

File-Sharing and Copyright¹

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1. Introduction

The advent of file-sharing technology has allowed consumers to copy music, books, video games and other protected works on an unprecedented scale at minimal cost. In this essay, we ask whether the new technology has undermined the incentives of authors and entertainment companies to create, market and distribute new works. While the empirical evidence of the effect of file sharing on sales is mixed, many studies conclude that music piracy can perhaps explain as much as one fifth of the recent decline in industry sales. A displacement of sales alone, however, is not sufficient to conclude that authors have weaker incentives to create new works. File sharing also influences the markets for concerts, electronics and communications infrastructure. For example, the technology increased concert prices, enticing artists to tour more often and, ultimately, raising their overall income.

Data on the supply of new works are consistent with our argument that file sharing did not discourage authors and publishers.² The publication of new books rose by 66% over the 2002-2007 period. Since 2000, the annual release of new music albums has more than doubled, and worldwide feature film production is up by more than 30%

¹ We would like to thank Josh Lerner, Scott Stern, Amitay Alter and participants in the NBER's 2009 Innovation Policy and the Economy Conference in Washington, D.C., for helpful comments.

² Copyright refers to a complex bundle of rights that includes the rights of authors (composers, lyricists) and publishers (for a detailed description of these contracts, see Towse 1999; Passman 2000). Throughout this essay, we use the term somewhat loosely, referring to all legal protections – including, for instance, the “neighboring rights” of performers – that encourage the creation, production, marketing, and distribution of works. Also, we neglect the tensions that exist in copyright between artist and publisher interests (see Towse, 1999; Gayer and Shy, 2006.)

since 2003. At the same time, empirical research in file sharing documents that consumer welfare increased substantially due to the new technology.

Over the past 200 years, most countries evolved their copyright regimes in one direction only: lawmakers repeatedly strengthened the legal protections of authors and publishers, raising prices for the general public and discouraging consumption.³ Seen against this backdrop, file sharing is a unique experiment that considerably weakened copyright protections. While file sharing disrupted some traditional business models in the creative industries, foremost in music, in our reading of the evidence there is little to suggest that the new technology has discouraged artistic production. Weaker copyright protection, it seems, has benefited society.

In this essay, we discuss the currently available research that sheds light on the effects of file sharing, particularly in music where its effects have been most pronounced. We start by describing the new technology and how consumers are using it. Section 4 reviews the evidence that file sharing reduces the profitability of creating and selling new works. We discuss the importance of complements to original works in Section 5 and describe the artistic and corporate response to file sharing in section 6. The concluding section offers policy implications.

2. File-Sharing and Copyright

In setting copyright terms, lawmakers trade off the increased incentives to create protected works and the higher prices that consumers face when books, movies, and recordings must not be copied freely (Landes and Posner, 1989). As this description suggests, the lawmakers' task is a challenging one. Setting copyright terms in a manner that benefits society requires an answer to two questions. First, we need to know how much weaker the incentives to create new works would be in a regime with more

³ In the United States, as elsewhere, the degree of protection has steadily expanded, from the modest Copyright Act of 1790, which offered 14 years of protection with a renewal period of 14 years, to the legislation passed in 1831 (28 years), 1909 (renewal extended to 28 years), 1976 (50 years after the author's death), 1992 (automatic renewal), and 1998 (70 years).

constrained copyright. Second, and equally important, is the question how producers would respond to weaker incentives. Would they offer fewer works? Or perhaps works of lesser quality? In this essay, we discuss what we know about these questions, using the advent of file-sharing as our example for a technology that considerably weakened copyright protection for music, movies, books and video games.

Weaker copyright is unambiguously desirable if it does not lessen the incentives of artists and entertainment companies to produce new works. To appreciate the impact of file sharing, we first need to know whether the technology did in fact reduce the profitability of creating, marketing, and distributing new works. Of course, we know that millions of consumers share billions of files without compensating artists or entertainment companies. But the fact that file sharing is popular tells us little about the impact of the technology on industry profits. At a price close to zero, many consumers will download music and movies that they would not have bought at current prices. This issue is likely to be important. In a sample of 5,600 consumers who were willing to share their iPod listening statistics, the average player held a collection of over 3,500 songs (Lamere, 2006). A full 64% of these songs had never been played, making it unlikely that these consumers would have paid much for a good portion of the music they owned. While it is difficult to say how representative this sample is, there is no doubt that trade groups such as the Business Software Alliance vastly exaggerate the impact of file sharing on industry profitability when they treat every pirated copy as a lost sale (Economist, 2005). The demand for titles is not completely price inelastic.

Weaker property rights can undermine industry profitability if consumers who would have purchased a recording obtain a free copy instead. The critical question is then whether consumers perceive protected and freely shared works as close substitutes. As the name suggests, substitutes are products that meet similar consumer demands. For two substitute goods, a price decline for one leads to a decline in the demand for the other.⁴ For example, if we allowed mash-up artists to freely copy parts of an original song, consumers who regard the derivative work as a close substitute would be less likely

⁴ A classic example is butter and margarine.

to buy the original.⁵ However, if consumers learned to better appreciate the original through the mash-up, demand for the original work might actually increase. In this case, the two versions of the song are complements, two goods for which a decrease in the price of one leads to an increase in the demand for the other. A well-known example for two complements is music and iPods. As file-sharing eroded the effective price of music for a large group of consumers, demand for mp3-players soared, allowing Apple to benefit from consumers' increased willingness-to-pay for its line of products.⁶

In practice, it is often surprisingly difficult to predict whether new products and technologies are complements or substitutes. As a result, we can often not be sure how changes in copyright will influence demand and industry profitability. The entertainment industry's history provides many examples of the difficulties involved in distinguishing substitutes, unrelated products, and complements. Music companies fought the introduction of radio in the 1920s, fearing the new medium would provide close substitutes to buying records. Since that time, the numerous attempts to bribe radio stations in the hopes of influencing playlists suggest the industry has come to see radio as an important complement to recordings (Coase, 1979). Similarly, the entertainment industry battled home taping⁷ and the introduction of the VCR, arguing the new technology "is to the American film producer and the American public as the Boston strangler is to the woman home alone" (Valenti, 1982). Once the Supreme Court decided to protect technologies like the VCR, it did not take the industry long to discover that selling videotapes (and now DVDs) presents a major business opportunity.

Similar uncertainty surrounds file-sharing technology today. Some argue that protected works and copies on file-sharing networks are substitutes because consumers who would have bought the copyrighted version now choose to download a free copy instead. Others see protected works and copies on file-sharing networks as largely

⁵ A mash-up is a song created out of pieces of two or more songs, usually by overlaying the vocal track of one song over the music track of another.

⁶ Leung (2008) estimates that piracy contributes 20% to iPod sales.

⁷ Stanley M. Gortikov, president of the Recording Industry Association of America (RIAA), explained in hearings before a House committee on 14 April 1982: "I'm scared, and so is my industry. Changing technology today is threatening to destroy the value of our copyrights and the vitality of the music industry. Our nemesis is home taping."

unrelated because they believe that file sharers are mostly consumers who are not willing to pay \$10 for Taylor Swift's latest release. Finally, protected works and copies on file sharing networks are complements if consumers rely on the new technology to discover CDs or DVDs they want to purchase. These views need not be mutually exclusive. In a recent survey among file sharers, we found some support for all three conjectures (Oberholzer-Gee and Strumpf, 2005). 65% of respondents acknowledged they did not buy an album because they had downloaded it. An even larger group (80%) claimed they bought at least one album because they sampled it first on a file-sharing network. Fortunately, there is now a body of research that studies in a more systematic manner whether copyright protected works and copies on file-sharing networks are complements or substitutes. We will discuss this literature in section 4 of this essay.

Even if a weakened copyright regime turned out to reduce industry profitability, it is not obvious whether a decline in profits would undermine the incentives to create, market and distribute artistic works. Two considerations seem particularly important. First, as copyright weakens, the effective price of music, movies, and books falls and consumer willingness-to-pay for complements increases. If artists derive income from these complements as well, the overall incentives to produce new works might not decline. For instance, as music becomes effectively available for free, the price of concerts, a complement to music, is likely to rise, and artists who earn income from concerts might not be hurt by a decline in music sales (Krueger, 2005; Mortimer and Sorensen, 2005). Similarly, authors might be better able to supplement their income from books through speaking tours if many more readers are familiar with their writings.⁸

A second reason that a decline in industry profitability might not hurt artistic production has to do with artist motivations. The remuneration of artistic talent differs from other types of labor in at least two important respects. On the one hand, artists often enjoy what they do, suggesting they might continue being creative even when the monetary incentives to do so become weaker. In addition, artists receive a significant portion of their remuneration not in monetary form – many of them enjoy fame,

⁸ Author Cory Doctorow, for instance, says: "I really feel like my problem isn't piracy. It's obscurity." (Rich, 2009).

admiration, social status, and free beer in bars – suggesting a reduction in monetary incentives might possibly have a reduced impact on the quantity and quality of artistic production.

There is no doubt that file sharing substantially weakened the protection of copyrighted works. Yet, as our discussion shows, the outcome of this experiment is far from certain. Three conditions need to hold for less-certain rights to undermine the incentives for artistic production: original works and copies on file-sharing networks must be reasonably close substitutes; artists and the entertainment industry must not be able to shift from previous sources of income to the (similarly profitable) sale of complements; and falling incomes must be an important-enough motivator for artists to reduce production. Only if all three conditions hold will file sharing hurt social welfare.

It might seem curious to some of our readers that we do not consider the welfare of artists and entertainment companies in our calculus. Our approach, however, reflects the original intent of copyright protection, which was conceived not as a welfare program for authors but to encourage the creation of new works. We know that stronger copyright protection can increase the market value of companies.⁹ But these gains are a mechanism to raise social welfare, not the intended consequence.¹⁰

3. A Brief History of File-Sharing

To better understand the impact of file-sharing technology on copyright protection, it is useful to review the basics of file-sharing. In this section, we will also describe recent changes in technology and review the most significant legal challenges that companies providing file-sharing software faced to date.

File sharing relies on computers forming networks to allow the transfer of data. Each computer (or node) may agree to share some files, and file-sharing software allows

⁹ Baker and Cunningham (2006), for example, estimate that a statute broadening copyright adds up to \$39 million to the market capitalization of a typical firm.

¹⁰ To frame our discussion in terms of efficiency (Pareto improvements), we argue that the relevant benchmark is the welfare of groups in a situation without copyright.

users to search for and download files from other computers in the network. Individual nodes are called clients if they request information, servers if they fulfill requests, and peers if they do both.

Shawn Fanning, an 18-year-old student at Boston's Northeastern University, started the file-sharing revolution when he released Napster in June of 1999 (table 1 provides a timeline). The software first allowed the freshman to trade music with his dorm mates. Prior to Napster, fans used search engines such as Lycos and music websites to download music. However, searching for files was cumbersome because the available music indices were often out of date. Many sites offered more broken links than hits. Napster was novel in that it maintained a central, dynamic index of all available files. This index was updated every time a user logged on or off. Thanks to its user-friendly interface and seemingly unlimited supply of music, the service gained 30 million users in its first year.

Napster's legal difficulties started not long after its initial release. In December 1999, the Recording Industry Association of America (RIAA) sued Napster for contributory and vicarious copyright infringement (*A&M Records, Inc. v. Napster, Inc.*, 239 F.3d 1004 (9th Cir. 2001)).¹¹ Two years and one appeal later, the Ninth Circuit Court of Appeals ruled against Napster, arguing the service's central directory of files gave its makers knowledge of and the ability to control user infringement. Unable to filter files from the network, Napster shut down. However, putting Napster out of business proved easier than ending file sharing. Most Napster users simply switched to second-generation peer-to-peer services, and they were joined by millions of file-sharing novices. Three major networks eventually developed: eDonkey; FastTrack, a network used by KaZaA and Grokster; and Gnutella, an open-source network for clients such as Bearshare, Gnucleus, LimeWire, and Morpheus.

The Circuit Court decision also proved influential for the further technological development of file-sharing services. If peer-to-peer companies had no direct knowledge

¹¹ A party is liable for contributory infringement if it knows of the infringing activity and materially contributes to it. Vicarious infringement occurs when the indirect infringer benefits financially from the infringement.

of and control over infringing activities, many in the industry believed, file-sharing services might be protected by the Supreme Court's Betamax decision (*Sony Corp. of America v. Universal City Studios, Inc.*, 464 U.S. 417 (1984)). The decision holds that companies are not liable for customers' acts of copyright infringement if their technology is capable of substantial non-infringing uses. In the Sony case, the Court estimated that about 9% of VCR recordings were of TV shows that consumers had taped to watch at a later time and that the producers of these shows did not object to time shifting. This was sufficient to shield Sony from liability.

Convinced that peer-peer technology had substantial legal uses – for example the exchange of files that were in the public domain or the sharing of documents within a company – second-generation file-sharing services eliminated centralized indices (Oberholzer-Gee, 2006). In these systems, users first connect to a single peer using a specific internet protocol. The peer then tells the software about other peers in the network, in effect decentralizing the search and download processes and making it impossible for peer-to-peer companies to know whether users trade copyrighted materials. At first, this strategy appeared to work. When the RIAA sued the makers of Grokster, a branded version of KaZaA, and Morpheus for contributory and vicarious copyright infringement, District Court Judge Stephen V. Wilson ruled that the two companies could not be held liable (*MGM Studios, Inc. v. Grokster, Ltd.*, 259 F. Supp. 2d 1029 (D. Cal. 2003): “All Napster search traffic went through, and relied upon, Napster... [But] when users search for and initiate transfers of files using the Grokster client, they do so without any information being transmitted to or through any computers owned or controlled by Grokster... If either defendant closed their doors and deactivated all computers within their control, users of their products could continue sharing files with little or no interruption.”

The entertainment companies appealed the case, but the circuit court upheld the earlier decision, affirming that decentralized peer-to-peer systems met the standard set in Sony. On June 27, 2005, however, the Supreme Court overturned the Ninth Circuit, sending the case back to the district court for further consideration (*MGM Studios, Inc. v. Grokster, Ltd.*, 545 U.S. 913 (2005): “Because substantial evidence supports MGM on all

elements, summary judgment for the respondents was in error. On remand, reconsideration of MGM's summary judgment motion will be in order.” The justices ruled that a company that distributed a device “with the object of promoting its use to infringe copyright” could be liable for the resulting illegal acts. The Court argued that Grokster and Morpheus had wanted to be the next Napster, showing their goal was to induce copyright infringement.

The Supreme Court's decision led most peer-to-peer companies to settle with the entertainment industry. An exception was LimeWire, a service that continues to operate to this day. LimeWire argues that its software provides substantial legal uses. For example, the company operates a digital music store that offers 500,000 songs, many of them from independent bands. And LimeWire insists that it does not induce consumers to infringe copyright. The RIAA filed a lawsuit against LimeWire in April 2006. At the time of this writing, no decision has been reached, leaving open the question whether services such as LimeWire are protected by the standard set in Sony. At the same time, several second-generation file-sharing programs such as Ares Galaxy and eMule, the former eDonkey, continue to be available as open-source software.

While pursuing the developers of peer-to-peer software in the courts, the RIAA also started suing P2P users who shared a large number of files—typically more than 1,000 tracks—starting in 2003. The association hoped its actions would help reverse the common view that file sharing was a legitimate activity. In a Pew Internet & American Life Project survey in 2000, 78% of internet users who downloaded music did not think they were stealing. A majority of the general internet population held the same view (Lenhart and Fox, 2000). By the end of 2008, the industry had brought suits against more than 35,000 file sharers. Most cases were settled, typically for a few thousand dollars.

In a surprising shift in legal tactics, however, the RIAA announced in December 2008 that it had decided to drop its campaign against individual file sharers. Instead, the industry hoped to collaborate with internet service providers (ISPs) to stop the transfer of copyrighted materials. The trade group has worked out preliminary agreements with

major ISPs under which it will send an email to the provider when it finds that customers share copyright-protected files (McBride and Smith, 2008).

While the RIAA had some success putting peer-to-peer companies out of business, file-sharing technology continued to evolve. The most important technical advance was the emergence of BitTorrent. BitTorrent file requests differ from classic full-file HTTP requests in that the client makes many small data requests, similar to internet telephony which breaks voices into small packets of data. In addition, BitTorrent downloads follow a “rarest-first” order which ensures high availability of files across the network. To start the downloading process, users first obtain a torrent, a small file that contains metadata about the file to be downloaded and information about the tracker, the computer that coordinates the file distribution. Torrents are hosted by a fairly small number of websites. The Pirate Bay is probably the best-known among them. The torrent allows the client to connect to the tracker, from which it receives a list of peers that currently transfer pieces of the file. As more peers connect to a tracker, they form a swarm and begin to trade pieces with one another.

The advent of BitTorrent is significant for a number of reasons. First, the improved technology significantly reduces download times. While the user experience varies significantly, it has now become possible to download a feature film in less than two hours. Second, the technology forces users to share the parts of files that they already own while they download the remaining bits. This procedure reduces the opportunity to free-ride that plagued older P2P systems. The protocol also rewards users who contribute more generously, for instance by allowing faster downloads for those with greater upload capacity. Sharing digital files was always non-rivalrous because the original owner of a file retained his copy. But more efficient file distribution systems such as BitTorrent have now also succeeded in reducing the negative externalities that users impose on one another when they transfer files.

a. Size of File-sharing Activity

Measuring the extent of file sharing is challenging (Karagiannis, 2003; Pasick, 2004). Initial studies relied on surveys to determine the number of users, but this

approach is flawed because respondents are likely to understate their participation in a potentially illegal activity. More worrisome, the level of understatement likely varies over time based on the legal climate and peer effects among teens. Surveys are also unreliable because it is difficult to survey a representative population of file sharers and due to recall issues.

A better approach involves identifying the packets traversing computer networks. These studies use special hardware to classify messages that are sent along networks by source, such as web (http) traffic, email, or file sharing. This approach is taxing because of the scale of the activity (ISPs typically handle many gigabits per second), the changes in the predominant protocol file-sharing protocol, and the recent move to encryption, which makes packets unreadable to unauthorized observers. Measurement studies employ three basic approaches to deal with these technical issues: flow monitors, deep-packet inspection, and direct interface with file sharing users.

Flow monitoring analyzes unidirectional sequences of packets from one IP address to another at the router level (Shalunov and Teitelbaum, 2001). This approach inspects packets in a rather shallow way, relying primarily on header information such as IP protocol and an examination of ports. Flow monitoring can analyze a large amount of traffic, at the risk of misclassifying some of it. A detailed flow analysis of Internet2, the U.S. high-speed network which primarily connects universities, is available at the weekly level back to 2003 (Internet2 Netflow Statistics, 2009). Figure 1 shows that file sharing traffic on Internet2 has roughly grown by a factor of ten – from about 1 terabyte to about 10 terabytes – from 2003 through 2009.¹² While this growth has been fairly steady, during 2003-2005 there were large traffic dips during late spring and early summer as well as smaller drops during Christmas. These drops in file-sharing activity reflect school vacations, periods during which college students, who are among the highest file sharing users, leave their high-speed campus internet connections.

The second type of evidence comes from deep packet inspection. Rather than relying just on the packet header, this approach considers characteristics of the payload

¹²Karagainni, et al (2004) employ a similar methodology in studying Tier 1 ISP traffic. They conclude that file sharing did not decline over the period 2003-2004.

itself (Allot Communications, 2007). Packet inspection is the most accurate method of identifying file sharing, but the technique requires extremely sophisticated equipment since huge amounts of data must be analyzed. The deep-packet inspection company Sandvine has been monitoring file-sharing trends for several years. The company's reports show that file sharing accounted for between forty and sixty percent of all bandwidth usage over 2002-2008 (Sandvine, 2002-2007 and 2008ab). CacheLogic, another deep-packet inspection company, finds similar trends in global file activity (Ferguson, 2006). Figure 2 shows the growing role of file sharing over 1999-2006. By 2006 sixty percent of all consumer internet traffic was due to file sharing, a majority of which was composed of video files.

The final approach to measuring file sharing comes from studying peer-to-peer networks directly. Observers use a modified version of file-sharing software to connect to a large number of users on the network. Direct observation can provide fine-grained information such as the identity of files. A difficulty with this approach is that direct observers need to monitor an ever-changing representative sample of networks. The leading practitioner is BigChampagne, a company which monitors individual search requests as well as the content of folders that users share. Figure 3 shows BigChampagne's count of the monthly number of U.S. file-sharing users from mid-2002 through mid-2006.¹³ By the end of this period there were about seven million simultaneous users in the U.S. Unfortunately, more recent figures are not publicly available. As with the earlier data on file sharing traffic, there is evidence of secular growth as well as reductions, or least a lack of growth, during summer months. The data also suggest one reason why the RIAA has abandoned its approach of suing individual file sharers. In figure 3, it is difficult to ascertain an effect of the beginning of the 2003 lawsuit campaign (Manuse, 2003). While the overall campaign may have been disappointing from the RIAA's perspective, research has documented a short-run decline in the number of files shared and in downloading activity in response to the first round of

¹³ User counts from the independent file-sharing site slyck.com largely mirror these numbers.

lawsuits (Bhattacharjee et al., 2006). In contrast, the *Grokster* Supreme Court decision in 2005 does not appear to have had much impact on the user-base.¹⁴

The data from these disparate sources paint a similar picture for trends in U.S. file sharing. There has been secular growth in both the amount of file sharing and the number of users. This upward trend has largely been unaffected by shifts in technology and the legal environment. At the same time, figure 1 shows that the intra-year cycle in file sharing observed in the early years has started to disappear. As broadband has proliferated outside of universities and to the home, young file-sharing users no longer rely on their university connections during the school year to download files.

b. Consumer Behavior

Three facts about consumer behavior on file-sharing networks strike us as particularly interesting: the narrow focus on a limited set of files; the truly global nature of file sharing; and the continued importance of industry marketing efforts. We discuss each of these in turn.

Users share a wide variety of files on P2P networks. Table 2 shows the distribution of a selected list of genres on a popular P2P network and compares it to store sales of these albums and downloads of songs (for a detailed description of the sample, see Oberholzer-Gee and Strumpf, 2007). Genres such as R&B, Rap and New Artists are overrepresented, while there is comparatively little country music. Looking at what users actually download, it is striking to see how dominant the Current Alternative category is. Almost one half of all downloads are transfers of songs in this genre. The data in Table 2 reflect the supply of music files in 2002, the stone age of file sharing. We don't know of any study that has systematically compared changes in content over time.

While the supply of files is vast, peer-to-peer users download only a small share of the files that are available. In our sample of 10,271 different music tracks, 60% are never downloaded over a period of 17 weeks, and 81% are downloaded less than 5 times,

¹⁴Similarly, Ferguson (2006) shows that eDonkey traffic levels were largely unaffected in 2006 when legal authorities forced the closure of a large network of servers.

a number that is just slightly above the mean.¹⁵ Even in movies, where the number of available titles is far smaller, there is a notable focus on the most popular titles. Table 3 shows the availability of and the demand for movies on Mininova, a popular BitTorrent index site. Not surprisingly, the top DVD rentals are all in high demand (column 2). But demand trails off markedly for older titles, many of which are not even available. A point in case is Malin Akerman, a Swedish actress voted number one on IMDB's starmeter in early 2009. Akerman was one of the stars of the then popular movie *Watchmen*. As the last column in Table 3 shows, there was in fact significant demand for that release. But movie buffs with an interest in Akerman's previous films faced rather slim pickings. At the height of the popularity of Akerman, four of her last ten movies were unavailable and there was no demand for two additional films.¹⁶ As in music, downloading activity for movies is heavily concentrated on current releases and the supply of titles is substantially broader than the demand.

A second interesting fact about consumer behavior on peer-to-peer networks is the truly global nature of file-sharing. Table 4 shows the top countries for users and downloads (from Oberholzer-Gee and Strumpf, 2007). Interactions among file sharers transcend geography and language. U.S. users download only 45.1% of their files from other U.S. users, with the remainder coming from a diverse range of countries including Germany (16.5%), Canada (6.9%) and Italy (6.1%). One implication of these interactions is that national regulations of file sharing will only have limited bite. For instance, if the RIAA and domestic ISPs discouraged U.S. users from making files available, as they currently hope to do, users in the U.S. could simply download files from other countries.

A final observation concerns the marketing efforts of the entertainment industry. In view of the vast supply of music and videos on the internet and the many electronic networks connecting individuals, it might seem reasonable to expect that the industry's

¹⁵ Our sample is drawn from SoundScan charts, which include all commercially relevant albums. Though some of the albums in the sample had low sales, many in fact were very high sellers.

¹⁶ The concentration of movie downloads in part reflects the current BitTorrent technology. Index sites, which list the files available for download, typically de-list a title when no one is sharing a complete copy for some length of time. As a result, less popular movies become often unavailable, as are older movies since the number of shared copies tends to decline over time.

ability to draw attention to particular products has been greatly diminished. But the data in figure 4 tell a different story. The graph shows downloads and sales of the popular Eight Mile soundtrack, a commercial success directed by Curtis Hanson, starring rapper Eminem. Note that the recording leaked about 6 weeks prior to the official album release, with Eight Mile songs becoming available on peer-to-peer networks. But, interestingly, the level of downloads remained small until the industry marketing campaign began. Unless the industry drums up support for a new release, it is apparently difficult to give it away for free. This pattern of downloads and sales is fairly typical in our data. Contrary to the view that the entertainment industry has lost its ability to create value in a networked world, these data suggest the recording industry remains unrivaled in its ability to steer consumer attention.

4. Does File-Sharing Reduce the Sale of Copyrighted Materials?

The sharing of information goods such as music, movies, and books has been the subject of a substantial literature, both theoretical and empirical. Theory has most often focused on two competing intuitions about the effects of file sharing. A first is obvious: copying hurts producers because consumers who would have purchased a product now obtain it for free. But there is a second effect that runs counter to this idea. Because consumers anticipate sharing products, their willingness to pay (and hence producer profits) might actually increase. For example, a family might be willing to buy an expensive videogame because the parents know that several children will enjoy playing it. The theoretical literature has successfully identified a number of factors that influence the balance of these two effects, including the relative cost of producing information goods and sharing, the variation in the size of groups that share protected works, as well as the diversity in consumer valuations and the correlation of valuations within a sharing group (Novos and Waldman, 1984; Johnson, 1985; Liebowitz, 1985; Besen and Kirby, 1989; Bakos, Brynjolfsson and Lichtman, 1999; Varian, 2000). Depending on the importance of the relevant parameters, theoretical modeling predicts that file-sharing can

either hurt or help producers (for a review of theory papers, see Peitz and Waelbroeck, 2003).

Because the theoretical results are inconclusive, the effect of file sharing on industry profitability is largely an empirical question. We summarize the findings of some of the major studies in table 5. As the list shows, the results are decidedly mixed. There are two studies that document a positive effect of file-sharing on sales: Andersen and Franz (2008) for a representative sample of Canadian consumers and, more narrowly, Gopal et al. (2006) for the effect of sampling on CD sales.¹⁷ The majority of studies finds that file sharing reduces sales, with estimated displacement rates ranging 3.5% for movies (Rob and Waldfogel, 2007) to rates as high as 30% for music (Zentner, 2006).¹⁸ A typical estimate is a displacement rate of about 20%. One implication of these results is that developments other than file sharing must have had a profound impact on sales. For music, the popularity of new types of (internet-based) entertainment and the end of the transition from LPs to CDs are leading explanations for the overall decline in sales (Hong, 2004; Oberholzer-Gee and Strumpf, 2007). While many studies find some displacement, an important group of papers reports that file-sharing does not hurt sales at all (Tanaka, 2004; Bhattacharjee et al., 2007; Oberholzer-Gee and Strumpf, 2007; Smith and Telang, 2008). And even among the studies that show some displacement, there tend to be important subsamples that were not affected. For example, Rob and Waldfogel (2006) find an average displacement effect of 20% but report that file sharing had no impact on hit albums.

In order to better understand why file-sharing studies come to varying conclusions, it is instructive to consider a number of challenges in the empirical literature.

Choice of Sample – Researchers frequently rely on convenience samples, typically students, to estimate the effect of file sharing on sales. This is problematic because surveys show high school and college students to be among the most active file

¹⁷ Gopal et al.'s (2006) results are consistent with the theoretical findings in Peitz and Waelbroeck (2006).

¹⁸ An outlier is Liebowitz (2008) who reports a displacement rate of more than 100% for a selection of U.S. music markets.

sharers (Pew Internet Project, 2003). As a result, the displacement rates documented in these studies are likely to lie above the true population rates. Convenience aside, we suspect that many scholars rely on unrepresentative samples of students because it used to be almost impossible, and remains often expensive, to gain access to representative sales data. For instance, U.S. sales data for music, traditionally shared among record companies, has only become available to researchers in the most recent years. And even today, short-term subscriptions to industry databases can cost thousands of dollars, excluding scholars with more limited research budgets.¹⁹ To arrive at a more complete understanding of file sharing, increased collaboration between industry and academia – and the employment of representative samples – appears essential to us.

Measures of piracy – A key difficulty in interpreting the findings of many studies is that they rely on self-reported data or poor proxies for actual file sharing. As table 5 indicates, surveys with self-reported measures of piracy play a significant role in the literature. Unfortunately, we do not know much about the accuracy of survey data in the context of file sharing. As Zentner (2006) points out, some individuals might play down their file sharing because they understand it is illegal. On the other hand, if file sharing is hip, as is the case on many college campuses, students might exaggerate the activity. In Andersen and Frenz (2008), more than 10% of respondents who report having downloaded music do not provide the number of downloaded files, suggesting recall or perhaps response bias might also be an issue. In view of the popularity of survey-based measures of piracy, we consider it important for future research to establish their accuracy. If these data turn out to be reliable, they could play a major role in future research because survey data are simple and inexpensive to obtain.

Where survey data on piracy is unavailable, researchers tend to rely on crude proxies for file sharing such as internet penetration. In a number of studies, internet-related measures (penetration, user sophistication) also serve as an instrument for downloading. In our view, both usages are inappropriate. Internet penetration proxies

¹⁹ Nielsen SoundScan, the dominant provider of record sales, offers an academic subscription for \$10,000 a year. Nielsen VideoScan is even more expensive. Box office numbers for theatrical releases are freely available from Box Office Mojo, but learning about geographic variation in sales is more difficult. Fortunately, Nielsen Bookscan data are available at a reasonable cost.

for new forms of entertainment – think YouTube and World of Warcraft – that compete directly with music and traditional film consumption, yielding a negative bias in displacement studies. Given these fairly obvious shortcomings, why are there so few papers that use actual data on file sharing to measure its effect on sales? One reason, we believe, is that collecting data on file-sharing networks is labor intensive and often cumbersome. Sometimes it is necessary to gain the trust of individuals operating file-sharing servers. And automated measurement studies require considerable programming skills and knowledge of file-sharing software. These hurdles notwithstanding, it is disappointing to see how few social scientists have made the effort to collect data on actual behavior. Many scholars prefer to use widely available, but in our view inappropriate, proxies for file sharing. The resulting research is poorer for it. The situation in the social sciences is in marked contrast to the research in computer science where many studies carefully measure individual file-sharing activity (e.g. Leibowitz et al. 2002; Gummadi et al. 2003; Pouwelse et al. 2005; Liang et al. 2005a, 2005b; Dhungel, et al. 2008).

We emphasize these issues because the results in table 5 seem to suggest that measurement choices have a systematic impact on results. While the majority of papers reports some sales displacement, the four studies using actual measures of file sharing (Tanaka, 2004; Bhattacharjee et al., 2007; Oberholzer-Gee and Strumpf, 2007; Smith and Telang, 2008) find that file sharing is unrelated to changes in sales.

Unobserved heterogeneity – A common difficulty in studying the link between downloads and sales is that file sharing is endogenous. That is, there are factors, some of them unobserved by the econometrician, that influence both downloads and sales. For example, music lovers are likely to download more songs and they also buy a larger number of albums, making it look like there was a positive relation between file sharing and sales. To see this, consider figure 5, taken from Oberholzer-Gee and Strumpf (2005). In this graph, downloads (horizontal axis) appear to increase sales (vertical axis). But an alternative explanation is that the popularity of a release increases both file-sharing activity and sales: popular recordings are in high demand on the internet and in the store.

Difference-in-difference (DD) estimates and instrumental variable techniques are popular means by which scholars hope to break the link between unobserved factors and the estimated impact of piracy on sales. DD models yield unbiased estimates if the unobserved heterogeneity is time invariant. Unfortunately, time-varying unobserved factors appear to play a major role in file sharing. Comparing DD estimates with results that take into account how cohort characteristics change over time, Hong (2008) finds that DD estimates attribute the entire 2002 decline in record sales to Napster. Once changes in unobserved heterogeneity are taken into account, the sales displacement rate drops from 100% to 20%. Similarly, Oberholzer-Gee and Strumpf (2007) show that the combination of album and week fixed effects is insufficient to control for unobserved heterogeneity.

Instrumental variable techniques provide a potentially more promising way to identify the effect of file sharing on sales. As noted above, we are skeptical of attempts to use measures of broadband adoption or user internet sophistication as instruments. More promising identification strategies exploit technical aspects of file-sharing systems – the availability of BitTorrent indexing sites, for instance, fluctuates considerably over time for largely technical reasons – and shocks to the global supply of content. For example, Oberholzer-Gee and Strumpf (2007) exploit the fact that many files downloaded in the US come from Germany. During German school holidays, file sharing in the US becomes easier: download times are shorter, a greater fraction of searches lead to a successful download, and fewer download requests remain incomplete. Because German holidays are unrelated to U.S. music sales, the holiday shock makes a promising instrument. More generally, because file sharing is a truly global phenomenon there are many shocks that spread from country to country. Some of these will be unrelated to the domestic demand for entertainment, making them promising prospects in the quest for proper identification.

5. How Important Are Complementary Sources of Income?

Even if file sharing displaces sales, the weaker copyright regime need not undermine the incentives to produce new works if artists and entertainment companies can shift their earnings from selling music, games and movies to selling complements to these products. An interesting example is concerts. As Table 6 shows, concerts and merchandising have become an important source of income for major artists (Connolly and Krueger, 2006). Concerts and new recordings are complements. A recording becomes more enjoyable if one can reminisce about the time at the concert, and knowing the songs in advance might make the concert more enjoyable. In the presence of complementary goods, file sharing will have two opposing effects (for a formal model, see Mortimer and Sorenson, 2005). As the effective price of music falls close to zero, a larger number of consumers will be familiar with an album, driving up the demand for concerts. At the same time, artists have weaker incentives to tour because concerts are a less effective way to increase revenues from a new recording if a large fraction of the audience shares files. Which of these effects is more important? Figure 6 shows that concert prices rose much more quickly than the CPI, and the difference appears to have widened since the advent of file sharing (Krueger, 2005). More detailed evidence on the link between file sharing and concerts comes from Mortimer and Sorenson (2005). Studying 2,135 artists over a ten-year period, they also conclude that the demand for concerts increased due to file sharing. One way to see this is to ask how many CDs an artist needs to sell to produce \$20 of concert revenue. This number fell from 8.47 in the pre-Napster era to 6.36 in the 1999 to 2002 period. Not surprisingly, artists responded to these incentives by touring more frequently. Overall, the shift in relative prices and activities led to a sharp increase in income for the typical artist included in the authors' dataset.

As these results show, income from the sale of complements can more than compensate artists for any harm that file sharing might do to their primary activity. We are not aware of empirical work that has looked at these effects in industries other than music. But the potential of complements to provide ancillary income is certainly not unique to the music industry. In film, for instance, the International Licensing Industry Merchandisers' Association (LIMA) estimates that Hollywood derives \$16 billion

annually from sales of entertainment merchandise, a figure that exceeds the value of ticket sales (Film Encyclopedia, 2008).

The role of complements makes it necessary to adopt a broad view of markets when considering the impact of file sharing on the creative industries. Unfortunately, the popular press – and a good number of policy experts – often evaluate file sharing looking at a single product market. Analyzing trends in CD sales, for example, they conclude that piracy has wrecked havoc on the music business. This view confuses value creation and value capture. Record companies may find it more difficult to profitably sell CDs, but the broader industry is in a far better position. In fact, it is easy to make an argument that the business has grown considerably. Figure 7 shows spending on CDs, concerts and iPods. The decline in music sales – they fell by 15% from 1997 to 2007 – is the focus of much discussion. However, adding in concerts alone shows the industry has grown by 5% over this period. If we also consider the sale of iPods as a revenue stream, the industry is now 66% larger than in 1997. Obviously, these numbers are no more than a rough back-of-the-envelope calculation. A more serious investigation would take into account differences in profitability across music and concert sales as well as the decreased spending in other electronics categories (CD players, speakers, etc.) The point of the graph, however, remains: technological change will often lead to changes in relative prices and shifts in business opportunities. Focusing exclusively on traditional streams of revenue to arrive at a sense of how new technology changes welfare will typically be misleading.

6. Does File-Sharing Undermine Artistic Production?

In any evaluation of file sharing, a key question is whether financial incentives are needed to encourage artistic output.²⁰ While this is in large part an open question, several indirect pieces of evidence suggest that financial incentives play a smaller role in the

²⁰ In this respect, the arts are similar to the production of open source software where many programmers appear to work for little monetary gain (Lerner and Tirole, 2005).

creative industries than elsewhere in the economy.²¹ For concreteness we will focus our discussion on popular music, but many ideas discussed here carry over to film, visual arts, writing, and high culture music (see Caves, 2000).

The economic prospects for the group of popular musicians as a whole are quite poor. An album selling a half million copies or more (a Gold Album) is considered successful. Typically, a few hundred albums reach this level each year. Yet over 50,000 albums are released annually, suggesting the chance of success is less than one in a hundred. Perhaps more strikingly, only 950 new albums sold more than 25,000 copies in 2007.

Moreover, it is difficult for musicians to earn substantial income from recorded music sales, regardless of the success of their album. This is in part due to the nature of recorded music contracts (Passman, 2000). Recording musicians are paid for album sales based on the product of a royalty rate and album sales. The royalty rate is quite low (usually about a dollar or two per album) and musicians are not paid this money until they recoup all expenses, primarily the advance which is typically applied to the cost of recording the album. If an earlier album did not sell well enough to pay for the advance, music companies often deduct the difference from future album payments under a system called cross-collateralization. Putting all this together, even a Gold Album may not provide a musician with an economic windfall.²²

Given these poor prospects, why are there so many musicians? One explanation is that musicians enjoy their profession. Under this view, musicians take pleasure from creating and performing music, as well as aspects of the lifestyle such as flexible hours and the lack of an immediate boss. If this theory is correct, the economic impact of file sharing is not likely to have a major impact on music creation.

An alternative explanation is that popular music is a tournament, where a few artists collect most of the economic rewards. This view is rooted in the theory of superstars (Rosen, 1981). Superstars develop in industries with low marginal cost of

²¹ The broader critique of Boldrin and Levine (2008) implies that for innovation to take place more generally, copyright and patents are not needed.

²²For specific dollar totals from insiders in the music industry, see Albini (1994) and Love (2000).

production, little relation between output and quality, and quality-conscious consumers. This seems to be a reasonable model of popular music: it is relatively cheap to produce CDs and even cheaper to make digital albums. Each album produced provides the same quality level, and most consumers would rather listen to one very good album than a few albums of lesser quality. Under the superstar theory musicians essentially consider their job to be a lottery. With some small chance they will become a star. In 2007, the top one percent of new releases accounted for 82% of new-release sales. In a superstar environment, file sharing has a muted effect on music output. Even if the new technology had a marked negative effect on the returns to stardom, it is not likely to have big effect on the chances of becoming a star.²³

Survey evidence (as well as the long lines of contestants hoping to be part of talent shows like American Idol) support these theoretical arguments. In a Pew study of 2,755 musicians and songwriters (Madden, 2004), over three-fourths of respondents reported having a paying non-music job.²⁴ These second jobs are the primary source of income for most musicians. Only 16% reported that at least sixty percent of their income derived from their music job, while 66% said they earned less than twenty percent of their income from music. The small income share is not simply due to spending few hours on music. Even among those who spent at least thirty hours a week on music-related activities, only 22% derived at least four-fifths of their income from music.

Overall production figures for the creative industries appear to be consistent with this view that file sharing has not discouraged artists and publishers. While album sales have generally fallen since 2000, the number of albums being created has exploded. In 2000, 35,516 albums were released. Seven years later, 79,695 albums (including 25,159 digital albums) were published (Nielsen SoundScan, 2008). Even if file sharing were the

²³Consider a model in which individuals must choose between being a musician and some outside reservation job. If p is the probability of being a star, S the income (and non-pecuniary benefits) of being a star, NS the income of a non-star, and R the income from the reservation jobs, then the person decides to be a musician when,

$$pU(S) + (1-p)U(NS) \geq U(R)$$

where $U(\cdot)$ is a utility function and $S \gg R > NS$. Even if file sharing has a large negative effect on S , this will only have a limited impact on the left-hand side presuming S remains large and $U'' < 0$.

²⁴The musicians surveyed come from a wide range of music genres including Pop, Folk, Country, Electronic, Blues, Rock, Jazz, Christian, Punk, Dance, Bluegrass, Latin, Reggae, and Hip Hop. This wide coverage suggests the responses should incorporate a range of viewpoints.

reason that sales have fallen, the new technology does not appear to have exacted a toll on the quantity of music produced.²⁵ Obviously, it would be nice to adjust output for differences in quality, but we are not aware of any research that has tackled this question.

Similar trends can be seen in other creative industries. For example, the worldwide number of feature films produced each year has increased from 3,807 in 2003 to 4,989 in 2007 (Screen Digest, 2004 and 2008). Countries where film piracy is rampant have typically increased production. This is true in South Korea (80 to 124), India (877 to 1164), and China (140 to 402). During this period, U.S. feature film production has increased from 459 feature films in 2003 to 590 in 2007 (MPAA, 2007).

7. Policy Implications and Conclusions

File-sharing technology considerably weakened copyright protection, first of music and software and increasingly of movies, games, and books. The policy discussion surrounding file sharing has largely focused on the legality of the new technology and the question whether or not declining sales in music are due to file sharing. While these are important questions, in our view, the debate has been overly narrow. Copyright exists to encourage innovation and the creation of new works; in other words to promote social welfare. The question to ask is thus whether the new technology has undermined the incentives to create, market, and distribute entertainment. Sales displacement is a necessary but not a sufficient condition for harm to occur. We also need to know whether income from complementary products offset the decline in income from copyrighted works. And even if income fell, welfare may not suffer if artists do not respond to weaker monetary incentives.

As our survey indicates, the empirical evidence on sales displacement is mixed. While some studies find evidence of a substitution effect, other findings, in particular the

²⁵ Similarly, recording contracts seem to remain appealing. In 2009, 1,900 acts performed at South-by-Southwest, a large music festival that attracts musicians looking to sign their first recording contract. The artists must typically pay their own travel and lodging expenses, in addition to any foregone wages from their secondary job. Clearly a large number of musicians thought attending the festival was a worthwhile investment (Pareles, 2009).

papers using actual file-sharing data, suggest that piracy and music sales are largely unrelated. In contrast, there is clear evidence that income from complements has risen in recent years. For example, concert sales have increased more than music sales have fallen. Similarly, a fraction of consumer electronics purchases and internet-related expenditures are due to file sharing. Unfortunately, we know little about the distribution of these impacts. How markets for complimentary goods have responded to file sharing remains an area of inquiry that is largely unexplored in academic research.

The same holds true for the question how artists would respond to weaker monetary incentives. Looking at aggregate output – the number of recordings, books, and movies produced every year – we see no evidence that file sharing has discouraged the production of artistic works. However, as with income from complementary goods, aggregate statistics need to be interpreted with some care. For example, digital formats not only encouraged file sharing; digital technology also lowered the cost of producing movies and music and they allowed artists to reach their audience in novel ways. The observed increase in output is in part due to these changes. The response of artists to technology-induced changes in income is a second area that we would like to single out as important for future research.

As this essay has made clear, we do not yet have a full understanding of the mechanisms by which file sharing may have altered the incentives to produce entertainment. However, in the industry with the largest purported impact – music – consumer access to recordings has vastly improved since the advent of file sharing. Since 2000, the number of recordings produced has more than doubled. In our view, this makes it difficult to argue that weaker copyright protection has had a negative impact on artists' incentives to be creative.

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TABLE 1
KEY EVENTS IN FILE SHARING

Date	Event
Spring 1998	First mass-produced MP3 player
October 1998	RIAA files restraining order against leading MP3 player manufacturer
June 1999	Napster begins operations
December 1999	RIAA sues Napster for copyright damages
July 2000	US District Court rules against Napster and in favor of RIAA. Case moves to US Court of Appeals which affirms in February 2001 that Napster is liable for damages
Spring-Summer 2001	Several alternative file sharing protocols are released including FastTrack/KaZaA, WinMX, Limewire, and BitTorrent
July 2001	Napster effectively shut-down
November 2001	RIAA and MPAA sue file sharing software distributors Morpheus and Grokster in <i>MGM v. Grokster</i>
Spring 2003	FastTrack/KaZaA peaks at about 4m simultaneous users.
September 2003	RIAA begins suing file sharing users. About 35,000 lawsuits have been filed by the end of 2008.
November 2003	The Pirate Bay, a BitTorrent index and tracker site, is founded
Fall 2004	A leading BitTorrent tracker + indexer has over 1m visits per day
June 2005	Supreme Court upholds the content-holders position in <i>MGM v. Grokster</i> . By the end of the 2005 distribution companies eDonkey and WinMX shut-down after receiving cease and desist letters from the RIAA
May 2006	In part due to pressure from the MPAA, Swedish police shut down The Pirate Bay and confiscate its servers. Site was operational again in three days, and servers are now spread over several countries
November 2008	25m users on leading BitTorrent tracker The Pirate Bay

TABLE 2
FILES ON FILE-SHARING NETWORKS

	% songs on network	% store sales	% downloads
Full sample	100.0%	100.0%	100.0%
Catalogue	8.0%	9.8%	12.6%
Current Alternative	19.1%	24.8%	48.6%
Hard Music Top Overall	3.0%	5.9%	5.3%
Jazz Current	2.9%	4.6%	0.4%
Latin	3.5%	5.8%	0.7%
New artists	8.0%	3.3%	1.8%
R&B	25.2%	9.7%	14.9%
Rap	13.7%	8.2%	4.6%
Top Current Country	10.2%	18.4%	7.3%
Top Soundtrack	6.4%	9.4%	3.9%

Source: Oberholzer-Gee and Strumpf (2007)

TABLE 3
AVAILABILITY OF MOVIES ON MININOVA

RANK	TOP DVD RENTALS MARCH 2009	# DOWNLOADS	MALIN AKERMAN MOVIES	# DOWNLOADS
1	Role Models (2008)	10,482	Watchmen	53,476
2	Transporter 3 (2008)	11,225	Bye Bye Sally	NA
3	Australia (2008)	17,244	27 Dresses	367
4	Milk (2008/I)	2,833	Heavy Petting	0
5	Beverly Hills Chihuahua (2008)	3,050	The Heartbreak Kid	53
6	Rachel Getting Married (2008)	1,705	The Brothers Solomon	0
7	Body of Lies (2008)	10,394	The Invasion	NA
8	In the Electric Mist (2009)	1,885	Harold & Kumar	382
9	Changeling (2008)	11,149	The Utopian Society	NA
10	Nights in Rodanthe (2008)	1,290	The Circle	NA

Sources: Internet Movie Database (<http://www.imdb.com/>) and Mininova (<http://www.mininova.org/>), accessed on 14 March 2009

TABLE 4
THE GEORGRAPHY OF FILE SHARING

Country	Share of users	Share of downloads	Users in U.S. download from (%)	Users in U.S. upload to (%)	Share World Population	Share World Internet Users
United States	30.9	35.7	45.1	49.0	4.6	27.4
Germany	13.5	14.1	16.5	8.9	1.3	5.3
Italy	11.1	9.9	6.1	5.7	0.9	3.2
Japan	8.4	2.8	2.5	1.8	2.0	9.3
France	6.9	6.9	3.8	4.7	1.0	2.8
Canada	5.4	6.1	6.9	7.9	0.5	2.8
United Kingdom	4.1	4.0	4.2	4.2	1.0	5.7
Spain	2.5	2.6	1.8	2.0	0.6	1.3
Netherlands	2.1	2.1	1.9	1.6	0.3	1.6
Australia	1.6	1.9	0.8	2.2	0.3	1.8
Sweden	1.5	1.7	1.8	1.5	0.1	1.0
Switzerland	1.4	1.5	0.9	1.0	0.1	0.6
Brazil	1.3	1.4	1.2	1.3	2.9	2.3
Belgium	0.9	1.2	0.5	1.0	0.2	0.6
Austria	0.8	0.6	0.6	0.4	0.1	0.6
Poland	0.5	0.7	0.7	0.5	0.6	1.1

Source: Oberholzer-Gee and Strumpf (2007)

TABLE 5
STUDIES OF THE ECONOMIC IMPACT OF FILE SHARING

Study	Study Question, Data and Sample	Methodology	Key Findings
Music			
Hui and Png (2003)	Do country-level piracy rates explain the decline in music sales? Macro data, 28 countries, 1994-1998	Sales regressions with country fixed effects; uses piracy rates for music cassettes and business computer software as instruments	For every pirated CD, sales fall by 0.42 units. Estimated effect is not robust to including year fixed effects and estimating separate displacement effects for high- and low-income countries.
Peitz and Waelbroeck (2004)	Do country averages in the likelihood of having downloaded music at least once predict music sales? Macro data, 16 countries, 1998-2002	Cross-sectional analysis relating changes in sales to the level of file-sharing in 2002; no measure for the intensity of file sharing	Piracy reduced sales by 20%; effect is significant at 10% level
Tanaka (2004)	Do albums that are popular on file-sharing networks sell fewer copies? Observed piracy; 261 best-selling titles; 2004	Study relates actual downloads on Winny, a popular Japanese file-sharing software, to CD sales; uses music genres as instruments	File-sharing does not reduce sales.
Gopal et al. (2006)	Are students who sample music they don't know more likely to purchase the CD? Survey; 200 students	Students indicate interest in buying and sampling music in a hypothetical-choice setting with set prices.	Students with faster internet connections are more likely to sample music; sampling increases the propensity to buy.
Rob and Waldfogel (2006)	Do students who downloaded music purchase fewer albums? Survey; 412 students; 2003/2004	Students report purchases and downloads of 8,200 specific recordings; study uses access to broadband to instrument for downloads	For hit albums the authors find no relationship between downloading and sales. For a wider set of music, downloading five albums displaces the sale of one CD. Instrumenting for downloads results in estimates that are too imprecise to draw any firm conclusions. Using student valuations of albums, the authors conclude that file-sharing increases social welfare.

Zentner (2006)	Do individuals who downloaded at least once buy fewer CDs? Survey; 15,000 European consumers, 2001	Cross-sectional analysis; uses measures of Internet sophistication and access to broadband as instruments; no measure for the intensity of file sharing	Having shared files reduces the probability of purchasing music by 30%.
Bhattacharjee et al. (2007)	Do albums that are more frequently shared drop off the Billboard charts in a shorter period of time? Observed piracy; best-selling titles; 2002-2003	Relates the supply of files on file-sharing network (WinMx) to chart rankings; study uses RIAA announcement of lawsuits as instrument	Overall, file sharing has no statistically significant effect on survival on charts. The authors find a small negative effect for weaker releases.
Oberholzer-Gee and Strumpf (2007)	Do albums that are popular on file-sharing networks sell fewer copies? Observed piracy; representative sample of recordings; 2002	Relates downloads of files to CD sales; uses the supply shock due to German school holidays to instrument for downloads	File-sharing does not have a statistically significant impact on record sales.
Andersen and Frenz (2008)	Do individuals who obtain music for free buy fewer CDs? Survey; representative sample of Canadians, 2006	Authors have information on many forms of sharing, including P2P, ripping, promotional downloads, and copying of mp3 files; cross-sectional regressions without instruments	File sharing increases music purchases. 12 additional downloads lead to the sale of an additional 0.44 CDs.
Hong (2004, 2008)	Do households with internet access report lower music purchases post Napster? Survey; 2000	Two-variate propensity score matching; probability of using Napster is unobserved; needs to be imputed from UCLA survey using demographic information	The introduction of Napster explains 20% of the decline in music expenditures. 80% of the decline is due to changes in the prices of other entertainment goods and the ending of the transition from LPs to CDs (Hong 2004). Using a conventional difference-in-difference approach, the effect of Napster would be significantly overestimated, explaining the entire decline.
Leung (2008)	Do students who indicate they would download music intend to buy fewer songs? Conjoint survey; 884 (270) students	Students report past consumption of music and make hypothetical choices between legal music, iPods, and pirated music; the study uses an assumed probability of getting caught and the size of the fine as instruments	When students pirate 10% more music, they intend to buy 0.7% fewer iTunes songs and 0.4% fewer CDs.

Liebowitz (2008)	Do U.S. cities with greater internet penetration have lower record sales? Macro data; 89 markets, 1998-2003	Compares changes in city-wide internet penetration with changes in record sales, controlling for demographics	Using all markets, internet penetration is unrelated to changes in music sales; for a subset of markets (60) the internet reduces per-capita-sale by 1.55, indicating file sharing explains more than 100% of the decline in record sales.
Movies and TV			
Smith and Telang (2006)	Does broadband help or hurt DVD sales? Macro data; 2000-2003	Market fixed effects specification with autoregressive errors	Broadband penetration increases DVD sales. Almost 10% of the increase in DVD sales during the study period is attributable to advances in broadband penetration.
Rob and Waldfogel (2007)	Are students who watch a pirated copy of a movie subsequently less likely to purchase the DVD? Survey; 500 students; 2002-2005	Students report their viewing of 50 top movies; no instrumental variables; person fixed effects control for time-invariant unobserved heterogeneity	Illegal burning of DVDs and downloading make up 5.2% of movie viewing; unpaid consumption reduces paid consumption by 3.5%.
Waldfogel (2007)	Do students who watch a TV series on the web less likely to watch episodes on TV? Survey; 287 students; 2005-2007	Students report the consumption of TV series on TV, YouTube and network websites; no instruments; demand for TV is estimated in first differences	Web consumption (authorized and unauthorized) reduces the number of shows that students watch frequently on TV but it increases the number of shows they watch sometimes. Additional web viewing exceeds the reduction in traditional viewing; even network-controlled viewing (excluding YouTube) increases by 1.5 hours per week.
Smith and Telang (2008)	Do TV broadcasts of movies and piracy reduce the sale of DVDs? Observed piracy; 267 movies; 2005-2006	The study uses TV broadcasts as shocks to identify the effect of piracy on DVD sales	Free broadcasts of movies on TV increase DVD sales on Amazon by 118% during the first week after the broadcast. Piracy does not affect this increase in demand.

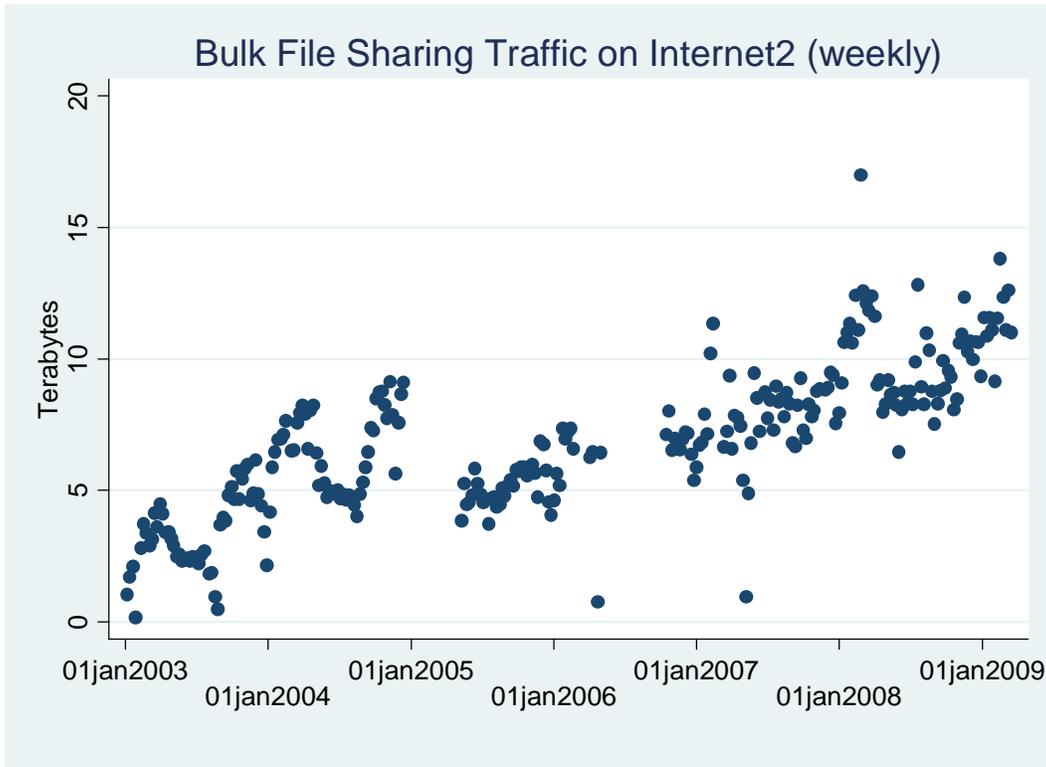
TABLE 6
ARTIST INCOMES (IN MILLIONS USD)

Rank	Artist	Concerts	Recordings	Publishing	Total
1	Paul McCartney	64.9	2.2	2.2	72.1
2	The Rolling Stones	39.6	0.9	2.2	44.0
3	Dave Matthews Band	27.9	0.0	2.5	31.3
4	Celine Dion	22.4	3.1	0.9	31.1
5	Eminem	5.5	10.4	3.8	28.9
6	Cher	26.2	0.5	0.0	26.7
7	Bruce Springsteen	17.9	2.2	4.5	24.8
8	Jay-Z	0.7	12.7	0.7	22.7
9	Ozzy Osbourne	3.8	0.2	0.5	22.5
10	Elton John	20.2	0.9	1.3	22.4
11	The Eagles	15.1	0.7	1.4	17.6
12	Jimmy Buffet	13.7	0.2	0.5	17.6
13	Billy Joel	16.0	0.0	1.0	17.0
14	Neil Diamond	16.5	0.0	0.3	16.8
15	Aerosmith	11.6	1.0	0.8	16.5
16	CSNY	15.7	0.0	0.3	16.0
17	Creed	10.9	1.1	1.6	13.4
18	Rush	13.4	0.0	0.0	13.4
19	Linkin Park	1.7	4.7	6.3	13.1
20	The Who	12.6	0.0	0.0	12.6
21	Red Hot Chili Peppers	6.1	3.4	2.7	12.1
22	Brian "Baby" Williams	0.2	2.7	0.9	11.8
23	Nsync	7.7	0.5	0.9	9.4
24	Barry Manilow	8.0	1.2	0.0	9.2
25	Britney Spears	5.5	1.8	1.0	9.1
26	Alan Jackson	4.6	3.0	1.4	9.0
27	Rod Stewart	6.6	1.4	0.8	8.8
28	Andrea Bocelli	8.1	0.2	0.4	8.7
29	Brooks and Dunn	6.7	0.4	1.4	8.1
30	Enrique Iglesias	4.4	1.5	1.7	7.6
31	Tom Petty	6.6	0.2	0.7	7.5
32	Tool	7.3	0.0	0.0	7.4
33	Kid Rock	3.4	0.8	1.3	7.0
34	Kenny Chesney	5.8	1.1	0.1	7.0
35	Santana	6.0	0.0	0.7	6.9
	Average	12.7	1.7	1.3	17.4

Note: Figures are estimates of pretax gross income in 2002.

Source: Connolly and Krueger (2006).

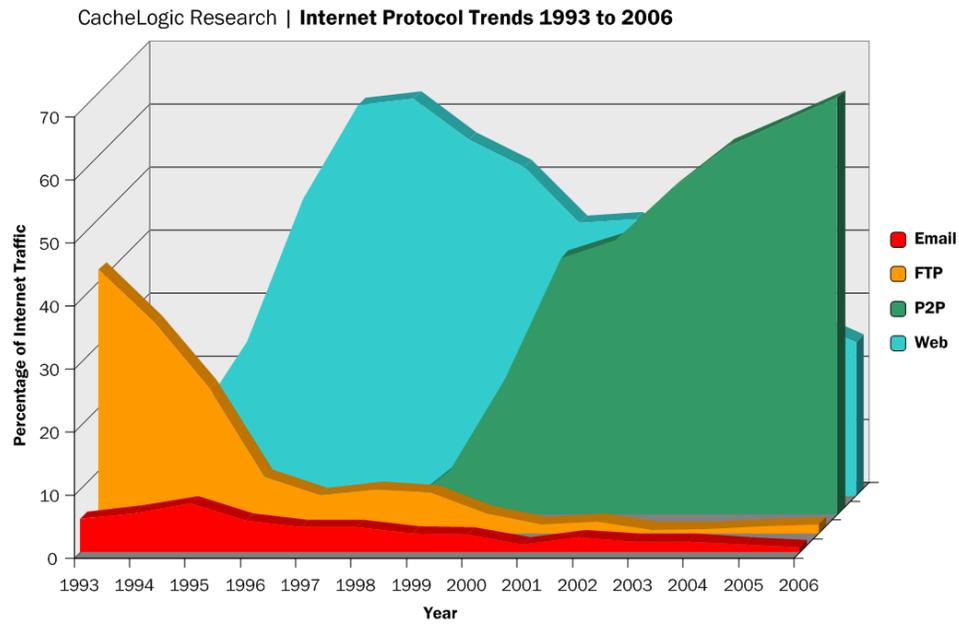
FIGURE 1
TRENDS IN U.S. FILE-SHARING ACTIVITY, 2003-2009



Notes: Bulk traffic is a TCP flow that transferred more than 10MB of data. No date is available for the following weeks: 2/3/03, 7/28/03, 2/23/04, 12/20/04-5/2/05, 7/11/05, 2/27/06-3/27/06, 4/17/06, 5/8/06-10/9/06, 2/19/07-3/5/07, 6/18/07, and 11/19/07.

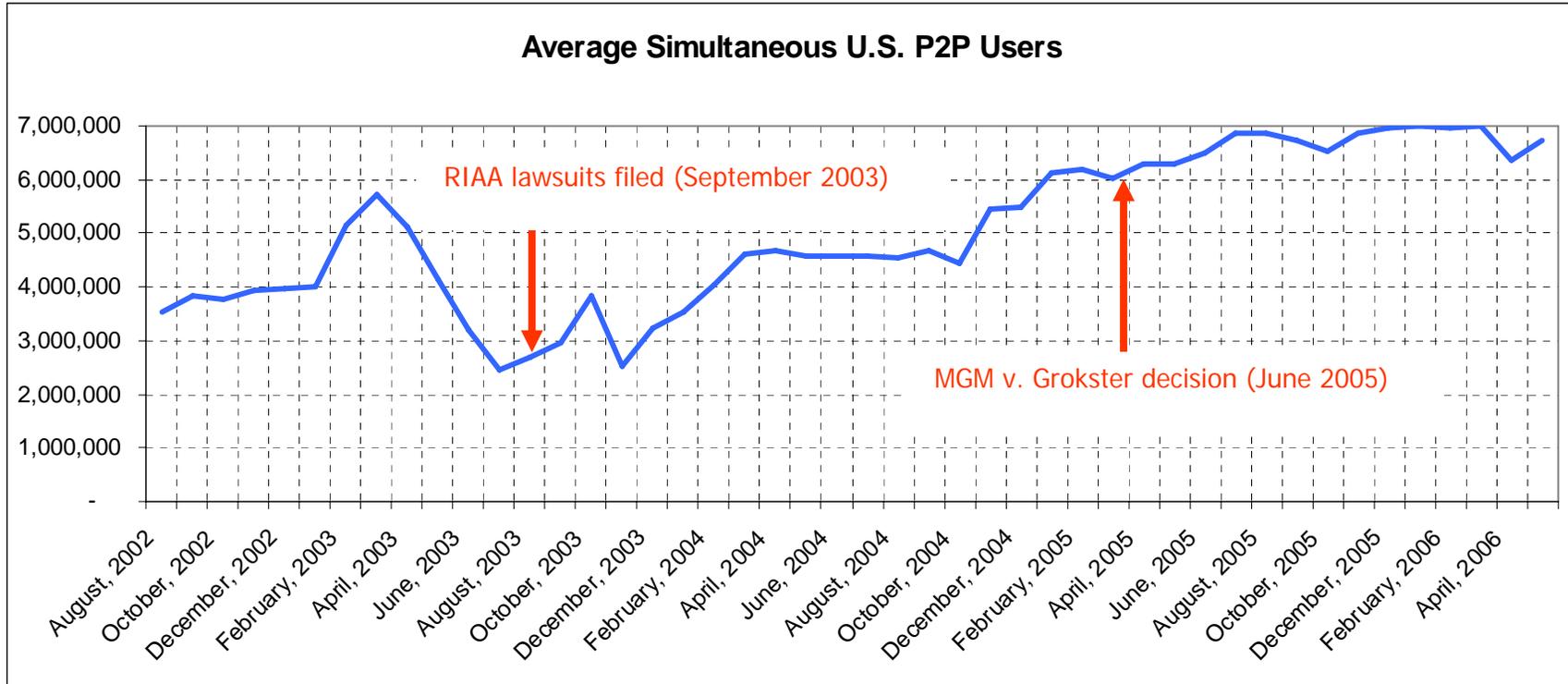
Source: Data from Internet2 Netflow Statistics (2009).

FIGURE 2
GLOBAL FILE SHARING, 1999-2006



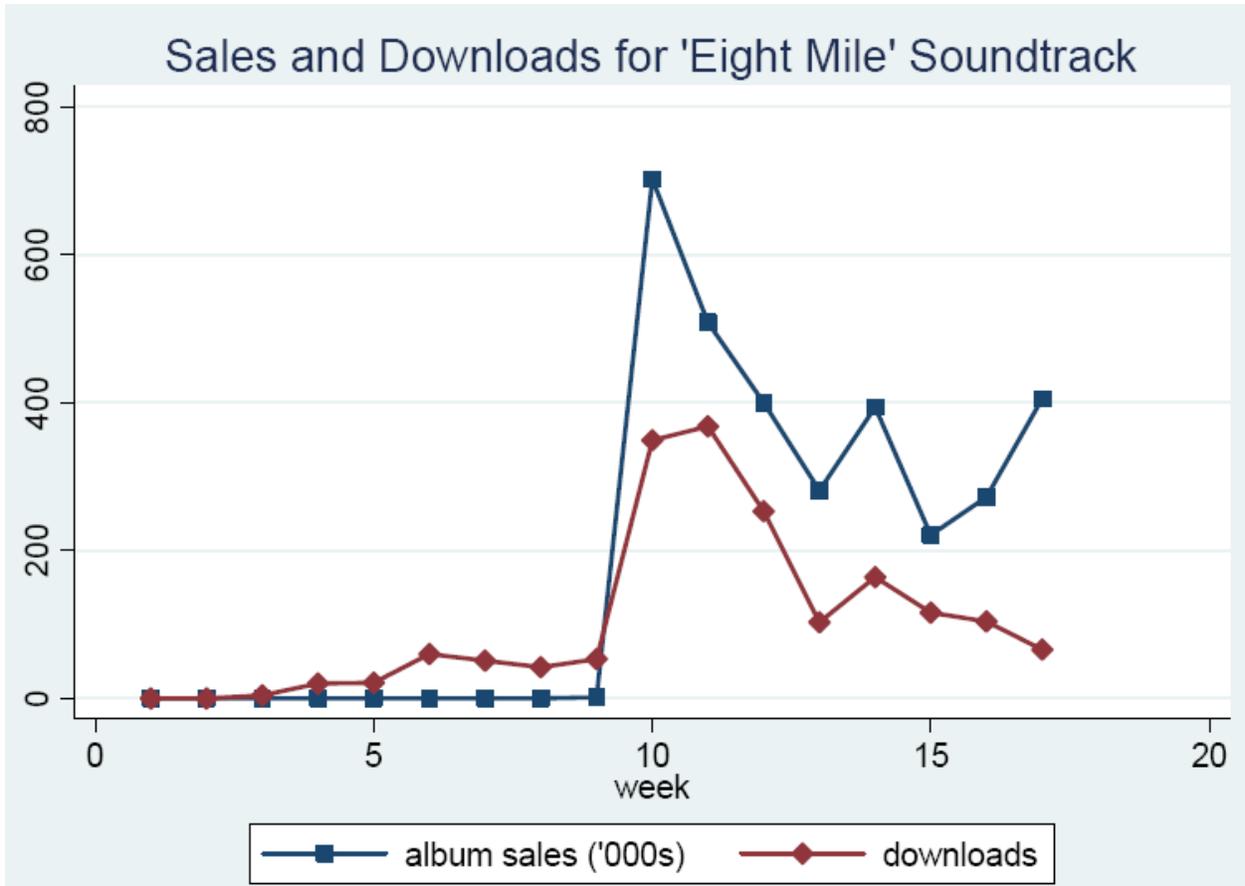
Source: Ferguson (2006)

FIGURE 3
TRENDS IN THE NUMBER OF U.S. FILE-SHARING USERS



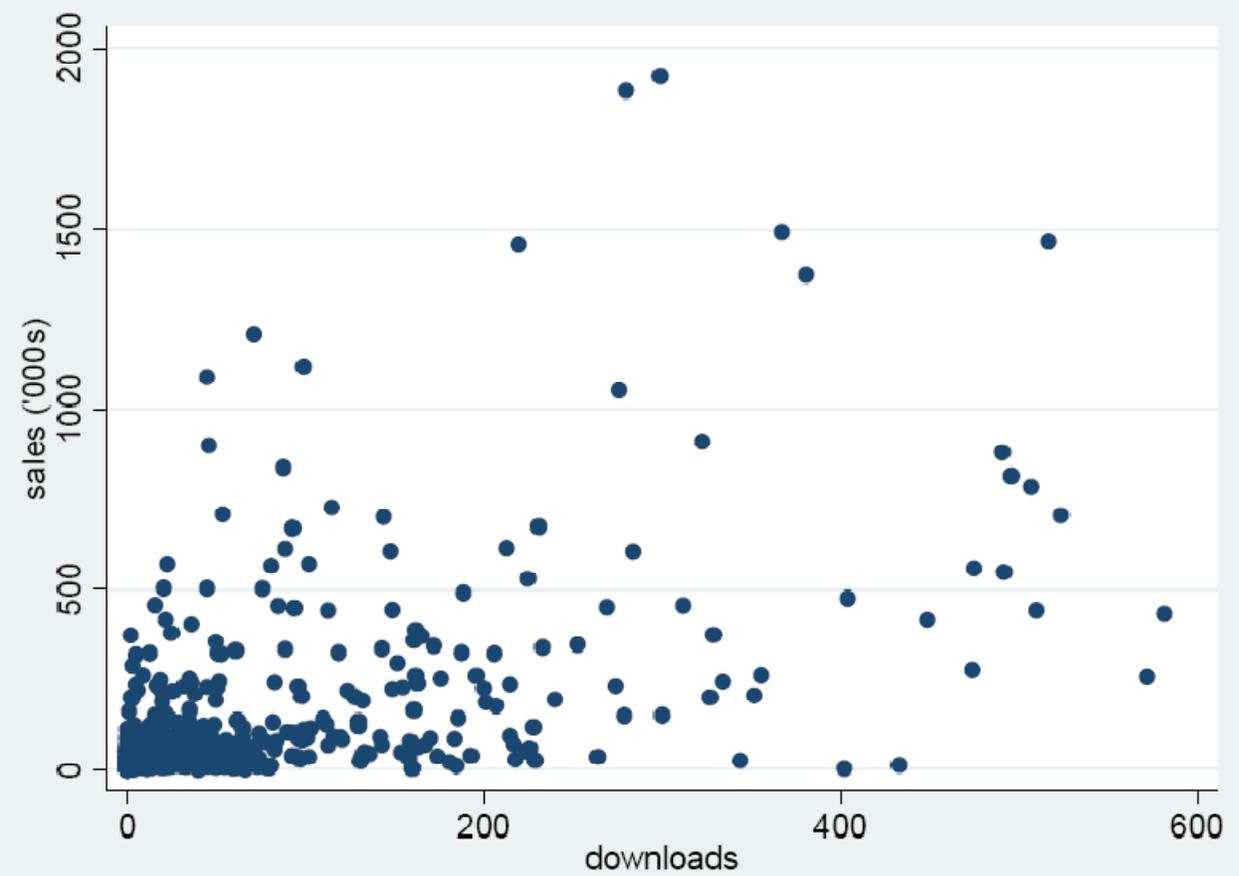
Source: BigChampagne.com

FIGURE 4
INDUSTRY MARKETING AND FILE-SHARING



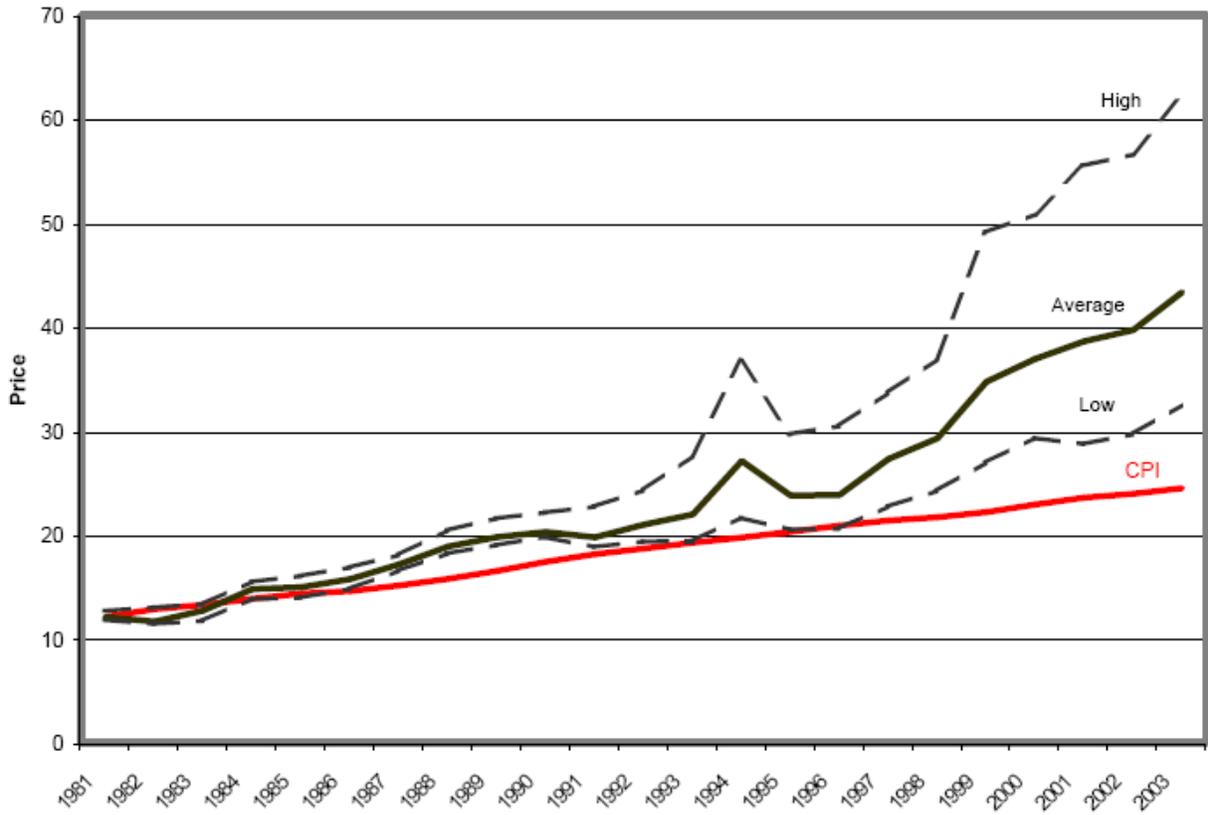
Data from Oberholzer-Gee and Strumpf (2007)

FIGURE 5
ENDOGENEITY OF FILE SHARING



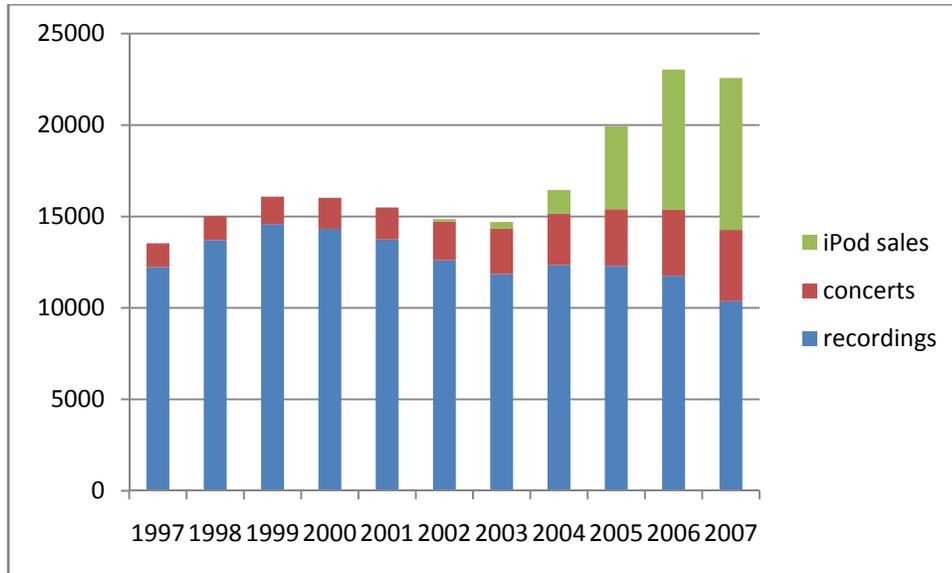
Data from Oberholzer-Gee and Strumpf (2007)

FIGURE 6
CONCERT PRICES 1981-2004



Source: Krueger, 2005

FIGURE 7
U.S. MUSIC INDUSTRY SALES TRENDS



Sources: Recording Industry Association of America, “2007 Year-End Shipment Statistics” (www.riaa.com), Pollstar (www.pollstar.com), Apple, Inc. Annual Reports (www.apple.com), accessed 18 March 2008.