly to the artist/producer. Such models have a rich history in economics, beginning with Hotelling's well-known paper[2] in location theory. I use very recent results[3] applied to the music industry to show that we should expect substantial excess entry into the music market (and differentiated product markets in general). For a wide range of plausible parameters, entry in equilibrium exceeds efficient entry by 40-60%. File sharing reduces industry profits and therefore reduces entry, but even using the very high estimates of P2P displacement of CD sales claimed by the recording industry, there is still excess entry, although mitigated by file sharing.

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[1] Advocates of file sharing do not accept this argument; they contend that file sharing is likely to increase music production as an alternative music distribution channel and a means by which customers can sample unpublicized artists. For a thoughtful (but provocatively titled analysis of this view, see O'Reilly, Tim, "Piracy is Progressive Taxation, and Other Thoughts on the Evolution of Online Distribution," at <http://www.openp2p.com/lpt/a/3015> (2002).

[2] Hotelling, Harold, "Stability and Competition," *Economic Journal* 39(1), 1929, 41 - 57

[3] Bhaskar, V. and To, T. "Is perfect price discrimination really efficient? An Analysis of free entry," *RAND J. Econ*, **35**(4) (2004) pp 762-776.

Intellectual property can also generate spillovers; this has long been recognized in technology and patents. Wagner[4] plausibly asserts that such spillovers also exist in the creative works, such as music and movies. If present, such spillovers would *ceteris paribus* lead to underproduction. Depending on the magnitude of such spillovers, privately excess entry may in fact be socially optimal when the incentives for underproduction in the presence of spillovers is accounted for. No measures of this spillover exist; I propose plausible bounds on the size of these spillovers based on other work. I find that taking all factors into account, overproduction or underproduction are both possible. The most important factors in determining which outcome obtains are (i) the shape of customer preferences; and (ii) the size of the spillover. Losses of CD sales to P2P file sharing and the effectiveness of DRM have relatively smaller effects. It is unfortunate that the least important factors are the easiest to measure and have attracted the most economic research. The more important factors constitute a very substantial measurement challenge for empirical work.

## 2. *History and Background*

Traditionally, the music business encoded its product on a physical medium, such as a vinyl record, magnetic tape, or compact disc (CD) and sold the physical CD through stores and other retail outlets. Their product was protected with copyright, which governed the relations among artists, producers, distributors, radio, jukebox and other methods of playing music. Customers listened to the music on devices sold separately, and occasionally copied the music (say, tape-to-tape copying) for personal or family use. However, mass copying was much too costly for customers, and so copyright enforcement at the customer level was not necessary to protect the economic interests of the artists and industry.

The advent of the Internet and P2P networks changed this stable situation dramatically. The Napster was invented and deployed over the Internet by Shawn Fanning in 1999. The service consisted of a program that could be downloaded and executed on any personal computer ("client") connected to the Internet, and the Napster servers. The program would catalog any music files on the client computer (at the direction of the computer's owner) and transmit the information to Napster's servers where the information was cataloged. Any Napster customer who was interested in acquiring a music file could query Napster's servers for the location of the music on other computers, connect to that computer and download the music to her own machine. Computer owners who "ripped" music from a CD to their computer hard drive could thus share music with the entire Napster community. The availability of free music attracted an enormous customer base, especially among high school and college students, and trading of copyrighted music soared.

Napster did not keep copyrighted music on its servers; it merely helped others find

[4] Wagner, R. Polk, *Information Wants to Be Free: Intellectual Property and the Mythologies of Control*, 103 COLUM. L. REV. 995 (2003), p 1009

the music they were looking for. They hoped to avoid prosecution as a copyright infringer, claiming that it was their customers that shared the material, copyrighted or not. Of course, enforcement costs against millions of individual Napster customers were simply too great to be feasible for music producers. Instead, they preferred to target Napster itself as a copyright infringer. Napster was sued successfully, and was shut down in 2001. However, new firms sprang up, such as Grokster, KaZaA and Morpheus, offering similar services. A key difference was that these services did not depend on a central server; their programs ran on client computers and when a customer wished to find a specific music file, her request went over the Internet to whichever computers were nearby (in cyberspace) running the same program. Downloading then ensued. No central server, no copyright infringement issues, it was thought. For good measure, the suppliers of these programs were physically located outside the US, distributing their product over the Internet. These developers generated revenues through the sale of advertising space but perhaps more important the programs carried "spyware" subprograms that collected information from clients' computers. However, Grokster was recently sued by MGM and other content producers for facilitating copyright infringement; the content industry won a victory at the Supreme Court (125 US Supreme Court. 1605, June, 2005).[5]

## 2.1 Copyright – When Does It Work?

The law regarding copyright is clear: individuals who are mass-sharing files of copyrighted music over the Internet are guilty of copyright infringement. So why is this not sufficient incentive not to file share such material? Why does copyright law, which has been so effective as the legal underpinning of the music industry's traditional business model, not work in a world of P2P?

The answer lies with the twin facts of the technology of mass distribution and the transaction costs of copyright enforcement. In the traditional model, copying and mass distribution was relatively expensive; only businesses could afford the costs and (possibly) turn a profit through (illegal) sales. Copyright enforcement was a *business to business* proposition.[6] Should a distributor, radio station, or other producer illegally distribute a producer's copyrighted material, it was easily detected, the infringer identified, and the potential loss to the producer sufficiently large to justify the transaction costs of an infringement suit. The potential business infringers numbered perhaps in the low hundreds. In contrast, the technology of ripping music and sharing it over the Internet using P2P reduced the cost of copying and distribution to near zero. As a result as many as 40% of music aficionados share billions of

[5] Grokster had been awarded summary judgment in District Court, upheld by the Ninth Circuit, on the basis of an earlier ruling in *Sony v. Universal City Studios* 464 U.S. 417, 78 L. Ed. 2d 574, 104 S. Ct. 774 permitting the sale of videocassette recorders. The Supreme Court reversed this decision and remanded the case to the District Court. While this decision is a victory for the entertainment industry, it is highly unlikely that this will end file sharing and P2P.

[6] This point was brought home to me in a discussion with Fred Wilf of Morgan Lewis, Philadelphia, PA.

copyrighted songs on a regular basis.[7] Sharing is the rule; no money changes hands. While this may or may not cause the recording industry economic loss, it is clear that bringing infringement suits against millions or even thousands of customers is far too costly. It has always been the case that copyright has never been feasible in the *business to customer* case; the transaction costs have always been too great. Traditionally, what has controlled customer copyright infringement has been that the costs of copying and mass distribution have been too great. Small scale copying was certainly feasible and was no doubt ubiquitous, but posed no threat to the recording industry's business model. Business to customer infringement enforcement was neither necessary nor feasible. All this changed, of course, with the advent of the Internet and P2P. With this new technology, the cost of copying and distribution became negligible, but the cost of enforcement did not. Music producers are now faced with a threat to their business model from (some of) their customers, but the costs of business to customer infringement suits remain high.[8]

In fact, the effectiveness of copyright law has always been limited to business to business transactions. The transaction costs of enforcement have been and continue to be greater than can be justified by economic harm for business to customer transactions. Much recent effort by the recording industry has been focused on P2P intermediaries, such as Internet Service Providers (ISPs) and the creators of P2P client software such as Grokster and KaZaA. For example, the RIAA successfully brought suit against Verizon Communications to divulge the identities of KaZaA users,[9] and the above-mentioned *Grokster* case. In seeking to target firms rather than customers, the recording industry is attempting to control file sharing by copyright enforcement in a business to business model rather than a business to customer model. Whether or not they will be successful in this attempt is unclear as of this writing.

## 2.2 Digital Rights Management

In light of this perceived threat to its business model, the recording industry also experimented with and deployed technological methods of protecting their intellectual property in the form of software locks embedded within the music content (either on a CD or as legally digitally distributed over the Internet) that limited the ability of customers to copy the music. More broadly, customers could be sold not only the music but rights to use the music. In this way, music producers sought to reduce, perhaps eliminate, the losses they claimed to be suffering from P2P file

[7] Surveys conducted in 2003, reported in Peitz, Martin and Waelbroeck, Patrick, *An Economist's Guide To Digital Music*, (November 2004). CESifo Working Paper Series No. 1333 http://ssrn.com/abstract=628961, pp. 12-15 (hereinafter "Guide"). The distribution of file sharers is highly skewed, with a very small fraction of file sharers responsible for most activity. The age distribution is also highly skewed toward the 18-24 year old demographic.

[8] In 2003, the recording industry launched thousands of suits against individual file sharers, and the amount of file sharing is reported to have dropped 15-20% (Guide, *op cit* p. 43). However, it soon recovered to its previous level.

[9] Guide, *op cit* p. 44.

sharing. DRM music, it was thought, could not be shared. DRM could be the protector of copyrighted materials from infringement by customers that copyright law itself could not provide. It might be argued that DRM was a substitute for copyright law. I do not find this argument persuasive; the almost exclusive practical purview of copyright law is business to business relationships, and DRM has absolutely no effect on such relationships. DRM is targeted as a business to customer tool, a relationship in which the application of copyright law is theoretical only, and has no practical significance.

Wagner has argued that copyright law and DRM are complements, not substitutes. He points to the Digital Millennium Copyright Act (DMCA), which criminalizes attempts to "crack" DRM schemes. Hackers who build decoding software in order that they and others can consume DRM-protected material may be held criminally liable.[10]

The initial rollout of DRM is generally regarded as a disaster. Early versions of DRM forbade all copying, and often did not work on certain types of devices such as computers. On top of that, CDs that were DRM-enabled were not labeled as such, so customers did not know what they were buying, and retail stores often didn't know what they were selling. When customers took their new purchases home and found that the CD did not play on their computer, they were outraged and attempted to return the CDs to their retail store. Often, the retail outlet refused to return their money. In 2001, a significant customer backlash began, with websites by outraged music fans listing albums with DRM attached, urging boycotts not only of those albums but also of the artists and producers that performed and sold them. Clearly, music fans' expectations were not met and there was a strong negative reaction against the industry.

It is possible (though unlikely) that this strong negative customer reaction would have been tolerable to the music producers had the early DRM actually controlled file sharing. However, it didn't. Virtually every DRM scheme has been "cracked" by software hackers within weeks after it came on the market, and the bootleg decoders were posted on the web. In one particularly embarrassing incident, Suncomm's MediaMax DRM software for music CDs could be bypassed simply by holding down the shift key on the computer as you loaded the CD into the reader. The Princeton graduate student who discovered this made it known on the web[11] and through news media; Suncomm originally threatened to prosecute the student under DMCA, but the embarrassment from the incident's publicity proved too much and they corrected the flaw instead.

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[10] In a high-profile case, the FBI arrested Russian programmer Dmitri Skylarov, leading him in handcuffs from the podium at the Defcon conference in Las Vegas in July, 2001. Dmitri is the author of a program that decrypted Adobe eBooks, distributed by his Moscow employer Elcom; he was charged with violating provisions in the DMCA against creating such software. Public reaction was largely negative to the arrest, leading Adobe to drop charges. However, criminal charges were pursued against Skylarov.

[11] See http://www.cs.princeton.edu/~jhalderm/cd3/ for the original paper (2003) describing the MediaMax DRM and the simple "crack" Mr. Haldeman discovered.

Extant economics work on the effectiveness of DRM has reflected this experience. The level of DRM (severity vs. laxness) is modeled as a tradeoff between protecting against illicit copying and degrading the product for listeners.[12] In this model, stringent DRM can limit copying but at a cost to the quality of the product itself. Meeting customer expectations by a more relaxed DRM would lead to more copying. However, subsequent developments in the market suggest that this model is not appropriate. In 2001, Apple released the iPod and its iTunes online music store. The product has been wildly successful (over 20 million iPods sold[13]) and its music is protected by a DRM called Fairplay. Its DRM permits multiple copies of the music: Fairplay permits the music to be transferred to up to five computer, to be burned on up to five CDs and downloaded to up to five iPods.[14] As a result of this more relaxed DRM, customer response to the iPod/iTunes combination has been enthusiastic (as the sales numbers attest). The irate reactions of customers to early DRM has not been repeated for iTunes. Apparently, Fairplay meets the expectations of legitimate customers by permitting them to do what they normally expect to be able to do. And the logic is clear: the music industry had no interest in stopping legitimate customers from doing what they want; they only had an interest in stopping mass distribution of their music, and Fairplay is designed to do this. It should be noted that Fairplay was cracked almost immediately after it came on the market. However, the iTunes pricing model and the lack of practical constraints for legitimate customers have maintained the iPod/iTunes business model in spite of cracks and potential file sharing. A newer entry into Internet distribution, RealNetworks' Rhapsody service, uses a very similar DRM scheme to that of iTunes. These early indications suggest the market will move toward DRM schemes that meet customer expectations with no loss of value to legitimate customers and can protect against unlimited mass distribution. However, we can continue to expect that all DRM will be cracked, and the decode scripts will be available on the web.

## 2.3 Reaction to DRM and Fair Use

The deployment of DRM technology and the passage of DMCA created an outcry from a number of legal scholars, particularly advocates of restricting or eliminating copyright control of creative works.[15] This line of criticism focuses on the increased level of control[16] that DRM gives copyright holders over their creative works, which

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[12] See, for example, Sundararajan, Arun, *Managing Digital Piracy: Pricing and Protection*, INFORMATION SYSTEMS RESEARCH, **15**(3) (2004) p. 289. "…implementing effective DRM-based technological deterrence often necessitates a direct reduction in the value of the legal product."

[13] See http://news.yahoo.com/news?tmpl=story&u=/ap/20050713/ap_on_bi_ge/earns_apple reporting on Apple's recent earnings.

[14] Apple has modified these numbers in response to consumer demand and music industry pressure.

[15] See, among many others, Lessig, Larry, *The Future of Ideas : The Fate of the Commons in a Connected World*, Vintage (2002); and Vaidhyanathan, Siva, *Copyrights and Copywrongs: The Rise of Intellectual Property and How It Threatens Creativity*, New York University Press (2003). Both of these works are copyrighted.

[16] See Wagner, *op cit*, pp. 995-98, reviewing arguments of the "control critics" of copyright.

in turn stifles future efforts of others to create music.

Their arguments against the use of DRM, at least some of which are compelling:

> DRM privatizes copyright law, apparently trumping years of copyright case law with a technological fix. Copyright law is replaced with contract conditions, and even worse, a "self-executing" contract in which the customer *cannot* break the terms (at least in principle).[17] This criticism is not only true, it is the whole point of DRM; at the customer level, copyright law is ineffective at stopping mass distribution of copyrighted material; privatization is a means by rights holder of regaining at least some control over their property.
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> File sharing is causing de minimis losses of CD sales, and so DRM is only useful to increase profits of the music producers.[18] The presumption in this literature (never directly addressed) is that there is no threat that production of music will decline due to file sharing; therefore, DRM is not necessary to avoid a decline in music availability. This is an empirical issue, and as I discuss below, there is a wide range of empirical estimates of CD sales displacement due to file sharing. The empirical research is sufficiently progressed that "de minimis" is rather unlikely; but whether the impact is great enough to impact the level of music production is still unsettled.
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> DRM provides much more than copy protection; it is an invasive technology that reports back to the retailer and the producer via an open Internet connection the usage of the music, without necessarily notifying the customer. The privacy implications of DRM are underappreciated and of great concern.[19] I find this criticism compelling and share the privacy concerns of the critics of DRM. However, it is not clear that this assault on privacy adds much burden to the already overwhelming assault on privacy of virtually all our economic activities, such as buying books online or using preferred customer cards at supermarkets.
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> DRM negates "fair use," a doctrine under which copyrighted materials may be

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[17] Jackson, M. "Using Technology to Circumvent the Law: The DMCA's Push to Privatize Copyright." *Hastings Communication and Entertainment Law Journal* 23: 607-646.

[18] A more extreme argument applies to copyright generally; some argue that artists will create music and other works without copyright, so establishing any form of property right in intellectual property reduces social welfare. This charmingly utopian view flies in the face of overwhelming evidence. See, for example, "Curtain Closes on Hong Kong's Film Industry," *Taipei Times*, May 16, 2005, 17. at http://www.taipeitimes.com/News/feat/archives/2005/05/06/2003253454/print for an account of the effects of rampant piracy of movie DVDs in mainland China on the once-thriving Hong Kong movie business.

[19] See, for example, Shaker, Lee, "An Overview of DRM System Types and Their Privacy Implications," submitted comments to the Federal Trade Commission (Public Workshop: Monitoring Software on Your PC: Spyware, Adware, and Other Software), (2004) at http://www.ftc.gov/os/comments/spyware/040416shaker.pdf

used without permission for certain restricted uses.[20] With DRM, these uses would not be possible, as they would be automatically restricted. This argument is in principle correct, but I argue (largely) irrelevant. The principal function of fair use in music[21] is to permit customers to make a small number of copies for personal or family use. Since copyright is not economically enforceable at the customer level, fair use is simply a means to decriminalize an activity (personal copying) that many customers engaged in with little impact on the economics of the music industry, and was never enforced. Since customer expectations included making such copies, music producers have moved to meet those expectations, after their initial wrongfooting. The market appears to be settling on a DRM solution that meets the needs of both music producers and music customers.[22] This solution is likely to conform to traditional fair use (since fair use seems to conform to customers' expectations) but the fit need not be perfect. If it is not, which is to be preferred? I would argue that a solution which emerges from the back and forth of interested parties in a market environment (especially if reasonably competitive) is likely superior to a solution arrived at by lawyers and judges in the seminar room or court chambers.

Creative works, like other intellectual property, generate spillovers; today's creative work is the wellspring for tomorrow's creative work. If DRM (or copyright, for that matter) interfere with the free flow of artistry among the creative community, these spillovers are likely to be lost. While I agree that spillovers from creative works are likely to be important, I argue that DRM has essentially no effect on spillovers. I draw on Wagner (*op cit*) who identifies several types of information that can flow from intellectual property. At one extreme is the actual property itself: the work itself, be it music, a book, or a patent (Type 1). At the other extreme, information that comes from the *observation* of the work generates spillovers (Type 3). For example, the first *Survivor* television series demonstrated that audiences liked a story in which non-actors were placed in apparently extreme conditions and competed for prizes. While the copyright holder to *Survivor* held rights to sequels of the

[20] This point and the following point grew out of a discussion with Professor van Houweling on DRM and fair use.

[21] There are also public interest arguments in fair use that have particular application to printed matter. However, in music it appears that the only fair use of copyrighted music is for purposes of parody. The relevant case is *Campbell v. Acuff-Rose Music, Inc*, 510 U.S. 569 Supreme Court, March 7, 1994, in which the rap group 2LiveCrew made a scatological parody of the earlier Roy Orbison song "Oh, Pretty Woman." The copyright owners refused to license the music to the group, and they performed and released the music anyway, claiming that parody was a fair use. The Supreme Court agreed. Note, however, that while this is a copyright issue, it is not a DRM issue. Any group wishing to parody a copyrighted song need not rip the music track from a CD; it can actually play and record the music itself with a voice-over of the parody lyrics. Note also that this is a business to business issue, not a business to customer issue.

[22] A DRM solution that meets customers' expectations while protecting producers' interests is the likely outcome of any market, even one in which producers exercise market power. Even monopolists wish to make their product as attractive as possible; annoying one's customers simply lowers the value of the product and thus the amount customers are willing to pay for it.

series, others could adapt the "reality TV" model to create new series, such as *The Amazing Race* and *American Idol*, without obtaining permission of the *Survivor* copyright holders. While the rights holders could capture the rents from their actual product, they could not capture the rents from the *idea* of a reality TV show. Type 3 information is a true spillover; a benefit generated from the original creation but not capturable by the creator. In this model, true spillovers cannot be captured either by copyright or by DRM. They arise from others observing the work, not by copying the material directly.

## 2.4 Has File Sharing Displaced CD Sales?

At the core of the file sharing and music production problem is the empirical issue of whether or not file sharing actually displaces CD sales. Certainly the economics literature has focused on this issue, as has the industry itself. On its website, the RIAA[23] claims that between one-third and 40% of CD sales have been displaced by illegal file downloads. Clearly, the music industry has an interest in supporting a large number in order to garner support for Congressional action, so we may take this number as an upper bound on the true displacement.

Liebowitz estimates that file sharing has displaced about 20% of CD sales, a number he describes as "not small" but unlikely to "annihilate" the industry.[24] Peitz and Waelbroeck arrive at the same 20% estimate, using cross-sectional evidence.[25] Waldfogel and Rob use a survey of University of Pennsylvania students and take account of post-download purchase behavior; they estimate that file sharing displaces about 10% of CD sales.[26] Oberholzer-Gee and Strumpf look at a very large sample of downloaded music and contemporaneous CD sales and find that there is no statistically significant effect of downloads on CD sales.[27]

Apparently, the empirical issue is not yet settled. Even among academic researchers, presumably with no economic interest in the answer, the range of estimates is disappointingly large.

But assuming losses of CD sales to P2P in the range of 10%-20%, is this loss "large"? For music industry executives, it is quite large; from an economist's point of view, it would appear quite small. After all, if music is available for free, why would anyone

[23] At <http://www.riaa.com/issues/piracy/default.asp>
[24] Liebowitz, Stan, "Will MP3 Downloads Annihilate the Music Industry? The Evidence So Far," working paper, University of Dallas (2003), at <http://www.utdallas.edu/~liebowit/>
[25] Peitz, Martin and Waelbroeck, Patrick, "The Effect of Internet Piracy on Music Sales: Cross-Section Evidence," *Review of Economic Research on Copyright Issues*, **1**(2) (2004), pp. 71-79.
[26] Rob, Rafael and Waldfogel, Joel, "Piracy on the High C's: Music Downloading, Sales Displacement, and Social Welfare in a Sample of College Students" (November 2004). NBER Working Paper No. W10874. http://ssrn.com/abstract=612076.
[27] Oberholzer-Gee, Felix, and Koleman Strumpf. "The Effect of File Sharing on Record Sales." Working paper, University of North Carolina (2004) at <http://www.unc.edu/~cigar/papers/FileSharing_March2004.pdf>

ever buy it? In fact, downloading music is costly to most customers, for a variety of reasons.

- File sharing is only feasible for customers with a broadband connection to the Internet; as of September, 2004, approximately 19% of US residential households subscribed to broadband service.[28]
- File sharing requires a modicum of experience with a computer and the Internet; it not only involves downloading the music itself, but downloading the software, installing it, and then burning the music to a CD. It is safe to assume that not every member of the 19% of households with broadband has these skills.
- Actually downloading a music file takes time, and may result in a corrupted or fake file. This suggests that file sharers have a low value of time; those with better things to do are unlikely to have the patience for file sharing.
- There are substantial risks of viruses, worms and Trojan horses being downloaded to a file sharer's computer, with the attendant cost to the customer.[29]
- All P2P programs come with spyware included; they do not function if the spyware is removed. Thus, even without actual downloading, P2P software involves a loss of computer resources (while spyware is running unannounced in the background at all times) and a loss of privacy.
- Some customers refuse to file share because it is illegal. Just like most hotel guests don't steal the towels (even if they won't be caught), the relatively low cost of legitimate downloads (e.g., from iTunes) makes theft, even if undetectable, unattractive to some.

File sharers have a high level of computer and Internet skills, a low value of time, a belief that they will remain virus-free, and a somewhat blunted sense of guilt over theft of intellectual property. It is unlikely that this profile fits all or even most Americans, so file sharing and loss of CD sales is likely to be bounded. The apparently low level of CD displacement (10%-20%) bears out this intuition.

## 2.5 What Is the Problem and Why Do We Care?

The advent of file sharing and its attendant "remedy," DRM, has clearly had welfare impacts beyond the financial health of music producers and artists. If the entire issue was that technological change in the form of the Internet and P2P was driving a restructuring of the music business, this issue would make an interesting case study for students but hardly be cause for a more general concern. But there are welfare effects. Rob and Waldfogel (*op cit*, p 2, 26-27) estimate welfare gains and losses

[28] Federal Communications Commission, Availability of Advanced Telecommunications Capability in the United States ("706 Report"), FCC 04-208, Docket No. 04-54 (2004) at http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-04-208A1.pdf

[29] A list of the most prevalent worms on P2P networks in 2004 is in Guide, *op cit* p. 11.

associated with file sharing, noting that the marginal cost of music is effectively zero. They find a net gain in social welfare from file sharing. However, they note that they do not account for the potential impact on possible reduction in the amount of music produced.

In this paper, I focus exclusively on the issue of the amount of music produced, as this appears to be the core welfare issue and the reason we care about file sharing and DRM. In Section 2, I develop a simplified model of the music market[30] as a differentiated products market. Using recent results from Bhaskar and To (*op cit*) I show that the traditional market for music is likely to produce too much music. File sharing (at least in the range of current empirical results) reduces the amount of music produced, but there is still excess entry. Deployment of "reasonable" DRM simply increases this excess capacity. In Section 3, I consider the possibility of spillovers from music production, which *ceteris paribus* would lead to underproduction. Putting the two concepts together, I use the model to estimate the conditions which lead to excess entry. Section 4 covers the caveats, exceptions and simplifications of the model which I trust future theoretical and empirical research can address. Section 5 concludes the paper.

## 3. *The Model*

I assume that the market for music consists of continuum of potential customers uniformly distributed over a single dimensional product space (unit interval) according to their musical tastes. Each customer $t$ ($0 \le t \le 1$) has a preferred type of music, corresponding to her location on the unit interval; consuming a unit of her preferred music yields a common utility level of $U$. Consuming music of another type $x$ yields a common utility level $U - f(|t-x|)$, $f(0) = 0$, $f'<0$. The function $f$ is often referred to as the "transport" function, following Hotelling's (*op cit*) original formulation of this problem as a location model.[31]

Modeling customer preferences for music in a spatial model imposes strict limitations on the structure of demand. One could, for example, use a more classical demand formulation, in which the demand vector (including all $n$ artists) is a function of the price vector (including all $n$ artists): $\boldsymbol{q} = \boldsymbol{Q}(\boldsymbol{p})$, which places no prior restrictions on demand. In music, however, we know that most of the demand interactions (cross-partials) among pairs of artists are zero; Britney Spears does not compete with the Philadelphia Orchestra which does not compete with Garth Brooks, etc. Imposing a

[30] I specifically do not model the music *industry*; this is a complex industry with attributes of venture capitalists picking "stars", very intense marketing and merchandising, and difficult contractual issues with its artists. My focus in this paper is how the *market* works; the music industry is presumed to (somehow) produce artists and their copyrighted material which it introduces into a differentiated product market.

[31] This is not the first paper to suggest that viewing music as a differentiated product market is a useful idea; this was put forward in Yoo, Christopher, "Copyright and Product Differentiation," 79 *N.Y.U. L. Rev.* 212 (2004). While this paper correctly described the model as applicable to copyright issues, there was no application of the model.

spatial model on demand focuses attention on competition among artists that are similarly located in product space, and therefore likely vying for the same music customers. Whether or not this is a reasonable model for the music market is a matter of modeling taste, and ultimately whether it explains the observed facts. In addition, the use of a spatial model forces attention to the issues of entry and location. The central questions of spatial models are where firms/artists locate and how many firms/artists enter, and this endogenous entry is at the core of the question of this paper.

The unit of production is the artist; music producers introduce artists at specific points in the unit interval product space; introduction involves fixed costs. An artist is conceived as a bundle of services and products; although I do not explicitly include time in the model, it is useful to think of the artist producing a stream of services over time. Since there are fixed costs to entry, there will be a finite number of artists, which we assume indexed by their location $a$, $\{a = 1,2,\ldots,n\}$ in the interval [0,1]. Consumers choose an artist to consume that generates the most net value for them: if artist $a$ charges customer $t$ a price $p_{at}$, then customer $t$ will select the artist $a(t)$ that maximizes $U - f(|t-a|)-p_{at}$. Let $a'(t)$ be the artist preferred second by customer $t$. I assume free entry. Artists are able to change their location in response to changing market conditions.

The various services offered by artists include CDs, concerts, T-shirts, coffee mugs, fan clubs, memorabilia, etc., which I assume can be supplied at a marginal cost of zero. These services permit artists to price discriminate among customers by intensity of preference (relative to the customer's next best alternative). Ardent fans buy all the services of the artist, more relaxed fans may buy only a CD from the remainder bin at Walmart. I assume this price discrimination captures all available surplus.[32]

In equilibrium, artists will be equally spaced in the unit interval; artists will enter until entry profits are zero. Customers will buy from the artist nearest them in product space; each customer is charged the difference in value between her preferred artist and her second-preferred artist: $p_{at} = f(|t-a'(t)|-f\{|t-a(t)|)$.[33]

This spatial model of this paper is highly simplified for analytic ease; it is intended as suggestive rather than definitive. Bhaskar and To (*op cit*) use a similar simple model to illustrate their more general model and general results, which I discuss at length below. The simpler model fixes ideas, frames questions, and illustrates results; it's purpose is to motivate deeper theoretical and empirical research. My exposition here primarily graphical; derivations of some of the results of this simple model are

[32] Online music distribution is likely to substantially increase the ability of music producers and online retailers to price discriminate. My assumption of perfect price discrimination is, of course, an approximation to actual practice.

[33] These results are derived in Bhaskar and To (*op cit*), but are generally well-known. See, e.g., Gabszewicz, Jean and Thisse, Jacques-Francoise, "Location," Ch 9 in Aumann, R. and Hart, S., *Handbook of Game Theory with Economic Applications, Vol 1*, North Holland: Amsterdam (1992) pp. 294-98,.

contained in the Appendix; for more formal proofs in the general model, refer to Bhaskar and To.

It is helpful to adopt the power function $f(x) = bx^a$, $b>0$, $a>0$ as a rather general parametric form for the transport function which I do for the remainder of the paper. For $a > 1$, utility is concave, or "broad"; music in the neighborhood of a customer's preferred music is valued almost as highly as the preferred music, dropping off more steeply with increasing distance. For $a < 1$, utility is convex, or "sharp"; music in the neighborhood of a customer's preferred music is disdained by the customer. For $a = 1$, utility is linear, dropping off at a constant rate the further is the music from the customer's ideal. These three shapes are illustrated below:

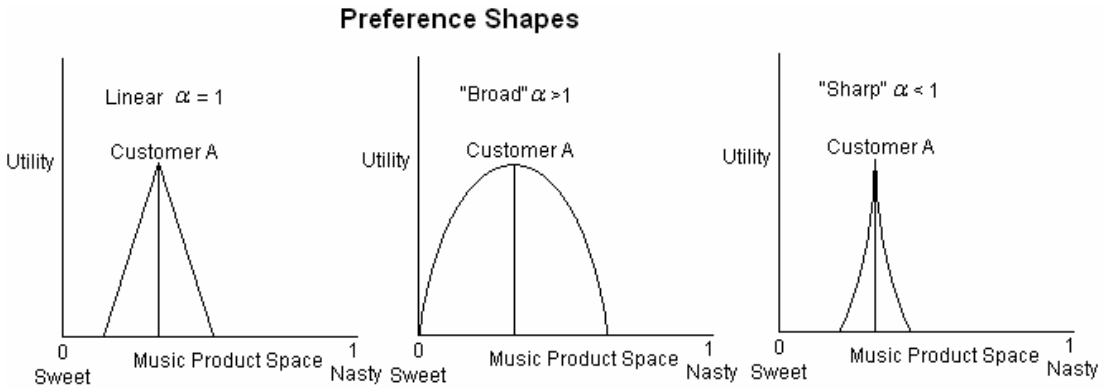


**Figure 1**

In equilibrium, artists are equally spaced in [0,1] and are able to price discriminate. The result is illustrated below, with an assumed three artists (and linear utility):

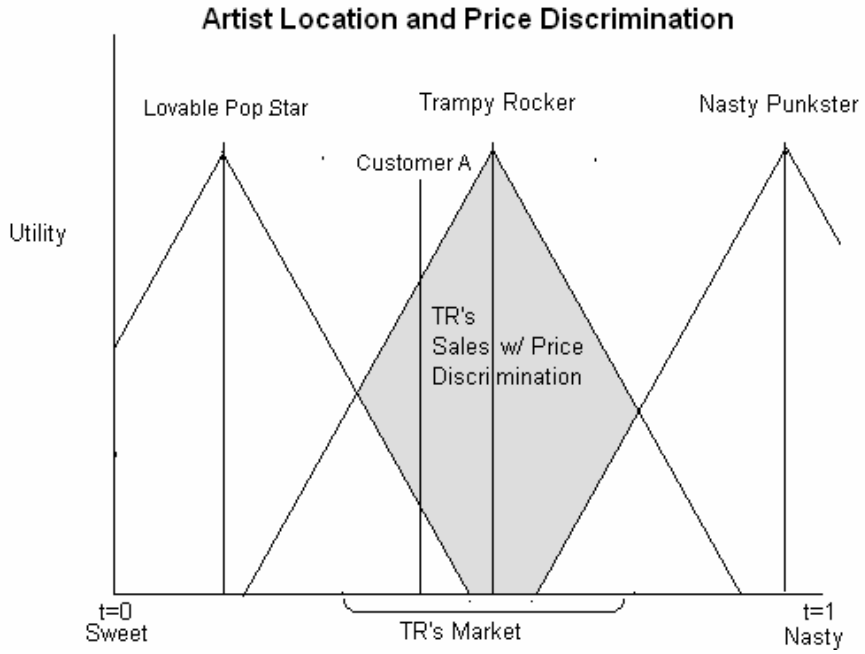


**Figure 2**

Using the power function approximation, the operating profit with $n$ firms in the market (equally spaced) can be shown to be:

$$p = \frac{2b\left(1-\frac{1}{2^a}\right)}{(a+1)n^{a+1}} \tag{1}$$

With free entry, artists enter until it is no longer profitable for them to do so. The number of artists in equilibrium is determined by the zero profit condition, in which the operating profit is just equal to the fixed cost $F$ of entry. This number can be shown to be::

$$. \quad n^* = \left(\frac{2b(2^a-1)}{(a+1)\cdot F\cdot 2^a}\right)^{\frac{1}{a+1}} \tag{2}$$

Welfare $W$ (consumer plus producer surplus) with $n$ firms can be shown to be

$$W = \left(U - \frac{2a}{(a+1)\cdot n^a \cdot 2^{a+1}}\right) - nF \tag{3}$$

The efficient number of firms is that which maximizes $W$, which can be shown to be:

$$: \hat{n} = \left(\frac{b\cdot a}{(a+1)\cdot F\cdot 2^a}\right)^{\frac{1}{a+1}} \tag{4}$$

If the free entry equilibrium resulted in the welfare-maximizing number of artists, then the ratio $n^*/\hat{n}$ would be unity. Unfortunately, such is not the case:

$$\frac{n^*}{\hat{n}} = 2\left(\frac{1-2^{=a}}{a}\right)^{\frac{1}{1+a}} \tag{5}$$

Note that this ratio depends only on the *shape* of the transport function, determined by $a$, but for all $a$ the ratio is greater than unity. In the linear case, $a$ = 1 and the ratio $n^*/\hat{n} = \sqrt{2} \approx 1.414$, so that in equilibrium there is over 40% excess entry. The chart below displays this ratio for a broad range of $a$:

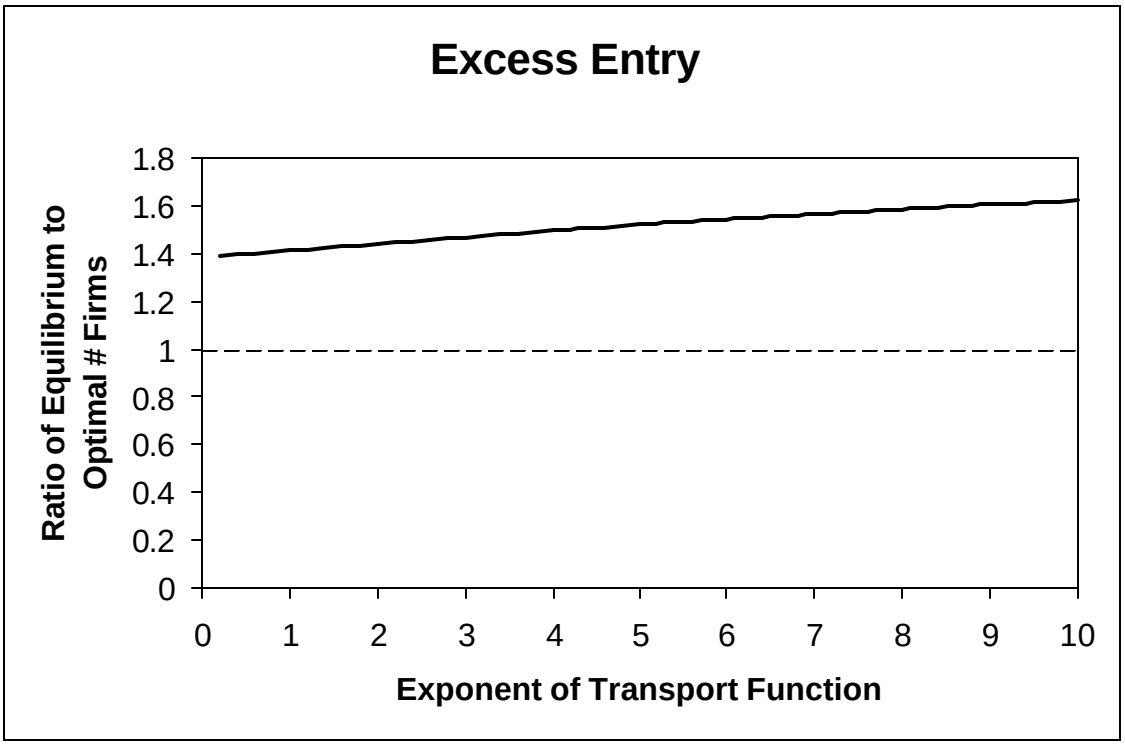


**Figure 3**

over which it varies from 40% to 60% excess capacity.

In equilibrium, pricing, consumption and location is efficient; it is only entry that is inefficiently excessive.

## 3.1 Intuition and Generalizability

The intuition for this result can be seen as follows. Begin with some number of firms less than the optimum, say, $m$, and let $W_m^*$ be the maximal welfare with $m$ firms (equally spaced, price discriminating). Consider that a new firm wishes to enter; decompose the actions this entry entails into (i) accommodation of the existing $m$ firm moving to new positions in response to new entry; and (ii) the actual entry of the $m$+1st firm. The accommodation of the existing $m$ firms (prior to entry) reduces total welfare to $W_m < W_m^*$, since they are no longer optimally arranged in product space for $m$ firms. Then the $m$+1st firm enters, and welfare now increases to $W_{m+1}^* > W_m^* > W_m$ (since $m$ is less than optimal). The total increase in welfare of this entry is $W_{m+1}^* - W_m^*$. However, the entrant is able to capture not only the welfare gain, but also the losses of the existing firms as they accommodate to her entry. Her profit then is $W_{m+1}^* - W_m > W_{m+1}^* - W_m^*$. Since the new entrant captures more than the increase in welfare, her incentives to enter are too great, and so excess entry occurs. This result

is quite similar to the well-known congestion externality: when a driver enters a crowded highway, she makes the entry decision based on the observed congestion and its cost to her. However, she does not include in that calculation the congestion cost she imposes on others on the highway. As a result, private incentives create too much congestion … and excess entry.

The simplicity of this model belies the generality of the Bhaskar-To model. In their general model there are:

1. The product space can be of arbitrary dimension, rather than a single dimension of the simple model.
2. Each customer can buy more than one unit, rather than the single unit of the simple model.
3. There can be many customers at each point, rather than the single customer of the simple model.
4. Customers could have a preference for variety, so they purchase the music of more than one artist, rather than the single purchase of the simple model.

In this general model, pricing, consumption and location is efficient, but there is excess entry. The key results generalize to this richer model.[34] However, as with the simple model, the result depends on three key assumptions:

1. Free entry. The apparently unending flow of new artists into the music market would appear to support this assumption. Clearly, there is a fixed cost to entry, but any artist willing to pay this fixed cost can enter.
2. Artists can change location in response to market conditions costlessly. This assumption would seem close to the facts, as Madonna's constant reinvention confirms.
3. Artists can perfectly price discriminate. This is clearly wrong if the unit of analysis is the CD. But it appears closer to how the market appears to function; both fans and recording firms focus on the artist and their stream of services and products. This stream yields a rich source of rent extraction from more or less faithful fans. Clearly, no real world price discrimination can be perfect, but I argue that artists and record firms have ample opportunities to price discriminate.

These results are quite surprising, as economists assumed the last word on this was from the influential work of Michael Spence: "…if sellers can price discriminate in an appropriate sense, the welfare aspects of the product choice problem are eliminated."[35] It is also surprising that the computed excess capacity is so flat over a

[34] There are a number of assumptions that are common to all spatial models, and deserve mention here: (i) customers are uniformly distributed throughout product space; (ii) customer preferences are identical up to their location, and (iii) customer preferences are symmetric.

[35] Spence, Michael "Product Selection, Fixed Costs and Monopolistic Competition." *Review of Economic Studies*, **43**, pp 217-8 (1976), as quoted in Bhaskar and To (*op cit*).

wide range of the shape parameter $a$.[36] This suggests that excess capacity is buried quite deeply into the structure of differentiated product markets.

## 3.2 What About File Sharing and DRM?

The result of excess capacity from this model completely reverses the core issue of music production. In the previous section, the underlying assumption was that file sharing could reduce the incentives to produce music, thus leading to the underproduction of music. The differentiated product market model strongly suggests that (without file sharing) there is substantial overproduction of music. Could it be that file sharing has a positive effect on music production, not by helping create more music but rather by reducing excess entry? If this in fact is the case, then the adoption of DRM to reduce file sharing may have a negative effect on welfare, causing music production to inefficiently increase.

To answer this question, I extend the model to incorporate the effects of file sharing. Again, I make simplifying assumptions: customers divide into those who will never file share, and those who will; the latter do not find it costly to do so. The two groups are otherwise identical. Those who file share may displace CD sales but their perception is that the downloaded product is a perfect substitute for the CD. Displaced CD sales correspond to an equivalent loss of revenue to the music producer.[37] However, downloaded music results in the same welfare as purchased music. I do not account for shared files with value to the customer less than the purchase price but more than the marginal cost of zero, [38] as my assumption of price discrimination eliminates that welfare loss. The result of these two simplifying assumptions is that maximal welfare with $m$ firms with file sharing is exactly the same as maximal welfare with $m$ firms without file sharing. However, the operating profit per firm is reduced with file sharing in proportion to displaced CDs.

Denote the fraction of CD sales displaced by file sharing as $D$; if the fraction $D$ of revenues is lost to file sharing, then the number of firms that enter is

$$n_s^* = \left( \frac{2b(2^a - 1)(1 - \Delta)}{(a+1) \cdot F \cdot 2^a} \right)^{\frac{1}{a+1}} \tag{6}$$

[36] Obviously, the numerical results are for the simple model only, not the fully generalized model of Bhaskar-To.

[37] This assumes (incorrectly) that file sharers will not purchase non-CD products such as concert tickets, memorabilia, etc.; the music producers lose all revenue from file sharers. It is straightforward to construct a more general model; which would lead to greater incentives for entry and therefore increase the ratio of equilibrium to optimal number of artists.

[38] This measure of welfare gain is a key issue in Rob and Waldfogel; including it here would increase welfare and therefore decrease the ratio of equilibrium to optimal number of artists.

and the ratio of equilibrium to optimal number of firms is

$$\frac{n_s^*}{\hat{n}} = 2\left(\frac{(1-2^{-a})(1-\Delta)}{a}\right)^{\frac{1}{1+a}} < \frac{n^*}{\hat{n}} \qquad (7)$$

Clearly, file sharing decreases the excess capacity. But by how much? In the following chart, I use the full range of empirical results: $D$ = 0, 0.2, 0.4:

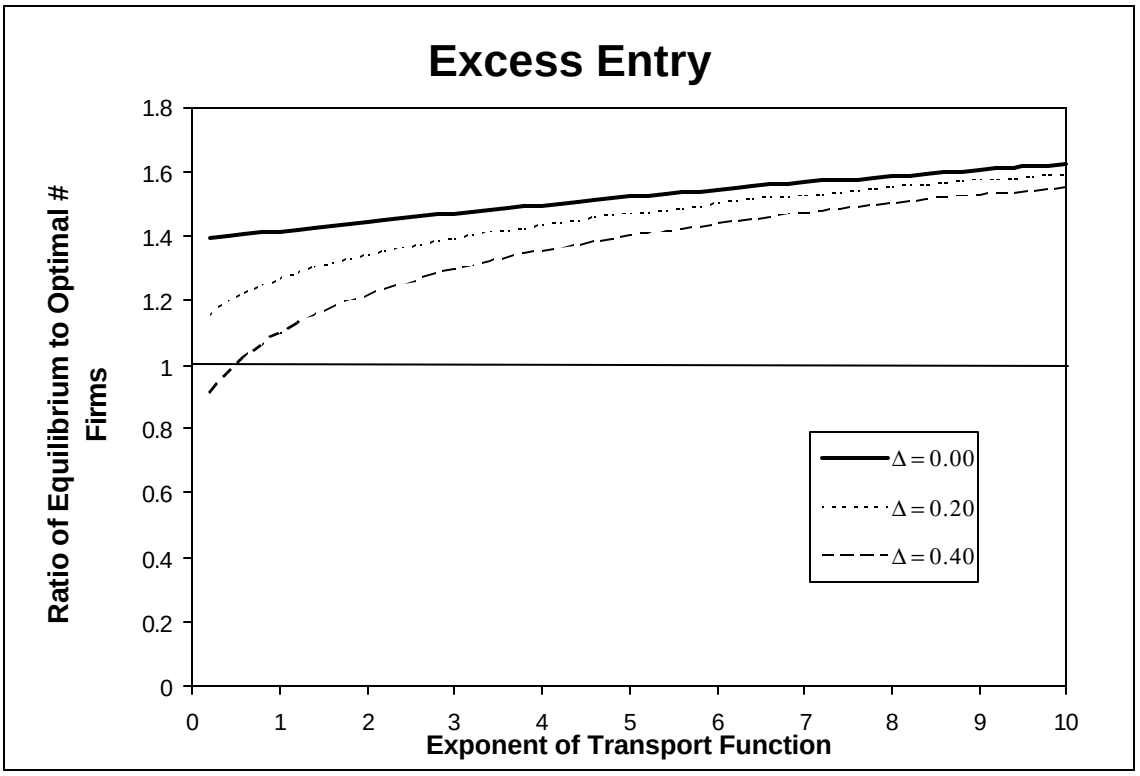


**Figure 4**

For all but the most fanciful estimate of file sharing displacement of CD sales, excess capacity is still substantial. While file sharing works to reduce the excess capacity that results from the differentiated product market, it is not sufficient to lead to anything close to efficient entry.

DRM was introduced as the counter-measure to file sharing, the technological means to protect copyrighted work and restore incentives[39] to produce music. For all its ills, DRM had the one benefit of ensuring that artists and recording companies still had incentives to produce music as before. In light of the results of this section, however,

[39] There are no claims that file sharing has actually led to the reduction of music production as of this date. The fears of reduced music production are prospective: if file sharing continues, so goes the story, it will eventually lead to a reduction. This would be an equilibrium result which could take some time to be realized.

restoring incentives to produce music as before actually increases inefficiency by encouraging excess entry.

Assuming that current market trends (as exemplified by iTunes and Rhapsody) result in DRM mechanisms in which (non-uploading) customers do not feel constrained by copying limitations so that their expectations are fully realized and DRM is not costly to them. Specifically, I assume that the use of DRM does not reduce welfare. The pricing of online music and the acceptance of "reasonable" DRM suggests that the displacement of legitimate CD sales by file sharing will likely be substantially reduced by DRM. However, the fact that even these "reasonable" DRM mechanisms have been cracked suggests that we may continue to see some displacement of legitimate sales, but at a reduced level. The reduction of displacement using DRM may be as little as 50% or it may be as much as complete elimination. Combining these estimates, a plausible range of displacement of legitimate sales with a "reasonable" DRM deployed is 0%-20%. Revisiting the graph above, I conclude that excess capacity with both file sharing and "reasonable" DRM schemes likely falls between the $D = 0.00$ and $D = 0.20$ curves.

What is striking about these results is that the current debates about file sharing, DRM and the attendant threat of underproduction of music are overshadowed by the magnitude of excess entry predicted by the model. Even the worst case equilibrium with the direst predictions of unrestricted file sharing makes only a modest dent in this excess capacity. While the legal and economic research communities have been focused on the "headline" issues of file sharing and DRM, we appear to have missed the much larger issue of excess entry in differentiated product markets such as music.

## 3.3 Spillovers

Intellectual property occupies a unique position in economics, law and policy not only for its dilemma of nonappropriability but also for its alleged spillovers. The lack of appropriability has led to the creation of intellectual property laws, such as patents, trademarks and copyright, as a means of socially constructing appropriability. However, intellectual property is also perceived to create spillovers: a new idea, creation or invention may lead others to the next new idea, creation or invention.

In the case of patent law, the important idea or method may not be evident from an inspection of the patented device. Therefore, patents are required to disclose the idea or method underlying the invention. The granting of a monopoly on the exploitation of the invention is conditional on the inventor revealing how she invented it. The purpose is clear: to encourage others to use the ideas to develop the next new invention. The inventor is granted exclusive rights to her invention, but is not and cannot be granted a right to the *idea* of their invention. Thus, a pharmaceutical firm that develops the first anti-anxiety medication has exclusive rights to sell this drug. But anyone else is free to note the great success (both pharmacologic and economic) of such a drug and to develop the next generation of anti-anxiety drugs, using the *idea*

embodied in the first such drug.

Wagner[40] identifies three types of information associated with inventions or creations. Type 1 is the invention or creation itself: the transistor, the movie, the song. Type 2 information is directly related material, such as the movie characters or guitar riffs from the music. Type 3 is indirectly related material, such as the popularity of a movie about fantastic creatures (as in Shrek) or the popularity of spoken lyrics (as in hip-hop). Type 1 is always covered under IP law, while Type 2 may or may not be included in IP law. Type 3 cannot be covered by IP law, and thus constitutes what economists call a spillover, an effect of the invention or creation which benefits others[41] but which cannot be captured by the inventor/creator. The focus in this paper is on Type 3 information: the spillover effect

In science, the spillover from one idea to the next, from one invention to the next, has the noble provenance of Sir Isaac Newton: "If I have seen further (than you and Descartes) it is by standing upon the shoulders of giants."[42] This emphasizes not only the spillover from one generation of scientists to the next, but also the *technologically cumulative* nature of the spillover. What we learn from one invention becomes the basis of the next invention; the existing technology is "baked into" the new technology. The transistor becomes the basis of the integrated circuit; the second is built upon the first. The recognition that these spillovers occur and the presumption that they are significant gives rise to concerns that technology is underprovided. Since inventors cannot internalize all the benefits of their invention, there is less incentive to invent than is socially optimal, so it is alleged. If the benefits of technological invention cannot be entirely captured by the innovator, then there will be less than optimal resources devoted to invention.

This has led to efforts by successive generations of economists (presumably standing on their predecessors' shoulders) to measure this spillover. Early work by Jaffe[43] and Bernstein and Nadiri[44] was summed and generalized by Griliches,[45] who estimated that the spillover from (patent-producing) R&D was between 0.5 and 1.5 of the private benefit. The most recent work by Bloom, Schankerman and van Reenen[46] estimates this spillover at 2.5 times the private benefit of the R&D, after correcting for the impact of the R&D on product market rivalry. Clearly, the magnitude of these

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[40] Wagner, R. Polk, *Information Wants to Be Free: Intellectual Property and the Mythologies of Control*, 103 COLUM. L. REV. 995 (2003), pp 999, 1005-9.

[41] A creative work may be perceived as hurting others (negative spillover), such as inciting to riot, fostering ethnic hatred, or be perceived as blasphemous by some religionists.

[42] Sir Isaac Newton (1642-1727) from Letter to Robert Hooke, Feb. 5, 1675/76.

[43] Jaffe, Adam (1986), "Technological Opportunity and Spillovers of R&D: Evidence from Firms' Patents, Profits and Market Value", American Economic Review 76, 984-1001.

[44] Bernstein, Jeremy and M. Ishak Nadiri (1989), "Research and Development and Intra-industry Spillovers: An Empirical Application of Dynamic Duality", Review of Economic Studies 56, 249-269.

[45] Griliches, Zvi (1992), "The Search for R&D Spillovers", Scandinavian Journal of Economics 94, supplement, S29-S47.

[46] Bloom, Nick, Mark Schankerman and John Van Reenen, "Identifying Technological Spillovers and Product Market Rivalry: Theory and Evidence from a Panel of U.S. Firms" LSE mimeo (July 2004), 45 pp

spillovers is substantial, and much of the literature also assesses the value of corrective mechanisms such as R&D subsidies.

In contrast to the attention paid in the economics literature to technological spillovers, there is no work estimating the impact of spillovers in the creative arts. Wagner suggests that spillovers are also present in creative works subject to copyright as well as in technological invention. The success of the movie *Gone with the Wind* revealed a preference among moviegoers for romantic movies set in historical war times. The success of the first *Survivor* TV show suggested that "reality-based" TV (unpaid actors in exotic locales competing for a prize while revealing their innermost feelings to a TV camera) would garner large audiences, spawning a host of imitator shows. While the copyright holder to the original *Survivor* show held exclusive rights to follow-on shows, they did not have the right to block other producers from airing *The Amazing Race*, *Big Brother* or indeed any other reality-based TV show. The creators of the original show are thus unable to capture the full social benefit of their creation; this is a case of true spillovers. These examples suggest that spillovers in the creative arts are *preference revealing* rather than cumulative, as they are in science and technology. This would suggest that spillovers in the creative arts have a more limited impact than in science and technology.[47] The fact that such spillovers have not been estimated leads us to make a (barely) educated guess that creative spillovers are likely to be at the low end of those estimated for technology spillovers.

The likely presence of positive spillovers from the production of music suggests that *ceteris paribus* the market outcome will result in the underproduction of music. However, the *differentiated product* market equilibrium results in overproduction of music. If we take account of both the (privately) excess entry of the market together with the possible underproduction of music due to spillovers, will the result be over- or underproduction of music?

Denote the value of the spillover as a fraction of the private value of the artist's music by $E$. Then total welfare including spillovers with $n$ artists optimally located is:

$$W_E = (1+E)\cdot\left(U - \frac{2b}{(a+1)\cdot n^a \cdot 2^{a+1}}\right) - nF \tag{7}$$

so the efficient number of firms is:

$$\hat{n}_E = \left(\frac{(1+E)\cdot b\cdot a}{(a+1)\cdot F\cdot 2^a}\right)^{\frac{1}{a+1}} \tag{8}$$

[47] This is merely a first approximation. In fact, there are a number of examples in which spillovers in the creative arts are cumulative. In animated films, the works of Dreamworks (*Madagascar* and *Shrek*), Pixar Studios (*Finding Nemo* and *The Incredibles*) and Miyazaki (*Spirited Away*) clearly influence each other, and in turn are influenced by the earlier works of Disney.(*Snow White* (1939) and *Steamboat Willie* (1927)).

The equilibrium number of artists with file sharing (adjusted for DRM) losses of $D$ is obtained from equation (7); the ratio of the equilibrium number of artists to the optimal number of artists is:

$$\frac{n_s^*}{\hat{n}_E} = 2\left(\frac{(1-2^{-a})(1-\Delta)}{a\cdot(1+E)}\right)^{\frac{1}{1+a}} \tag{9}$$

The ratio of equilibrium to optimum number of artists is plotted below. I show this ratio for file sharing (with "reasonable" DRM) displacement of $D$ = 0.0 and 0.2, and the spillover $E$ toward the low end of that estimated for technology spillovers: $E$ = 0.5 and 1.0:

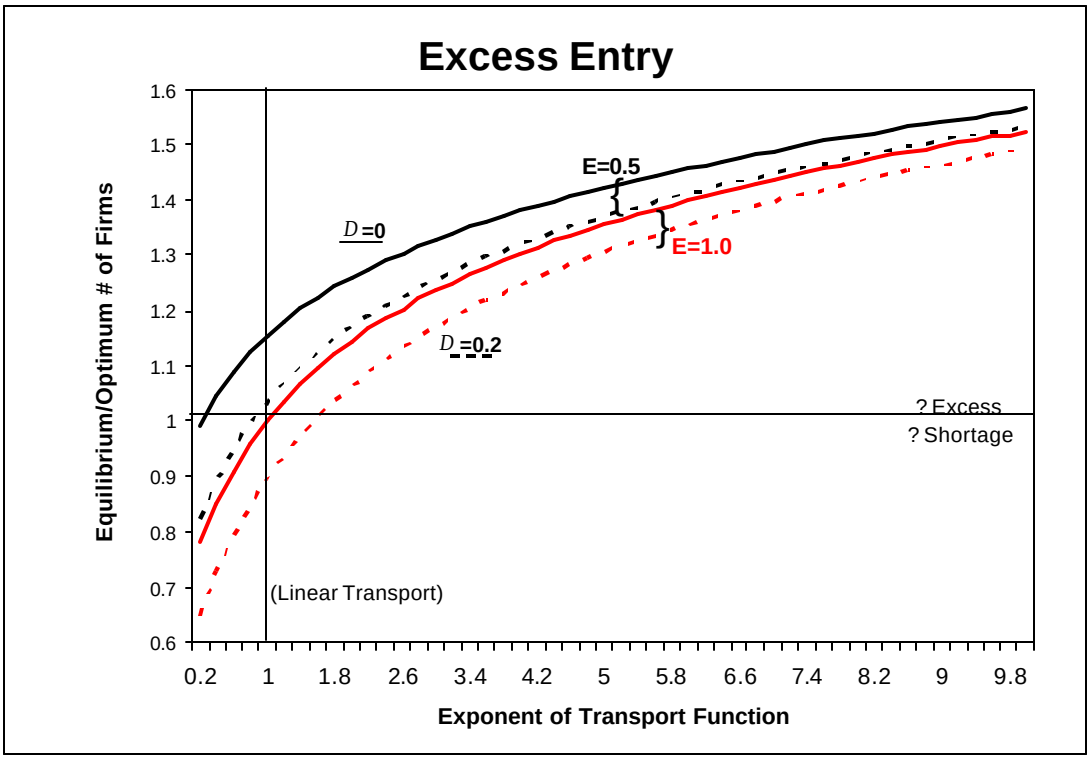


**Figure 5**

The possibility of spillovers somewhat mitigates the problem of excess entry. However, while excess entry is reduced in the presence of spillovers, optimum or even underproduction occurs only under optimistic views of spillovers, pessimistic views of displacement due to file sharing, and a view that customers have "sharp" preferences ($a$ < 1).

Without further evidence or even plausible assumptions to guide us, I conclude that while excess capacity is a likely outcome, the answer must await empirical evidence.

## 4.0 *Empirical Implications*

The model provides guidance as to what evidence we should be looking for. Empirical work thus far as focused on measuring displaced CD sales due to file sharing, and how DRM may affect that. However, the above chart suggests that these two variables are of lesser importance in determining whether or not music is to be under- or overproduced. Far more important are (i) the shape of customer preferences over the music product space; and (ii) the existence and size of music spillovers. Unfortunately, it would appear that these variables are least likely to be easily measured. For example, economists have worked over twenty years estimating the spillovers in technology using patent data; there is no similarly rich and available dataset for content creation, and no reason to suspect that spillover measurement for creative works would be any easier. In particular, the literature on technological spillovers has benefited from a readily available data source: patents. There is no obvious data source for creative works. Nevertheless, the rich history of dealing with estimation problems in measuring technological spillovers may help in measuring spillovers in creative works. But the empirical problems are still daunting.

I also note that measuring the shape of customer preferences in a spatial model in which the relevant artist characteristics are unobserved presents a significant empirical challenge. The foundation paper for discrete choice estimation with unobserved characteristics is Berry (1994).[48] This paper develops a method of inverting a mapping from mean utility levels to market shares under certain conditions, permitting (when inversion is possible) recovery of the mean utilities from market share data. Relevant characteristics may be recoverable using instrumental variables. However, this approach appears to be dependent upon uniform pricing and exogenous firms/artists; Berry is quite clear that his approach is unlikely to generalize to endogenous location decisions, which of course are the crux of the model of this paper.

There are many papers that estimate demand with observed characteristics; an early seminal paper is Bresnahan (1987).[49] More recent work includes Cohen and Mazzeo (2004)[50] estimating demand for banks with geographic location and measurable characteristics of banks; Netz and Taylor (2002)[51] estimate demand for gasoline retailers using location data and other observed characteristics of gas stations. Pinkse and Slade (2004)[52] analyze the UK beer market based on observed characteristics;

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[48] Steven Berry, "Estimating Discrete Choice Models of Product Differentiation," *RAND J. Econ*, **25**(2), (1994), pp 242-62.

[49] Tim Bresnahan, "Competition and Collusion in the American Automobile Industry: the 1955 Price War," *J Indust Econ* **35** (1987) pp. 457-82.

[50] Andrew Cohen and Michael Mazzeo, "Competition, Product Differentiation and Quality Provision: An Empirical Equilibrium Analysis of Bank Branching Decisions," FEDS paper 2004-46, Federal Reserve Board at <http://www.federalreserve.gov/pubs/feds/2004/200446/200446pap.pdf>.

[51] Janet Netz and Beck Taylor, "Maximum Or Minimum Differentiation? Location Patterns Of Retail Outlets," *REStat* **84** (2002) pp. 162-75.

[52] Joris Pinkse and Margaret Slade, "Mergers, Brand Competition, and the Price of a Pint," *Eur Econ Rev*, **48** (2004) pp 617-43.

they formally include unobserved characteristics by including a random variable they assume (problematically) is mean independent of the observed characteristics and are uncorrelated with prices, thus finessing the problem of estimating unobserved characteristics.

Closest in spirit to the model of this paper is Goettler and Shachar (2001),[53] who estimate a spatial model of TV programs in the US, using microdata on 3,286 individual viewers over a one week period in 1992 from Nielson Media Research. They are able to identify (i) the attribute space; (ii) product locations in this space; and (iii) the distribution of customer preferences. This problem bears at least some resemblance to the music market, and the variables they are able to identify and estimate are similar to those required to estimate the model of this paper. They use maximum simulated likelihood estimation, coupled with methods designed to improve simulation performance.

On the basis of this one paper, it appears that estimation of the model in this paper is possible in principle. Development of an appropriate microdata set and the empirical methods necessary to estimate the model awaits further research.

The old saw concerning the person looking for her lost watch underneath the street lamp because the light is so much better there is perhaps relevant. The model of this paper suggests that we have been looking under the street light (file sharing and DRM) but if we wish to find the important results, we must return to the middle of the block (shape of preferences and spillovers), where it is very dark indeed. I leave this as a challenge to my empirically oriented colleagues.

## 5.0 *Caveats and Cautions*

The surprising nature of the results of the model invites very close scrutiny of the application of the model to the problem at hand as well as the plausibility of the range of estimates of file sharing losses ($D$) and spillovers ($E$). I make no effort to defend the latter; plausibility is certainly in the eye of the beholder, and these estimates appear to me to be plausible. The reader is invited to make her own judgments, and explore the implications using equation (9).

The suitability of this particular model to the music market is more amenable to analysis. There are several levels at which questions can be raised.

> *Is a differentiated products spatial model appropriate to the music market?* Applying a spatial model on the music market appears intuitive and plausible, but it comes at a cost of imposing restrictions on demand interactions. The power of the model to incorporate both demand and supply conditions in a

[53] Ronald Goettler and Ron Shachar, "Spatial competition in the network television industry," *RAND J of Econ*, **32**(4) (2001), pp. 624-656.

rich context that appears to conform to our (or at least my) intuition of how the market works seems persuasive.

*Does the model generalize to something more realistic?* The model of this paper has only a single dimensional product space, customers purchase only a single unit, and preferences are symmetric and identical up to location. Price discrimination, free entry and artists' ability to modify their location are both assumed. Bhaskar and To (*op cit*) present a much more general and richer spatial model, and find that as long as price discrimination, free entry and artist flexibility hold, excess capacity is the result. The numerical results of this paper only encompass the simpler model; a similar analysis of the more general model awaits further research.

*Do artists price discriminate and are they flexible in their location in the face of new entry?* These are the most important assumptions that drive the excess entry result. If either is false, then the results as derived do not hold. In this paper, I assert that the appropriate unit of analysis is the artist; in this view, artists and their music producers have a wide range of services that that allow fans to express their intensity of preference. The ability to price these services, as discussed in the text, is in fact the ability to price discriminate.[54] Other authors (e.g., Rob and Waldfogel (*op cit*)) have taken the CD as the unit of market analysis and assert that no price discrimination can occur. Clearly, the CD is the physical product that shows up on the music store rack, and is the unit of the transaction. However, simple observation suggests that fans are loyal to and interested in artists, and recording firms invest heavily in developing and promoting artists. The focus on the artist as the product in the music business suggests a similar focus in the model.

The ability of artists to shift their location in response to market forces appears to be fairly obvious.[55] Pop and country singers often evolve their music in response to market demands,[56] and even symphony orchestras can make marginal changes in their market position. If, however, we take the view that the CD is the unit of analysis, then obviously the CD is what it is

[54] The most well-known treatment of price discrimination in the context of information goods is Shapiro, Carl and Varian, Hal, *Information Rules*, Cambridge, MA: Harvard Business School Press (1998).

[55] In a recent interview, Liz Phair spoke of her musical shift since her early albums and her fans' unhappiness at that move, saying, ""If you are an old fan and [my new album] doesn't fit what you need, don't buy the disc"; "The Independence of Liz Phair," *New York Times*, Aug 2, 2005. Also, aspiring Philadelphia artist Nora Whittaker described her own relocation in product space in response to market pressures; see Hillis, Roger, "Songwriter to Unveil New CD in Rehoboth," *Delaware Beachcomber*, July 22,2005, at <http://www.delmarvaheadlines.com/debeachcomber/stories/20050722/2184238.html>

[56] Some obvious cases in point: Britney Spears has evolved her music from "bubble gum" music targeted at 13 year old girls to a more mainline pop style as she herself has grown older. Madonna appears to change with every new album. On the other hand, it is unlikely that the Rolling Stones can ever change their particular location in music space; their long history playing a particular kind of music suggests a sunk cost in their location choice.

and cannot change in response to market demands. But as I note above, the appropriate focus is on the artist rather than the CD.

*Are there spillovers from musical works and what is their magnitude?* This is the most problematic issue of this paper; there is no research suggesting these spillovers exist and are important. While it seems plausible that such spillovers might exist, it is impossible to tell whether or not they are important. My use of an estimate range of $E = 0.5$ to 1.0 seems very optimistic; it could easily be much smaller. Unfortunately, estimating the magnitude of these spillovers promises to be a daunting task, at least as difficult as the estimation of technological spillovers. Yet it appears that the magnitude of the spillover is likely an important determinant of the optimal level of music production.

There are many open questions about the modeling approach of this paper and consequently about the results. Careful scrutiny of the model suggests a need for future theoretical and empirical work to ensure that its application to the music market yields credible results.

## 6.0 *Conclusion*

The turmoil in the music industry due to P2P file sharing has attracted scholarly attention in both economics and the law. The primary issue has been the extent to which file sharing (with or without DRM) displaces CD sales, with the focus on welfare changes due to (*inter alia*) reduced music production. In this paper, I introduce a differentiated product model of the music market, and find that the form of the market induces excess entry in equilibrium. File sharing, to the extent it reduces profits from music production, reduces this excess entry but not to the efficient level. A "reasonable" DRM mechanism would increase entry (by making file sharing less attractive) but that simply makes matters worse. I then consider the possibility of spillovers from music production, which would be expected to drive a wedge between private and social benefits. Accounting for possible spillovers does indeed reduce entry closer to the efficient level, but only if the spillover is relatively large and customer preferences are "sharp." Thus, while the previous literature was concerned with sales displacement due to file sharing and the attendant concern of underproduction of music, this paper suggests that the overproduction of music that is a result of the structure of the music market is a much more serious issue. Empirically, the efficiency of entry is principally determined by the shape of customer preferences and the size of (potential) spillovers; the effect of file sharing and DRM is relatively small in comparison.

The implications for empirical research are clear but daunting. Both the magnitude of spillovers and the shape of customer preferences present substantial measurement difficulties. The Goettler and Shachar (*op cit*) paper offers a way forward, but estimation of the model of this paper presents a fresh challenge to my empirically

oriented colleagues.

# -- Appendix --

With $n$ artists in the market, the operating profit of artist $a$ for the general transport function is

$$p_a = \int_{a-1/2n}^{a+1/2n} \min_{j \neq a} f(|j-x|) - f(|a-x|)\,dx = \frac{2}{n} \cdot \int_{1/2}^{1} f\left(\tfrac{z}{n}\right) - f\left(\tfrac{1-z}{n}\right) dz$$

using the change of variable $x = i + (z-1)/n$.

Under the power function assumption, profit for each firm is

$$p = \frac{2}{n} \cdot \int_{1/2}^{1} b \cdot \left(\tfrac{z}{n}\right)^a - b \cdot \left(\tfrac{1-z}{n}\right)^a dz = \frac{2b}{n^{a+1}} \int_{1/2}^{1} z^a - (1-z)^a \, dz$$
$$= \frac{2b}{n^{a+1}} \left[ \frac{z^{a+1}}{a+1} + \frac{(1-z)^{a+1}}{a+1} \right]_{1/2}^{1} = \frac{2b\left(1 - \frac{1}{2^a}\right)}{(a+1)n^{a+1}}$$

With fixed cost of $F$, the free entry zero profit equilibrium results in $n^*$ firms, satisfying

$$F = \frac{2b}{(a+1)n^{a+1}} \left(1 - \left(\tfrac{1}{2}\right)^a\right), \text{ or } n^* = \left( \frac{2b\left(1 - \frac{1}{2^a}\right)}{(a+1)F} \right)^{\frac{1}{a+1}} = \left( \frac{2b(2^a - 1)}{(a+1) \cdot F \cdot 2^a} \right)^{\frac{1}{a+1}}$$

which fully characterizes the equilibrium.

Social welfare $W$ is

$$W = \left( U - 2n \int_0^{1/2} \tfrac{1}{n} n \left(\tfrac{z}{n}\right)^a dz \right) - nF = \left( U - \frac{2a}{(a+1) \cdot n^a \cdot 2^{a+1}} \right) - nF$$

Welfare is maximized at $\hat{n}$ firms, satisfying

$$\frac{dW}{dn} = \frac{a}{(a+1)} \frac{b}{2^a} n^{-(a+1)} - F = 0$$
$$\hat{n} = \left( \frac{b \cdot a}{(a+1) \cdot F \cdot 2^a} \right)^{\frac{1}{a+1}}$$

If the free entry equilibrium resulted in the welfare-maximizing number of artists, then the ratio $n^*/\hat{n}$ would be unity. Unfortunately, such is not the case:

$$\frac{n^*}{\hat{n}} = 2\left(\frac{1-2^{-a}}{a}\right)^{\frac{1}{1+a}}$$

Note that this ratio depends only on the *shape* of the transport function, determined by $a$, but for all $a$ the ratio is greater than unity.