IMPACT OF LEGAL THREATS ON ONLINE MUSIC SHARING ACTIVITY: AN ANALYSIS OF MUSIC INDUSTRY LEGAL ACTIONS*

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Abstract

The music industry has repeatedly expressed concerns over potentially devastating impacts of online music sharing. Initial attempts to control online file sharing have been primarily through consumer education and legal action against the operators of networks that facilitated file sharing. Recent legal action against individual file sharers marked an unprecedented shift in the industry's strategy. The focus now is on well-publicized legal threats and actions on a relatively small group of individuals to discourage overall music file sharing. To determine the resulting impact of these legal threats, we passively tracked online file-sharing behavior of over 2,000 individuals. We found that individuals who share a substantial number of music files react to legal threats differently from those who share a lesser number of files. Importantly, our analysis indicates that even after these legal threats and the resulting lowered levels of file sharing, the availability of music files on these networks remains substantial.

I. Introduction

In recent years, peer-to-peer (P2P) file-sharing technology has opened new channels for legitimate online distribution of digital products including recorded music. This has resulted in challenges and opportunities for entities involved in the production, distribution, and consumption of such digital goods (Bakos, Brynjolfsson, and Lichtman 1999; Gopal, Bhattacharjee, and Sanders 2006). But this same technology also provides the means for unauthorized copying and distribution of such goods (Gopal and Sanders 1997; Gopal et al. 2004). The popularity and availability of online music file-sharing

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networks has attracted the interests of diverse groups including the music industry, consumers, artists, the popular press, and government legislative bodies.

The Recording Industry Association of America (RIAA), the trade group that represents the U.S. recording industry,[1] has repeatedly expressed concern over music-sharing activities. Claiming that the impact of online music piracy on its business has been "devastating" (Feuilherade 2004), the music industry has called for greater copyright enforcement and stronger regulations. In the past, RIAA has issued threats aimed only at the "operators" of P2P networks (Harmon 2003). In 2000, RIAA sued and successfully shut down Napster, one of the first P2P file-sharing networks that facilitated digital music sharing. But the popularity of music sharing, instead of being dampened by the forced closure of Napster, was reinvigorated by the advent of several second-generation P2P networks, the so-called Sons of Napster. The new networks do not maintain a central directory of files like Napster did, hence they have avoided legal repercussions from appearing to aid illegal file sharing.[2] Consequently, these networks act as decentralized peer groups, where individual file sharers act as both file and information repositories. Among these networks, Kazaa, launched in March 2001, appears to be currently the most popular, with over 60 million subscribers (Kazaa.com 2004).

In response to this "epidemic of illegal file sharing" (RIAA 2003a), on June 26, 2003, RIAA redirected legal threats toward individual subscribers of these networks who, in the past, enjoyed anonymity in P2P environments. Prior to RIAA's recent legal efforts, individual file sharers were almost completely immune from legal liability when violating copyright law. These recent legal developments have considerably altered that perceived notion (Graham 2003; Lichtman 2003). Owing to the impracticality of filing lawsuits against every individual file sharer, RIAA has chosen to focus on a relatively small group of individuals and maximize the publicity surrounding its legal action to discourage the overall participation in file-sharing networks.

But how did music sharers actually react to these legal threats? To date, we have anecdotal evidence provided by two very popular sharing sites, Kazaa and Grokster, but little detailed or specific information. For example, Kazaa and Grokster indicated that traffic on June 26, 2003, after the threat did not decrease significantly. With an average of 4 million users at any time, Kazaa reported 4.2 million users around 5:30 P.M. on June 26 (post threat). Similarly, Grokster reported 3.8 million users at 6:00 P.M. (normal range, 3.5–4.5 million users) (Manuse 2003). Without access to detailed real data,

[1] The four major music companies are Universal Music Group, Warner Music Group, Sony-BMG. and EMI.

[2] The very recent Supreme Court holding in the *Grokster* case suggests that peer-to-peer (P2P) operators must take care. Currie (2005) suggests that P2P operators must "not induce copyright infringement" and must make sure "that there is a non-infringing use for the software" such as sharing photos or personally developed software.

there is little to confirm or refute the claims of interested parties such as RIAA and the music industry or Kazaa and Grokster. Other research studies (for example, a recent Pew Survey) have relied on surveys of private individuals in an effort to gauge an individual's piracy activity (Wingfield 2004, p. B4). But this involves asking individuals to report, however assuredly "anonymously," on their own illegal activity. Wingfield (2004, p. B1) noted, "The Pew survey relies on consumers honestly reporting their online habits; some users may be less likely to admit they are downloading music owing to negative publicity surrounding file-sharing."

We began our work by asking whether we could track actual individual behavior and identify what actually was happening following legal threats. Because file sharing occurs on the Internet, it is possible to gather relevant data in real time. Acting solely as an observer and not as a participant, it is possible to track an individual's file-sharing behavior across time and analyze any potential behavioral shifts surrounding major events. To accomplish this, we developed innovative data observation and capturing processes that directly measure the online P2P file-sharing activity of individuals. In effect, these tools act as proverbial "flies on the wall," silently observing file-sharing behavior (Bhattacharjee et al., in press).

Our analysis provides before-and-after scrutiny of individual file-sharing behavior for the time frame during which four important events unfolded. These events are (1) the RIAA threats of legal action, (2) the initiation of legal actions, (3) a legal setback to RIAA, and (4) a reiteration by RIAA of continuing legal actions. All these events were widely reported by both popular media (Mainelli 2003). The research hypotheses, drawn from the theory of consumer utility maximization, provide the basic foundation to address the research questions. While we observe individual behavior that is consistent with utility theory, we also observe stark behavioral differences in P2P patterns (sharing files versus being online) and across groups (those sharing large versus small numbers of files). Finally, despite RIAA's efforts to the contrary and despite a general reduction in individual sharing, opportunities for anyone seeking to download music files continue to be abundant. The current study represents an early exploration of individual behavioral research at a general observation stage that can then lead to formal theory formulation (see Smith 1976, 1982, 1985; Hoffman et al. 1987; Hoffman, Marsden, and Whinston 1990) of online music sharing.

The remainder of the paper is structured as follows. A brief description of the four events studied is presented in Section II, followed by a theory framework and hypotheses in Section III. The data collection details are covered in Section IV. Empirical results are discussed in Section V, which includes the overall impact of the events, a detailed analysis of different types of sharers, and a discussion of the overall impact on file-sharing opportunities following these legal actions. We conclude the paper in Section VI with a summary of findings and future research directions.

II. Description of Events Studied

A. Event 1: Announcement of Intention to Pursue Legal Actions (June 26, 2003)

On June 25, RIAA announced for the first time that it would pursue legal action against individual participants of P2P file-sharing networks. On June 26, it was widely reported in the media that RIAA would "spend the next month identifying users who offer a significant number of songs for others to copy on file-sharing networks in the United States and will target those individuals with lawsuits" (Zeidler 2003). A *Seattle Times* article reported by the Associated Press dated June 26, 2003, stated, "The embattled music industry disclosed aggressive plans today for an unprecedented escalation in its fight against Internet piracy, threatening to sue hundreds of individual computer users who illegally share music files online" (Bridis 2003). Prior to this announcement, no individual file sharer had been held accountable for his participation on P2P networks. This announcement signaled a marked shift in RIAA's policy, increasing an individual sharer's risk of getting caught and prosecuted for sharing unauthorized music files.

B. Event 2: Lawsuits Filed against Alleged Music File Sharers (September 8, 2003)

After 2 months of evidence gathering, RIAA filed lawsuits against 261 alleged music sharers on September 8, 2003. Although P2P network administrators do not require users to reveal their true identities, computer terminals of P2P sharers can be identified by their IP addresses. In order to facilitate its lawsuits against individual P2P sharers, RIAA filed for subpoenas using provisions under the 1998 Digital Millennium Copyright Act to force Internet service providers to reveal "the names of suspected copyright infringers" through their IP addresses (Gross 2003). As a result, RIAA was able to identify the alleged file sharers through their Internet service providers. According to RIAA, the defendants of the lawsuits "have been illegally distributing substantial amounts (averaging more than 1,000 copyrighted music files each) of copyrighted music on peer-to-peer networks" (RIAA 2003b). Although most people associate music piracy with teenagers and college students, the wide range of people named in the lawsuits included a preteen, an elderly grandparent, and several parents who claimed to be completely unaware of their children's online activities (Ahrens 2003).

C. Event 3: Court Ruling against Revealing Identities of Sharers (December 19, 2003)

In an ongoing legal dispute with RIAA, Verizon, a major Internet service provider, filed an appeal in the U.S. Court of Appeals on the lower court

decision that permitted RIAA to obtain the names of the 261 music sharers for its September 8, 2003, lawsuits. On December 19, 2003, the appeals court argued that the Digital Millennium Copyright Act, passed in 1998, does not directly address P2P file trading and overturned the lower court's decision (Enders 2003). This decision denied RIAA's unconventional use of subpoenas and, in effect, allowed Internet service providers to reject RIAA's request for the identities of P2P sharers. Although RIAA could still proceed with lawsuits by naming IP addresses as defendants, it would have to go through a rather lengthy litigation process during which the defendants would be eventually identified during the court proceeding (McCullagh 2003). In spite of RIAA's plan to proceed with this new form of lawsuit, it was expected that the increased legal cost would hinder RIAA's ability to sue large numbers of file sharers (Ahrens 2004).

D. Event 4: John Doe Lawsuits (January 21, 2004)

After the decision by the U.S. Court of Appeals, RIAA was no longer able to file a subpoena and obtain the names of online file sharers but still continued its data collection to monitor file-sharing activity. On January 21, 2004, RIAA filed additional lawsuits against 532 alleged file sharers, identified by their IP addresses (Roberts 2004). This new form of lawsuit, RIAA claimed, is "more intrusive" for individual file sharers (Borland 2003). In addition, without knowing the names of defendants, RIAA could no longer offer the opportunity to such individuals for private settlements outside of court litigation (Borland 2003).

In the next section, we detail our basic utility maximization framework and set forth the two hypotheses that we study empirically related to the aforementioned legal actions.

III. Utility Theory and Implicit Hypotheses

Since the early pioneering work by Becker (1968) and Ehrlich (1973), research on the economics of illegitimate activities has widely employed a utility maximization approach to model individual decision making related to engaging in illegal activity. We employ a similar approach to draw our research hypotheses. Earlier works have also explicitly incorporated constraints on resources (either time or monetary) that dictate that an individual solve an allocation problem—how much (time) to devote to legal versus illegal activities. One key difference in the environment we study is that such constraints do not naturally exist with online file sharing—participation in legal and illegal activities can take place simultaneously and can occur at large quantitative levels. A music consumer can purchase or listen to digitized music on an authorized retailer's Web site and, at the same time, participate in illegal file sharing of the same or other music. Thus, our hypotheses are developed from the consideration of cost and benefit of engaging in online

file sharing. Further, the environment is in isolation from the constraints imposed by other external choices.

Consider an individual consumer, i, whose computer has n_i music files (or songs) stored and available for sharing. We focus on music sharing for modeling purposes since RIAA's legal measures are aimed specifically at individuals who share music files rather than those who download. Drawing from theories of altruism (Constant, Sproull, and Kiesler 1996; Nordblom 1997; Rapoport 1997; Levine 2001), we assume that i's benefit from sharing his files with other consumers is tied directly to the number of individual songs, n_i, that he makes available for others to download and the amount of time that he is connected to the P2P network, t_i (and thus is available for sharing). Let F_i be the potential cost faced by individual i from the legal actions undertaken by RIAA. Thus, F_i represents the level of legal threat that is assumed to be nondecreasing with respect to the amplified threats and legal actions by RIAA to curb file sharing. We formulate a general utility function for individual i as $V_i = U_i(n_i, t_i|F_i)$. We use n_i^* and t_i^* to indicate optimal choices for individual i for a given value of F_i; n_i^* and t_i^* are obtained by solving $\max U_i(n_i, t_i|F_i)$ with respect to n_i and t_i.

An individual's reaction to increased enforcement depends on the risk profile of the individual. Economic studies on criminal behavior indicate that many individuals seem to prefer risk, which results in law enforcement activities being less effective than expected (see, for example, Heineke 1978; Ehrlich 1973; Becker 1968; and Kolm 1973). Heineke (1978) and Ehrlich (1973) concluded that an increase in law enforcement efforts might cause risk-preferring individuals to increase their illegal activities. Similarly, an increase in penalty could also be shown to have the same effect (Ehrlich 1973).

The RIAA's announcement and subsequent legal actions were clearly intended to up the ante, to increase the perceived risk of being caught participating in unauthorized music sharing (see Graham 2003). The RIAA's expectations for the outcomes of its action in 2003 appeared to hinge on the assumption that the majority of the individuals are risk averse and rational. These observations lead us to posit the following formal hypotheses:

IMPLICIT RIAA HYPOTHESIS 1 (reduced number of files shared): $\partial n_i^*/\partial F_i < 0$ (an increase in the level of legal threat would reduce the number of music files being shared).

IMPLICIT RIAA HYPOTHESIS 2 (reduced frequency of sharing): $\partial t_i^*/\partial F_i < 0$ (an increase in the level of legal threat would reduce the amount of time an individual spends on file-sharing networks).

The formal test of hypotheses is conducted from observations on the sharing behavior of over 2000 P2P subscribers of Kazaa, over the period of time during which the four events unfolded. The formal analysis can shed important insights on the differential impacts of legal threats on the patterns of sharing behavior (number of files shared versus time spent online). Such

analysis can also provide indirect evidence of the risk profiles of these subscribers, that is, the proportions of P2P subscribers who are risk preferring, risk neutral, and risk averse. Further, we evaluate the hypotheses across two important subscriber groups: high-level (substantial) sharers and less active (nonsubstantial) sharers. This comparison is important since RIAA specifically hinted that they were targeting the former group. Did this group react as RIAA intended? Did the nonsubstantial group feel less threatened and thus react differently? Overall, were the legal steps taken successful in decreasing music file sharing under a P2P environment?

The automated data collection process we employed to garner the data provides us a unique vantage point to evaluate the hypotheses. The access to microlevel data enables us to directly test the hypotheses, without a need to make further behavioral assumptions that are often necessary when working with either macrolevel data or with survey data. The length of the data set utilized (spanning a year of observation on each individual) also adds temporal stability and robustness to our empirical findings. We begin the analysis by first describing the sample selection and data gathering process.

IV. Data

We developed an automated process to passively track sharing information from over 2,000 sharers on Kazaa, the most popular P2P file-sharing network at the time (Graham 2003). The process operates in the background, taking snapshot observations of the file-sharing activities of P2P participants. As no direct contact was established with the monitored individuals, the process provided no reason for individuals to alter their file-sharing behavior.

A. Sample Selection

On the Kazaa network, a subscriber is identified through a user ID. Music files available on the network are categorized into genres (for example, alternative, bluegrass, classical, country, easy listening, folk, hard rock, and hip hop). We began our data collection effort by conducting searches based on music genres over a period of 1 week to identify the music files in each genre[3] and to capture the user ID associated with each music file. We selected over 6,000 subscribers (that is, 6,000 unique user IDs) who were on the network most frequently for the initial pool. We decided on this pool of most frequent sharers for three reasons: (1) More active sharers would be more likely to be found or observed on Kazaa; (2) with more active users and no new users, we sought to minimize any learning effects; with new sharers (new Kazaa subscribers joining during our sampling period) or novice users,

[3] In Kazaa, subscribers can conduct a search based on genre and obtain a list of files in these specific genres.

TABLE 1

MUSIC GENRES TRACKED AND NUMBER OF ASSOCIATED SHARERS

Music Genre	Unique Sharers	Music Genre	Unique Sharers
Alternative	143	Latin	111
Bluegrass	56	Pop	110
Classical	93	Punk	93
Country	74	Rap	104
Easy Listening	231	R&B	141
Folk	132	Rock	100
Hard Rock	124	Soundtrack	116
Hip Hop	107	Top 40	223
Jazz	98		

NOTE.—There are 2,056 total sharers.

learning effects might confound the results; and (3) more active sharers appear to be the type of individuals that RIAA intended to target.

From this initial pool, we sought a sample that would be representative of the music genre mix. We first examined the distribution across music genres of our sampling pool.[4] From this distribution, it appeared that in order to obtain at least 50 sharers for bluegrass (the smallest stratum), we would need a total of about 2,000 in our overall sample.[5] We continued to run searches and the random selection process until we obtained a minimum of 50 sharers for each stratum. This resulted in 2,056 unique user IDs distributed as shown in Table 1.

B. Data Capture

After obtaining a sample of 2,056 user IDs, we initiated our data-capturing process as summarized in Table 2. Kazaa's search engine provided no ability to search directly by user name or otherwise directly seek out a specific sharer. Instead, we had to develop an indirect search process to seek out each of our 2,056 individual sharers, a process we now detail. To obtain a balanced portfolio of sharers, we took care to randomly initiate our searches over each day's 24 hours. We initiated searches at a random time on Monday of each week. The program begins by entering a randomly selected keyword identifying one category of music (for example, hard rock) and then conducts a search to determine if any of our identified user IDs are currently online at

[4] Since a sharer could be associated with files that belong to more than one music category, a sharer may be identified more than once from different search results. When purging any duplicate IDs, we assigned the individual to that category for which the individual had the highest percentage of files made available for sharing.

[5] One caveat is that the distribution of music categories naturally changes as sharers download new files, sign on and off, or clean up their hard drives. The distribution in our sample could be different from the actual current distribution on Kazaa. In addition, Kazaa does, from time to time, add some new music categories.

TABLE 2

SIX-STEP AUTOMATED DATA CAPTURE PROCESS

Step	Process
1	Initiate a search process using a randomly selected music genre (country, hard rock, jazz, and so on) and obtain a list of music files identified with the genre
2	Find a match between the user ID on the search result and the preselected list of 2,056 sharers
3	If a match is found, go to step 4; if a match is not found skip to step 6
4	Activate Kazaa's "Find More From Same User" function to obtain a list of shared files on the matched user's computer
5	Capture and convert the search result into a text file; flag user ID so if found to be online again, hard drive is not searched again over the week; record each time user ID is found online; go to step 2
6	If no more music genres are left to search, stop; else, initiate another search based on the next music genre; go to step 2

Kazaa. If there is no match (that is, none of the preidentified sharers is currently online at Kazaa and available for sharing), our program randomly selects one of the remaining unsearched genres as the next keyword and repeats the search. If a match is found, the program explores the shared folder on the sharer's hard drive. This shared folder is the file directory and subdirectories designated by the individual as a shared resource available for download by other Kazaa users. The list of files in the shared folder is shown on the Kazaa search result screen, and our program captures and stores the list. After all matched user IDs from a category (music genre) search are fully exhausted, another randomly selected keyword (music genre) is entered and the search process continues. This process is repeated each day until the end of the week (Sunday). Once an individual sharer's hard drive is scanned to obtain the shared list of music files, that individual's hard drive is not explored again during the remainder of the week. However, we do record whether or not an individual is found online during each complete search process.

C. Data Summary

The formal data collection started on the week of March 3, 2003, over 3 months prior to the first legal event. For analysis purposes, we report on data collected until the week of March 1, 2004, a date some 5 weeks after the final legal event. Table 3 shows the summary of the file-sharing activity during the first 4 weeks of the monitoring period. We note a few additional facts about our observations during the first 4 weeks of the monitoring period: 72 of the individuals observed shared fewer than 10 music files, 350 of the individuals observed shared fewer than 50 music files, and 697 of the individuals observed shared fewer than 100 music files.

TABLE 3

INITIAL PROFILE OF 2,056 KAZAA SHARERS

	Average	Median	Lowest	Highest
Number of audio files shared	216	140	1	3,901
Number of times a sharer appeared per week	1.397	1.5	0	7

V. EMPIRICAL ANALYSIS

We conduct a formal test of the hypotheses following an event study approach. Event studies are commonly used in financial and economic studies to evaluate the impact of significant events (see, for example, MacKinlay 1997; Peterson 1989). This approach has been applied widely, and specific applications include evaluating the impact of an earnings announcement on the stock price and studying the market reaction to environmental legislation (Blacconiere and Northcutt 1997), among others. One requirement for event study analysis to be appropriate is that the event or events were unanticipated. We conducted searches on Google and Yahoo search engines as well as Factiva for news stories prior to the actual announcement of each event. We found no indication of any related news stories preceding the actual announcements. We also monitored several technology related discussion forums (such as slashdot.org) and found no indication of pre-event public knowledge. Section V*A* presents the formal test statistic and results from the evaluation of the hypotheses using the overall data. Section V*B* presents a comparative analysis of two key sharer segments—those who share a large number of files (substantial sharers) and those who share fewer files (non-substantial sharers). As the former group represents the main target of RIAA, this comparative analysis can provide useful insights on the overall success of the legal strategy. Finally, Section V*C* addresses the demand side of file-sharing. Clearly, individuals share music files online in order to satisfy the demand by other users to download and acquire these files. We examine the demand side of the file-sharing equation by evaluating the opportunities to download music files, before and after the four legal events. This analysis provides another important perspective on the overall likelihood of success of the legal strategy employed by the music industry.

A. Overall Impact of Events

The statistical test to evaluate the impact of the four legal events was designed to accommodate two keys factors related to file sharing: (1) the file-sharing behavior (both frequency of being online and the number of files shared) between events was not static and exhibited a trend, and (2) the distribution for both measures of file-sharing behavior was asymmetric. To

TABLE 4

SIGN TEST: RESULTS OF HYPOTHESES TESTS FOR EACH EVENT

Event	*Z*-Statistic for Number of Files Shared	Support for Hypothesis 1	*Z*-Statistic for Frequency of Being Online	Support for Hypothesis 2
1. Initial announcement	43.325 (0)	Not supported	−17.161 (0)	Supported
2. Lawsuits filed	−28.135 (0)	Supported	−17.364 (0)	Supported
3. Identity roadblock	9.592 (0)	Supported	.140 (.4)	Not supported
4. John Doe lawsuits	−8.861 (0)	Supported	−9.897 (0)	Supported

NOTE.—Values are in parentheses are *p*-values.

account for the former, we tested for changes in the trends of file-sharing behavior succeeding each legal event. We employed a nonparametric procedure to account for the latter (Cowan 1992; Sanger and Peterson 1990; Hite and Vetsuypens 1989; Doukas and Travlos 1988; Brown and Warner 1980). The analysis was designed as follows.

For each legal event, the week during which it was announced was designated as the event window. The pre-event and postevent windows were the 4 weeks before and after the event window, respectively. Trend shifts in two variables, the number of sharers who increased their frequency of being online and the number of sharers who increased the number of files they shared, were evaluated following each of the events.

The sign test used in the analysis (see Cowan 1992) is a binomial test on the frequency of increased file-sharing activity. Under the null hypothesis, the proportion of sharers who exhibit increased activity has a binomial distribution with parameter $\hat{p}$. The sign test examines whether the proportion of sharers with increased activity is altered in the postevent period. Cowan (1992) reports that the test is well specified and powerful under a variety of conditions. The test statistic is

$$Z = \frac{w - n\hat{p}}{\sqrt{n\hat{p}(1 - \hat{p})}},$$

where n is the sample size and w is the number of sharers with increased activity in the postevent 4-week period. Two specifications of $\hat{p}$ are commonly used. In one, $\hat{p}$ is set to .5. Another specification is based on the estimation of $\hat{p}$ from the sample unaffected by the event. For the latter specification, we estimate $\hat{p}$ by splitting the 4-week pre-event period into two 2-week segments. The estimate of $\hat{p}$ is the proportion of sharers who increased their activity from the initial 2-week segment to the latter 2-week segment. Overall, both estimations yielded consistent results, but, for brevity, we report only those with $\hat{p} = .5$.

The results, presented in Table 4, provide support for the two hypotheses for all cases except two: hypothesis 1 for event 1 and hypothesis 2 for event

TABLE 5

CHANGES IN FREQUENCY OF BEING ONLINE AND FILES SHARED, BY NUMBER OF SHARERS

	Increased	Decreased
Post event 1:		
Frequency of being online	609	1,143
Number of audio files shared	1,490	299
Post event 2:		
Frequency of being online	590	1,115
Number of audio files shared	712	1,124
Post event 3:		
Frequency of being online	926	701
Number of audio files shared	1,059	641
Post event 4:		
Frequency of being online	683	961
Number of audio files shared	132	1,292

3. While hypothesis 1 is not supported for event 1, the overall response to event 1 does indicate some degree of risk mitigation behavior on part of the file sharers. In response to the RIAA's initial announcement to pursue lawsuits, even though the sharers increased their file-sharing levels, they did lower their frequency of being online. Note that hypothesis 1 is supported for event 3. Even though the number of files shared exhibited an upward trend, this event actually represents a setback for RIAA in its legal strategy. While the frequency of being online did not exhibit a concomitant statistically significant increase in response to event 3, the frequency of usage levels did not drop. Table 5 presents summary data that indicate the number of sharers increasing or decreasing their number of files shared and their observed frequency of being online. The data in Table 5 are quite consistent with the findings discussed above.

While the preceding analysis suggests that a significant number of individuals altered their file-sharing behavior in response to legal threats from RIAA, the analysis does not indicate the magnitude of these shifts. Table 6 reports the results from the Wilcoxon signed-rank test to assess whether the magnitudes of file-sharing levels before and after each event are significantly different. These results are consistent with the sign test and suggest that the number of files shared increased significantly following events 1 and 3 and decreased significantly following events 2 and 4. A categorical breakdown summarizing the magnitudes of changes following each event is presented in Table 7. The average and median file-sharing levels are reported in Table 8. Despite increases following events 1 and 3, overall the average number of files shared by an individual dropped dramatically. This drop was most pronounced following legal event 4.

Table 9 focuses on sharers found at least once in a 4-week period preceding and a 4-week period succeeding each of the four events. The results presented

TABLE 6

MAGNITUDE TEST: RESULTS OF HYPOTHESES TESTS FOR EACH EVENT

Event	*Z*-Statistic for Number of Files Shared	Support for Hypothesis 1
1. Initial announcement	25.545 (0)	Not supported
2. Lawsuits filed	−12.023 (0)	Supported
3. Identity roadblock	9.204 (0)	Supported
4. John Doe lawsuits	−30.451 (0)	Supported

NOTE.—Values are in parentheses are *p*-values.

TABLE 7

MAGNITUDE OF CHANGES IN SHARING LEVELS

Change	Event 1	Event 2	Event 3	Event 4
Increased by more than 1,000 files	3	1	11	0
Increased by 501–1,000 files	24	10	52	0
Increased by 101–500 files	545	147	485	8
Increased by 1–100 files	918	554	511	124
No change	267	220	356	632
Decreased by 1–100 files	184	720	314	601
Decreased by 101–500 files	96	363	285	613
Decreased by 501–1,000 files	12	34	34	66
Decreased by more than 1,000 files	7	7	8	12

in Table 9 indicate that the number of sharers found at least once in the 4-week period dropped steadily, except for an increase in the 4-week period after event 3. It is interesting to note that since the 4-week period prior to event 3, the average and median usage levels of sharers found online has increased. This suggests that while a number of sharers appear to have stopped using the file-sharing network, those who remained in the latter part of the legal action periods studied increased their frequency of usage. However, this increased frequency of usage did not reach the level that occurred before the RIAA initiated legal threats and actions. In the next section, we delve a bit deeper and present a comparative analysis of sharers differentiated by their levels of file sharing.

B. Impact on Substantial and Nonsubstantial Sharers

As part of its legal strategy, RIAA specifically targeted those who share "substantial amounts of copyrighted music" (RIAA 2003a). While RIAA did not officially provide a clear definition of what constitutes "substantial," at various points in its interaction with the media, references were made to numbers such as 800 and 1,000 files shared (CNN.com 2003; Van Buskirk 2003; Lymann 2004). In this section, we compare and contrast the behavior of substantial sharers and nonsubstantial sharers. The results presented use

TABLE 8

NUMBER OF FILES SHARED

	Average	Median
Pre event 1	342.82	227.0
Post event 1	397.65	294.2
Pre event 2	279.04	204.6
Post event 2	238.03	177.8
Pre event 3	168.29	89.0
Post event 3	199.83	133.0
Pre event 4	199.83	133.0
Post event 4	93.25	10.5

TABLE 9

OBSERVED FREQUENCY OF BEING ONLINE BEFORE AND AFTER EACH OF THE FOUR EVENTS

	NUMBER OF SHARERS FOUND ONLINE AT LEAST ONCE IN 4 WEEKS	TIMES FOUND PER WEEK	
		Average	Median
Pre event 1	1,963	1.4335	1.50
Post event 1	1,925	1.1974	1.25
Pre event 2	1,842	1.0187	1.00
Post event 2	1,704	.8120	.75
Pre event 3	1,414	.6390	.50
Post event 3	1,519	.6950	.50
Pre event 4	1,519	.6950	.50
Post event 4	1,060	.8432	.75

NOTE.—Values for sharers found online at least once in each 4-week period are reported.

800 files shared as the cutoff to demarcate substantial sharers. The results of our sensitivity analysis show that all the findings continue to hold in the range of 500–1,000 files shared.

Tables 10 and 11 provide the results for sign and magnitude tests (detailed in the previous section) for nonsubstantial sharers. The results for nonsubstantial sharers are very similar to those reported in Tables 4 and 6 for the entire group studied. In fact, the test outcome pattern is identical.

However, when we perform the tests on the data for substantial sharers (Tables 12 and 13), we observe several differences. The sign test results indicate that a significant number of substantial sharers decreased their sharing levels in response to event 1. Thus the proportion of sharers who decreased their sharing levels was substantially more than the proportion that increased their sharing levels. However, the overall magnitude of file-sharing levels did not decrease in response to event 1. Substantial sharers responded to event 3 by lowering both the sharing and the usage levels, despite the fact

TABLE 10

SIGN TEST: RESULTS OF HYPOTHESES TESTS FOR NONSUBSTANTIAL SHARERS

Event	*Z*-Statistic for Number of Files Shared	Support for Hypothesis 1	*Z*-Statistic for Frequency of Being Online	Support for Hypothesis 2
1. Initial announcement	28.568 (0)	Not supported	−17.121 (0)	Supported
2. Lawsuits filed	−18.684 (0)	Supported	−16.698 (0)	Supported
3. Identity roadblock	10.654 (0)	Supported	.829 (.2)	Not Supported
4. John Doe lawsuits	−7.889 (0)	Supported	−8.9358 (0)	Supported

NOTE.—Values are in parentheses are *p*-values.

TABLE 11

MAGNITUDE TEST: RESULTS OF HYPOTHESES TESTS FOR NONSUBSTANTIAL SHARERS

Event	*Z*-Statistic for Number of Files Shared	Support for Hypothesis 1
1. Initial announcement	26.794 (0)	Not supported
2. Lawsuits filed	−10.938 (0)	Supported
3. Identity roadblock	9.991 (0)	Supported
4. John Doe lawsuits	−29.688 (0)	Supported

NOTE.—Values are in parentheses are *p*-values.

that this event represented a setback for RIAA. This behavior is markedly different from that of the nonsubstantial sharers.

Note that the constitution of the substantial sharer group is temporally fluid. A sharer who in a particular week shares over 800 music files may reduce his sharing levels in the subsequent weeks sufficiently to move into the nonsubstantial group. To obtain insights on these temporal dynamics, we segment the overall duration into five time epochs: before event 1, between events 1 and 2, between events 2 and 3, between events 3 and 4, after event 4. Within each time epoch, we classify an individual sharer into the substantial group (denoted as S) if at any point in the time window 800 or more music files were shared by that individual. Otherwise, the individual is placed in the nonsubstantial group (denoted as N). With this segmentation, an individual sharer could potentially take any one of 32 (2^5) possible paths. Figure 1 displays the number of individuals in each path. For ease of exposition, only those paths followed by 10 or more individuals are shown. Table 14 illustrates the average sharing levels and frequency of online usage along each of the shown paths.

We note the following:

1. While RIAA targeted the segment that shared a large number of files, the legal threats also appear quite effective against individuals whose initial file-sharing levels were low. An overwhelming majority of these individuals

TABLE 12

SIGN TEST: RESULTS OF HYPOTHESES TESTS FOR SUBSTANTIAL SHARERS

Event	*Z*-Statistic for Number of Files Shared	Support for Hypothesis 1	*Z*-Statistic for Frequency of Being Online	Support for Hypothesis 2
1. Initial announcement	−1.651 (.049)	Supported	−2.4188 (.0078)	Supported
2. Lawsuits filed	−4.715 (0)	Supported	−4.7691 (0)	Supported
3. Ldentity roadblock	−1.923 (.027)	Not supported	−3.6537 (.00013)	Not Supported
4. John Doe lawsuits	−6.953 (0)	Supported	−5.3300 (0)	Supported

NOTE.—Values are in parentheses are *p*-values.

TABLE 13

MAGNITUDE TEST: RESULTS OF HYPOTHESES TESTS FOR SUBSTANTIAL SHARERS

Event	*Z*-Statistic for Number of Files Shared	Support for Hypothesis 1
1. Initial announcement	1.395 (.0815)	Not supported
2. Lawsuits filed	−5.398 (0)	Supported
3. Identity roadblock	−2.536 (.0056)	Not supported
4. John Doe lawsuits	−7.048 (0)	Supported

NOTE.—Values are in parentheses are *p*-values.

not only stayed consistently below the threshold of 800, they further reduced the average number of files they shared by more than a third.

2. The group that initially shared a substantial number of files displayed a staggered reaction to the legal threats. The largest segment of this group reduced their sharing levels after event 2; the second largest segment of this group reduced below the threshold after event 3. Together, by the end of the span of the four legal events, these two segments eliminated over 90 percent of the files they initially shared. There was, however, a small segment (11 individuals) that appears to be undeterred by the RIAA threats and actions.[6]

3. Note that with the exception of the 11-member S-S-S-S group, the frequency of usage was quite similar between the substantial and nonsubstantial groups, both before and after legal events. Of particular note, the 11-member S-S-S-S group increased their usage levels after event 4.

With the exception of one set of 11 individuals (the persistent S-S-S-S group), individuals exhibited behavior changes consistent with avoided being

[6] Consider the results reported in Figure 1. While there remain 11 "stubborn" substantial sharers, these may actually be non-U.S. sharers. Given the unlikely reach of U.S. legal sanctions to foreigners, one would expect foreign residents to largely ignore legal threats. There were initially 137 substantial sharers, but only 11 remained at the end of our study period. Put another way, some 92 percent of substantial sharers reduced their activity enough to fall into the nonsubstantial level. Thus, our results may understate the impact of the events on U.S. sharers.

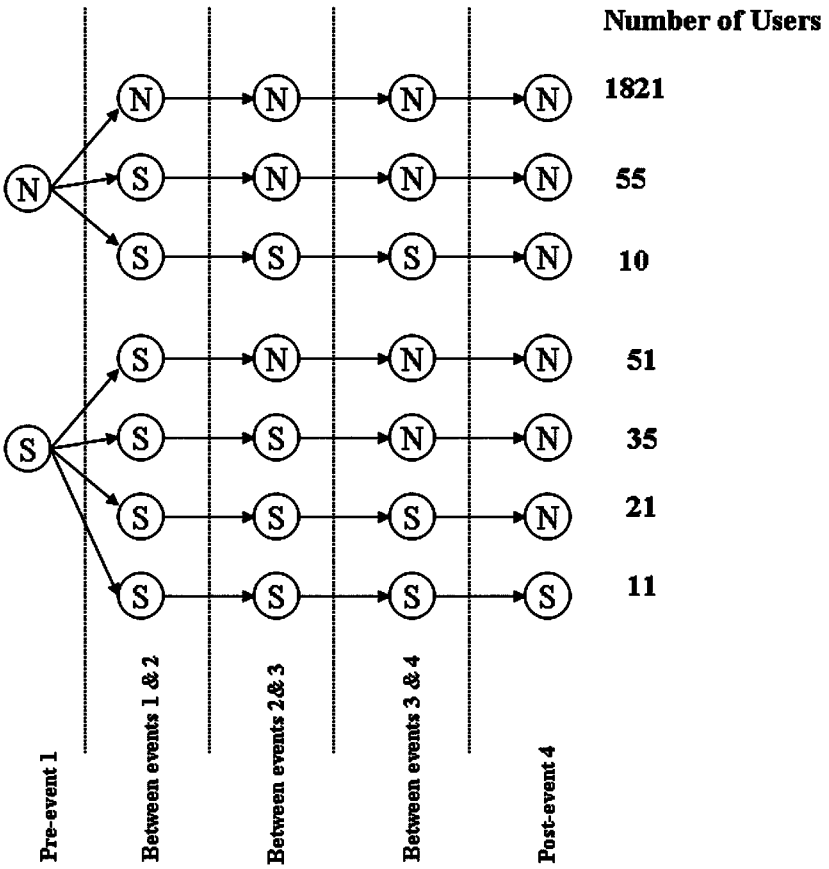

FIGURE 1.—Substantial and nonsubstantial sharer dynamics

targeted for suit by RIAA. By the end of the fourth event, all groups but the "stubborn 11" had reduced average number of files shared to 355 or fewer.

In the next section we consider the changing music file-sharing landscape by looking from the perspective of a potential downloader. Have the RIAA actions effectively reduced opportunities to share?

C. Overall Impact on Peer-to-Peer File-Downloading Opportunities

Thus far, we presented our results based on our observations and analysis of 2,056 individual sharers. But consider a different perspective, that of an individual seeking to obtain music files for downloading. That is, consider how the individual sharer reactions collectively affect the overall availability of music files on a P2P network. In a sense, RIAA has chosen a strategy

TABLE 14

SHARING DETAILS FOR EACH PATH FROM FIGURE 1

	AVERAGE NUMBER OF FILES SHARED					WEEKLY AVERAGE FREQUENCY OF BEING ONLINE				
Path	Pre Event 1	Between 1 and 2	Between 2 and 3	Between 3 and 4	Post Event 4	Pre Event 1	Between 1 and 2	Between 2 and 3	Between 3 and 4	Post Event 4
N→N→N→N→N	256	312	210	157	71	1.4	1.3	.8	.5	.4
N→S→N→N→N	619	879	457	278	127	1.5	1.3	.9	.6	.4
N→S→S→S→N	585	941	1,054	1,049	307	1.1	1.5	.9	.5	.4
S→S→N→N→N	1,432	1,626	426	291	123	1.3	1.3	.8	.4	.3
S→S→S→N→N	1,223	1,319	1,190	253	114	1.2	1.2	.7	.6	.2
S→S→S→S→N	1,292	1,432	1,311	1,137	355	1.5	1.2	.6	.6	.5
S→S→S→S→S	1,414	1,474	1,291	1,411	1,168	1.3	1.6	.7	.4	1.0

NOTE.—The five time epochs are before event 1 (before the initial announcement), between events 1 and 2 (between initial announcement and lawsuits filed), between events 2 and 3 (between lawsuits filed and identify roadblock), between events 3 and 4 (between identify roadblock and John Doe lawsuits), after event 4 (after John Doe lawsuits).

TABLE 15

AVAILABILITY OF FILES PER ALBUM OF BILLBOARD TOP 100 ALBUMS ON PEER-TO-PEER NETWORK

Week of	Average	SD	Low	High
March 17, 2003	487	401.96	123	1,682
March 15, 2004	351	370.86	33	1,245

that seems consistent with the "war on drugs." Drug enforcement agencies have targeted the supply side (large suppliers and large shipments—sharers) rather than the demand side (users—downloaders). There are repeated stories of massive drug shipments seized and kingpins arrested, but drug usage continues. Drugs remain pervasive. What about the music availability for those who wish to download? We selected the top 20 best-selling albums on the *Billboard* chart during the reporting weeks of March 17, 2003 (before the legal events), and March 15, 2004 (after the events), and track the availability of music files associated with these top-selling albums. During each of these two 1-week periods, we performed a daily search on WinMx, another popular file-sharing network, to capture the number of individual music files associated with each of the top 20 albums. We selected WinMx instead of Kazaa for this analysis because Kazaa returns no more than 200 results in response to a search query for a music file, while WinMx has no such restrictions. (It is important to note that Kazaa has no limitation on individual sharer searches that we analyzed in the previous sections.) WinMx continually searches for the selected music file until the searcher terminates the search.

As shown in Table 15, although the average number of files available from each search (each album) decreased by almost 30 percent, a search for music files associated with these popular albums still returns more than 300 individual files available for download. Even though RIAA threats and legal actions appear to have had some success in reducing the total number of music files available on P2P networks, there remained at least 33 copies (and up to 1,300) of items on each of the *Billboard* top 100 albums.

Given the results observed in earlier subsections, it would seem that RIAA actions did affect the sharing behavior of individuals. There is indication that the average number of files shared declined, at least by event 4, across almost all sharers. Still, for any individual wanting to download, there remain quite a few options. The RIAA may have succeeded more in reducing the average availability of files than in reducing piracy. If Grokster's and Kazaa's statements are correct and P2P traffic quickly bounced back after legal threats and actions, then it may simply be that individuals are not downloading less but are sharing less (that is, making fewer of their music files shared or accessible for downloading).

VI. Conclusion

Our research question centered on illegal music sharing and involved the analysis of how individuals actually responded to legal threats from the recording industry. By developing an automated process, we were able to track the sharing behavior of 2,056 individuals before and after four RIAA-related events. That is, our analysis utilized microlevel data tracked across time. Three of the events were RIAA's formal threat that they would be pursuing legal action, the announcement that initial suits had been filed, and the announcement that a second round of suits had been filed. The other event involved an appellate court ruling that RIAA could not subpoena certain sharer identifying information from Internet service providers.

Our analysis indicates mixed success for RIAA's strategy. On the positive side, before- and after-event comparisons suggest that over the course of the four events, the majority of substantial sharers decreased the number of files shared, typically by more than 90 percent. During this period, a majority of nonsubstantial sharers reduced sharing activity, typically to a third of their original levels. Further, a substantial number of sharers exhibited some risk mitigation behavior. On the other hand, some findings pose concern for the recording industry. We found an upsurge in the frequency of usage after event 3 from the sharers who continue to use the file-sharing network. These individuals are continuing to find value in accessing and using P2P networks. Next, although our analysis identified RIAA-intended behavioral changes following RIAA's legal threats and legal actions, there remain fairly wide downloading options. That is, after the four events, we still found a fairly wide choice for anyone seeking to download music files. Another cause for concern is that even if the individual behavioral changes we observed are linked to an actual lessening of piracy, there is still the fact that the legal action did not come without a price to RIAA itself. Many critics of RIAA's actions against individual consumers suggested that its legal efforts may be perceived as heavy-handed and could create a backlash on the music industry itself (Graham 2003; Ahrens 2003). The *New York Daily News* also reported a potential public backlash as it featured on its front-page headline a 12-year-old child named as defendant in an RIAA lawsuit (Sangha and Furman 2003). Shell (2003) pointed out that in dealing with music piracy, the music industry's legal success in suing its own potential customers may not be as important as its potential future success in adjusting its business strategy (Byrne 2003; Evans 2002). There are various signs of experiments with new strategies, as recently evidenced from new licensing options that allow sharers rights to freely share the music (Bhattacharjee et al. 2006; Smith 2004).

While our results are consistent with the effect intended by RIAA, we feel it necessary to add the following caveat. It is possible that the observed reduction in file sharing on Kazaa may have been at least partially linked to a shift by sharers to other sharing networks. While we cannot rule this out,

we do have information from another sharing network (WinMx), which is noted in Section V*C*. As described above, we found a similar general downward trend in the P2P file-downloading opportunities, which suggests that there was no large-scale shift in usage from Kazaa (the largest sharing network during our observation period) to WinMX (the second largest sharing network during our observation period). Finally, we found no reported sharp increase in the usage of smaller networks in the popular press.

Taken as a whole, our results lead us to posit that individuals have, to a very large extent, responded in the direction intended by RIAA. In fact, the effect on U.S. sharers may be stronger than our numerical results indicate because the few (11) who remained as stubborn sharers may well be foreign-based sharers (see note 6). However we also note that a significant number of sharers tended to move below the threat levels (800 or 1,000 files shared) rather than exit from sharing activity. The RIAA could lower the threat level or the number of files shared at which an individual sharer might be pursued. But lawsuits cost real money. How many suits is it reasonable for RIAA to pursue? At the present time, what we can say is that the previously substantial sharers are tending to still actively share (albeit fewer files), and downloading options still abound for those seeking to download. We continue to track and monitor while we watch for the development by the recording industry of market mechanisms that might be more effective—will market options emerge that do not require costly legal actions and yet both enhance industry net revenue while lowering the cost of music to consumers?

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