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The Relation of Prerecorded Music Media Format, Consumer Recreational Spending Patterns and the U. S. Recording Industry Piracy Claims: 1972-2009

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Abstract. Using data from 1972 to 2009 this study finds results consistent with the recording industry's piracy claims by comparing record sales normalized by personal consumption expenditures in periods of piracy friendliness (music available on cassettes or online) to periods of piracy unfriendliness (music formatted on vinyl records and earlier CDs). This study also confirms that reduced record sales in the piracy friendly eras was not part of a larger phenomenon of changing patterns in consumer recreational spending.

Keywords: Music piracy, prerecorded music purchases, recreational spending

JEL classifications: JEL820 - Entertainment; Media, JEL830 - Sports; Gambling; Recreation; Tourism, JEL860 - Information and Internet Services; Computer Software

1 Introduction

The main purpose of this article is to determine if the data are consistent with the Recording Industry Association of America's (RIAA) claims, beginning in 1971, that unauthorized copying (piracy) has caused it serious economic harm. In contrast with the preponderance of recent empirical studies on music piracy which have focused on digital downloads, this study seeks to determine whether the data are consistent with the domestic recording industry's piracy loss claims across the analog (tape) and digital eras. Another contribution of this paper is the examination of the potential impact of changes in recreational spending on piracy. Previous studies have determined that various

substitutes for or complements to music purchases (replenishing album collections as formats change, newspapers, magazines, books, video purchases, video rentals, movies, plays, operas, concerts, electronic games and toys) cannot fully explain piracy based losses. Prerecorded music purchases and related substitute and complementary goods are components of the broader category of recreational goods and services.[1] This study seeks to determine if drops in spending on prerecorded music attributed to piracy may be part of a larger phenomenon of concomitant drops in consumer spending on recreational goods and services.

The remainder of this paper is organized as follows. Section 2 discusses technology and copyright law as they relate to the music industry. Section 3 discusses the results of previous studies. Section 4 analyzes the recording industry's claims of piracy losses over periods characterized by various recording technologies, some of which are piracy friendly and others which aren't. In addition, consumer spending patterns on prerecorded music are compared to those on recreational goods and services. Section 5 is a summary and conclusions.

2 Technology and copyright law's impact on recording industry revenues

The topic of illegal digital file downloads has received much attention recently (Liebowitz 2006). However, the recording industry has been gravely concerned with piracy since 1971. Over the years pre-recorded music has been delivered in various formats, some of which were more amenable to piracy (tapes, later CDs, on-line digital songs) than others (celluloid discs (78's), vinyl records, earlier CDs). The recording

[1] A list of recreational goods and services in included in the Appendix.

industry has resorted to legal and technological remedies for piracy with limited success. This section recaps a brief history of the impact of changes in technology and copyright law on recording industry revenues.

The recording industry was created with the invention of record players and celluloid discs in the late 1870s. The industry enjoyed increased prosperity with the public's acceptance of vinyl records in the mid 1940s. The profitability of recorded music was tapped into by offshore plants that reproduced and sold unauthorized (counterfeited) albums. It was limited to a small number of players due to fairly substantial barriers to entry and the economic loss associated with being apprehended and convicted. Their main protection was ineffectual prosecution by their government (Burke 1996).

Cassette tapes displaced vinyl records in the late 1960s. Some consumers took advantage of the recording capacity of cassettes and began duplicating and swapping songs with each other. By 1971 the RIAA estimated that the volume of unauthorized taping was one third the volume of legitimate recordings. In response to the piracy threat the recording industry persuaded Congress to amend the 1909 Copyright Act. Effective February 15, 1972, the act contained two provisions that greatly enhanced record labels ability to prosecute copyright offenders. Prior to the amendment record labels had no cause for legal action since copyrights were attached to the song and only the song writer or his delegate could sue for copyright violations. The amendment gave copyright status to the master sound recording, allowing record labels to pursue infringements through the court systems. Also prior to the amendment there was no national standard for enforcing copyright infringement, that infraction was covered by individual state statutes and case law. The amendment prohibited the unauthorized copying of a sound recording at the federal level, simplifying record labels' ability to prosecute offenders.

The home taping piracy problem partially self effaced with the introduction of digitally recorded compact discs (CDs) in 1983. There was no cheap, effective mechanism for consumers to copy songs from pre-recorded music CDs to blank CDs. The high cost of CD equipment delayed initial consumer acceptance of the media, but the lowering costs of CD players spurred growth and by 1991 the sales of full length CDs outstripped the sale of full length cassettes.[2]

The technological advances allowing individuals to copy songs to CDs was slow and expensive. In 1991 CD copying equipment was introduced to the consumer market by Sony and Philips at a cost of $40,000. The costs of blank CD-Rs (single copy CDs) was $80. By 1995 the price of the equipment had been "reduced" to $995. Besides costs, consumers had to contend with the decision of which CD technology would ultimately prevail. CD-RW equipment (rewritable CDs) was introduced in 1996 at a cost of $1,000. The discs cost $12 and were not backward compatible with CD-R equipment. By 1998 two competing interfaces of CD-RW to personal computers were on the market. Compounding the consumer's dilemma was the introduction of DVD-Rs around this time. Initially CD-Rs and CD-RWs wouldn't play on DVD-R equipment. It is estimated that by 1999 only 14% of music consumers owned a device capable of burning CDs (Farwell 2003). Simply put, by 1999 song swapping via CDs was circumscribed by costs and technical constraints and not a widespread phenomena.

The growth of the Internet in the 1990s expanded the potential for piracy. Internet users had the capacity to share digital files (which included songs) with one another. Song sharers were no longer limited by physical proximity. To protect its interests in the digital era the recording and film industries lobbied Congress to pass a barrage of

[2] RIAA 1998 Consumer Profiles (10 year summary), RIAA web site http://www.riaa.com.

legislation: the Audio Home Recording Act of 1992, the Digital Performance Right in Sound Recordings Act of 1995, the No Electronic Theft Act of 1997, and the Digital Millennium Copyright Act of 1998.[3]

Two developments in the late 1990s exponentially exacerbated the potential for song sharing. The emergence of the MP3 format facilitated online file sharing by making files easier to swap due to their increased density. In 1999 Napster introduced a web site devoted to file sharing (which included song swapping). Song swappers now had a clearing house and were no longer limited to personal acquaintances. By 2001 the RIAA claimed that worldwide the industry was losing over $4 billion a year to piracy.

The recording industry turned to the courts to ameliorate piracy losses. It sued Diamond Multimedia, the manufacturer of MP3 players, but lost the case. It sued Napster, effectively putting it out business. However, other web sites sprung up that allowed computer to computer file sharing without a central file server, Napster's legal downfall. The industry responded by suing the major peer-to-peer (P2P) Internet file sharing portals as well as the Internet Service Provider Verizon and individual users of Internet song swapping portals.

In conjunction with legal action, the recording industry turned to technology to combat piracy. It partnered with electronic retailers and released songs with Digital Rights Management (DRM) software which limited the user to one or a few copies of an electronic file. Legitimate purchases of on-line songs from all the major record labels began in 2002 at the web site Listen.com. Most of these songs were sold with some type of copy protection feature. For a brief time the recording industry experimented with a two tiered pricing system. Downloaded songs with DRM sold for a lower price than

[3] See Menell (2002) for an analysis of copyright law as it applies to the music and computer industries.

songs with unlimited copying capability. Due to consumer backlash about the incompatibility of legally obtained DRM files with their listening devices the industry eventually gave up on copy protecting on-line music. EMI and Apple began offering online music free of copying restrictions in April of 2007. The other major record labels soon followed suit. By 2008 the four major record labels: EMI, Sony/BMG, Warner and Universal as well as a host of independent record labels offered most if not all of the songs in their music catalogs online in a DRM free format.

Between 1972 and 2009 pre-recorded music was delivered in four formats, two of which, tapes and digital songs, were amenable to piracy, and two of which, vinyl records and CDs weren't as amenable. This technological demarcation provides a framework for a longitudinal study to assess whether the data are consistent with the industry's claims that losses caused by piracy are long lived and significant. Prior studies, which have focused primarily on the digital era, mainly support the industry's claims.

3 Prior studies

Although generally supportive of the industry's claims of piracy induced revenue losses, some empirical studies cast doubt on its magnitude. Using a sample of international data from 1994 to 1998 Hui and Png (2003) conclude that the impact of piracy on CD sales was about 42% of industry estimates. Liebowitz (2004) studies the effects on annual trends in national record sales from 1973 to 2002 of various factors: album prices, income, music quality, markets for substitutes and complements, portability and "librarying" (replenishing album collections as formats change). He finds these factors cannot fully explain declines in record sales over the period and deduces, based on 1999 to 2002 data, that digital file sharing has reduced aggregate record sales. He

finds a large increase in the sales of pre-recorded albums in the cassette era which he attributes to increased portability and suggests that sales may have been more robust absent piracy. Rob and Waldfogel (2006) collect data on albums obtained via purchase and downloading, as well as consumers' valuations of these albums, among a sample of U.S. college students in 2003. They estimate that each album download reduces purchases by at least 20%. Peitz and Waelbrock (2004) measure the change in record sales over the period 2000-2001 using data from 16 countries. They conclude that downloading couldn't have been responsible for more than 25% of the record sales decline in 2002. Zentner (2006) estimates the effect of music downloads on the probability of purchasing music using an individual-level cross section of 15,000 people from Europe in 2001. His results indicate that peer-to-peer usage reduces the probability of buying music by 30 percent. Using National Income and Product Account data from 1990 to 2004, Stevans and Sessions (2005) find that music downloading, subsequent to 2000, affects consumer spending on tapes, LPs, and CDs through the price elasticity of demand. Falling DVD prices have also served to reduce the demand of recorded music during this same period. They conclude that while people who file-share typically purchase more music in aggregate, the probability of purchasing music (i.e., proportion of music legally purchased) is reduced. Liebowitz (2006) surveys the piracy literature and concludes that the evidence strongly suggests that file sharing harms the sound recording industry.

Most subsequent studies have supported this assertion. Using Consumer Expenditure Survey data from 1996 to 2002 Hong (2007) studies the effect of Internet usage on the demand for entertainment. He finds that for purchases of newspapers, magazines, books, video purchases, video rentals, movies, plays, operas, concerts, electronic games and

toys, the effect of Internet growth are small or statistically insignificant. In contrast, a negative effect still remains significant for purchases recorded music, potentially reflecting the result of file sharing.

Using a data set that includes album sales, Internet penetration, and various demographic measures for 99 American cities over the period 1998-2003, Liebowitz (2008) examines the extent to which file sharing has caused the U.S. decline in sound-recording sales. He concludes that file sharing appears to have caused the entire decline in record sales and appears to have vitiated what otherwise would have been growth in the industry.

Oberholzer-Gee and Strumpf's (2007) results differ from previous studies. They find that digital downloads have an insignificant effect on recording industry revenues. They analyze sample data of domestic music down loads over a 17 week period in the fall of 2002 and compared that activity with a sample of United States released albums over that time period. They conclude that "While downloads occur on a vast scale, most users are likely individuals who would not have bought the album even in the absence of file sharing." In a working paper Liebowitz (2007) disputes their results.

The preponderance of empirical studies support the contention that piracy harmed recording industry revenues in the digital era, but not to the extent claimed. The RIAA's claims of piracy losses in the analog era haven't been substantiated. The only empirical study to date on the analog era does not support the industry's claims. Liebowitz (2004) finds the empirical evidence supportive of the recording industry's claims of piracy induced losses due to file sharing he cannot corroborate similar claims in the analog era.

With the exception of Liebowitz (2004), studies have focused on digital file sharing based piracy. The piracy induced economic implications of the introduction of taped

music by the recording industry are not clear cut. Although recording industry revenues may have been diminished by audio tapes since they facilitated unauthorized copying, audio tapes expanded the market for pre-recorded music by expanding its portability from the home to automobiles and anywhere a cassette player could be heard. Furthermore, when compared to file sharing audio taping should have had a much less pronounced effect on record label revenues. Audio taping had a much smaller pool of potential music "sharers." Internet based piracy is delimited only by the number of people willing to share their music files, whereas audio taping requires getting a physical copy from a personal acquaintance, who may have had a limited library of albums. The capacity of a person making an audio copy of a song to pass that song along to others is greatly diminished because of sound degradation in copying. Because of the natural damping effect in audio taping that is not present in file sharing an unbiased observer would have grounds to believe that the RIAA's claims of revenue losses attributable to piracy in the 1970s were an exaggeration.

The goal of this paper is to assess whether the data are consistent with the domestic recording industry's piracy loss claims in both the digital and analog eras. Its contribution to the literature on music piracy is primarily its scope. It studies the potential of piracy effects on domestic record label revenues, scaled for personal consumption and conditioned on pre recorded music media format, since record labels have had the legal standing to file suit for copyright violations. The finding of significant differences in scaled recording industry revenues between piracy friendly and unfriendly eras would support the industry's claims. Any lack of significant change across piracy friendly and unfriendly eras would cast doubt on the industry's claims.

In many prior studies piracy has been surmised as a source of reduced industry revenues via the elimination of other causes (album prices, income, music quality, markets for substitutes and complements, portability, librarying, and internet usage). This study examines another potential explanation for dips in prerecorded music spending. The recording industry's piracy claims is analyzed against the backdrop of trends in consumer spending on recreational goods and services. Reduced spending on prerecorded music during piracy eras may have been a component of reduced overall spending on recreational goods and services.

4 Media format and piracy potential

Studies supporting and refuting consumer piracy's effect on record label revenues have mainly focused on the effect on record sales of illegal digital downloading, a phenomena that became significant with the appearance of Napster in 1999. However another change in technology, tape recording, aroused the recording industry's piracy fears as far back as 1971, when it convinced Congress to strengthen copyright protection law. From this date forward there have been periods where technology easily facilitating piracy was readily available to consumers (cassettes and P2P file sharing) as well as periods when the predominant forms of pre-recorded music (vinyl records, CDs before 1999) were not easily susceptible to home recording. Declining recorded music sales attributed to file sharing on the Internet spurred the recording industry to legal action. However, during the tape era the industry thought piracy was a sufficient enough issue to warrant legislative action. The partitioning of data based on piracy friendliness can shed light on current piracy studies. If recorded music sales slumped in the digital era, did a

similar effect occur in the tape era? Finding similar effects would be consistent with the industry's claims of longstanding piracy induced revenue losses.

In order to put RIAA's claims of the effect of piracy loss on revenues into perspective, the metric used is recording revenues expressed as a percentage of personal consumption in the United States. The RIAA's claims of piracy are based on downward trends of recording revenues. However, record sales dropped from $75 million in 1929 to $6 million in 1933. During the same time frame personal consumption fell from $77.4 billion to $45.9 billion. The downward trend in record sales was caused by shifts in spending patterns due to an overall reduction in personal consumption in the United States during the Depression.

Comparisons are made of record sales (relative to personal consumption) in periods of home recording/downloading friendliness (when music was primarily delivered on cassettes or readily available through P2P) to periods not amenable to home recording (music formatted on vinyl records and CDs). Finding no significant difference across all four eras would not be supportive of the RIAA's piracy claims. If there are significant differences between at least two of the populations, further tests can be made. Finding significantly lower recording revenues as a percentage of personal consumption in periods where home recording was readily available compared to periods where it was not would be consistent with (but not prove) the RIAA's contention that consumer piracy hurt revenues. If there is no significant difference, then, although piracy existed, it either likely had no net material effect on recording revenues, or was offset by other factors. If there is a significant difference, further comparisons can be made between like periods with respect to home recording friendliness. Finding no significant differences in relative record sales between the vinyl record and CD periods as well as between the cassette and

P2P periods would indicate no significant change of record sales purchases (relative to personal consumption) within like home recording capability periods. The significant shifts in record sales purchases occurred during periods when readily available technology facilitated home recording.

Even if the results indicate significant drops in purchases of music during piracy friendly eras, record label losses ascribed to piracy could be explained as a component of downturns in spending on recreational goods and services. To test this potential explanation comparisons are made of consumer recreational spending in periods of home recording/downloading friendliness to periods not amenable to home recording/downloading. Finding no significant difference across all four eras would support the industry's piracy claims. If there are significant differences between at least two of the populations, further tests can be made. Finding significantly lower consumer recreational spending in piracy friendly eras compared to piracy unfriendly eras would support the view that all or a portion of losses ascribed to piracy could be explained by shifts in consumer recreational spending patterns.

4.1 The Data and Method of Analysis

Since the focus of this study is on piracy in the United States, the relevant analytical time span is from 1972 to 2009. The study commences in 1972 since that was the first year record labels had the legal status to prosecute copyright offenders. The data sample ends in 2009. Data are derived from the RIAA on annual domestic record sales.[4] Personal consumption data is obtained from the United States Bureau of Economic Analysis.

[4] The RIAA data is based on suggested retail prices, which may be higher than actual sales prices in some instances.

During this period advances in technology provided the recording industry four forms of song delivery: vinyl records (primarily LPs) cassette tapes, CDs and downloadable songs. Technology also provided consumers with P2P file swapping. Vinyl records were introduced in the late 1940s. Cassette tapes were introduced in 1967, but it was 1984 before they replaced vinyl records as the predominant form of pre-recorded music sales.[5] To combat the inherent piracy capabilities of cassettes, the recording industry introduced CDs in 1983. Reduced equipment cost and increased reliability enabled the sales of CDs to surpass cassettes in 1991.[6] Napster and subsequent web sites appeared in 1999 and allowed individuals to share songs on the Internet (P2P). To characterize eras where record sales were most susceptible to piracy, they are stratified by period based on the medium that was the predominant delivery mechanism of prerecorded music or where P2P file sharing was readily accessible. The periods selected for comparison in this study are: vinyl records (1972-1983), cassette tapes (1984-1990), CDs (1991-1998) and P2P (1999-2009).

In each of these categorized eras piracy existed to some extent. Counterfeit vinyl records were produced by offshore plants. Vinyl records could be copied to cassettes. Cassettes could be copied to other cassettes. CDs could be copied to cassettes. CDs weren't readily copyable to other CDs until the early 2000s when this feature became standard on personal computers. The reason for categorizing the vinyl record, tape and CD eras by when they became the predominant delivery media as opposed to when they were introduced is the presumption that a critical mass of users with the appropriate equipment would be necessary for piracy to have a meaningful effect on record sales.

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[5] Source: RIAA Market Research Committee *Manufacturers Unit Shipments 1978-1989.*

[6] Source: RIAA Market Research Committee *Manufacturers Unit Shipments 1990-1999.*

For instance, pre-recorded cassette sales were of sufficient magnitude to be separately categorized by the RIAA in 1967, but by 1972, the first year of this study, they comprised only 28 % of sales, vinyl records still accounted for 72%. (Table 1). Although available in cassette form, most purchasers of music preferred the vinyl record format. In other words, the data seems to be saying that there wasn't much incentive for most music listeners to pirate a cassette tape, they preferred vinyl records. By 1984 over half of all music purchases were cassettes. At this point the majority of music listeners had adapted to cassettes and had the capacity to copy and listen to a pirated cassette.

Based on delivery format the data provide four distinct populations. The Kruskal-Wallis rank sum procedure is employed to test the null hypotheses that mean record sales as a percentage of personal consumption are similar across the populations. Acceptance of the null hypothesis would not be supportive of the RIAA's claims that, when scaled by personal consumption, revenues were appreciably smaller in the piracy friendly cassette tape and P2P eras compared to the piracy unfriendly vinyl record and CD eras. If the null hypothesis is rejected, then least squared differences (LSD) tests on ranks will be used to pair wise compare the four eras. If vinyl records and CDs have higher mean sales as a percentage of personal consumption compared to tapes and P2P, and if significant differences are found in mean sales as a percentage of personal consumption when comparing vinyl records to tapes, vinyl records to P2P, CDs to tapes, and CDs to P2P, these overall results would be consistent with the RIAA's contention that consumer piracy hurt record sales. If these results hold, a further check will be made of mean record sales as a percentage of personal consumption comparing vinyl records to CDs and tapes to P2P. If no significant differences are found, these results would further support the RIAA's contention that consumer piracy hurt record sales.

A key assumption for the above tests is that absent piracy consumer purchases of prerecorded music as a percentage of personal consumption would have remained constant or increased over the period 1972-2009. One way to validate this assumption is to examine the constancy of consumer spending on recreational goods and services, of which prerecorded music is a component. If consumer spending on recreation was constant over time then shifts in spending on prerecorded music could be explained by piracy. However, if significant recreational spending downturns occur on the same cycles as downturns for pre recorded music purchases, then one possible explanation for piracy losses is that they were a component of reduced consumer recreational spending.

The Kruskal-Wallis rank sum test is employed to test the hypothesis that recreational goods and services spending as a percentage of personal consumption is similar across the piracy friendly and unfriendly periods. Acceptance of the null hypothesis would indicate that reduced record label revenues in piracy friendly eras weren't part of changes in recreational spending. If the null hypothesis is rejected, then ranked least squared differences (LSD) tests will be used to pair wise compare the four eras. If significantly higher recreational goods spending occurred in the vinyl records and CDs eras compared to tapes and P2P these results would support the contention that reduced music purchases during piracy friendly eras could be viewed as part of the larger phenomenon of reduced consumer recreational spending during those time frames.

4.2 Prerecorded Music Analysis

According to the RIAA, record sales increased from $1,924,000,000 in 1972 to a peak of $14,584,700,000 in 1999 and declined to $7,686,000,000 in 2009 (Table 1). According to the Bureau of Economic Analysis during this same time period personal

consumption expenditures in the United States increased from $770,600,000,000 in 1972 to $10,088,549,000,000 in 2009. As a percentage of personal consumption, record sales varied from a high of 0.29% in 1978 to a low of 0.08% in 2009 (Figure 1). During this 38 year span, the year of the lowest dollar value of record sales, 1972, had the 35th highest percentage of record sales to personal consumption, and the year with the highest dollar sales, 1999, ranked 26th in percentage. This exemplifies the need to normalize record sales with respect to personal consumption to gauge any significant movement in record sales caused by factors other than changes in personal spending.

<< Insert Table 1 about here >>

Figure 1 displays record sales as a percentage of personal consumption from 1972 to 2009. Although the overall trend of record sales is downward sloping, the sub-trends in the graph support the view that relative record sales were lower overall in the piracy friendly cassette tape (1984-1990) and P2P (1999-2009) periods than the piracy unfriendly vinyl record (1972-1983) and CD (1991-1998) periods. The raw data are supportive of this observation. Both in terms of mean record sales as a percentage of personal consumption and rank, record sales in the cassette tape (0.1771%,13.43) and P2P (0.1484%, 9.55) eras are lower than in the vinyl record (0.2268%, 26.58) and CD (0.2280%,27.88) eras. (Tables 2 and 3).

<< Insert Table 2, Figure 1 about here >>

The first hypothesis tested is that the mean percentage of record sales to personal consumption in all four eras is the same. Using the Kruskal Wallis rank sum test, this hypothesis is rejected at the 99% confidence level (Table 3). Consistent with the raw

data, the test rejects the assertion that ranked relative record label revenues were statistically equivalent across all four eras.

<< Insert Table 3 about here >>

To determine if the data are supportive of the RIAA's claims two further sets of null hypotheses are tested using Fisher's Least Significant Difference (LSD) procedure on the ranked data. The first set tested is that the ranked mean relative record sales in the piracy unfriendly eras (vinyl records, CDs) should be higher than the piracy friendly eras (tapes, P2P). Finding the null hypotheses true would be consistent with the RIAA's contention that piracy usurped record sales. If found false, the results support the view that piracy has no significant effect on record sales. The second hypothesis set tested is that the ranked mean percentages of piracy alike eras (tapes and P2P, vinyl records and CDs) are the same. If the percentages are statistically equivalent, this finding would further support the view that shifts in record sales as a percentage of personal consumption across time are related to changes in consumer accessibility to recording technology. Table 4 contains the results of the tests at the 99% confidence level.

The difference in the mean ranking of vinyl records and tapes (13.15) is greater than the LSD statistic (10.10) indicating that relative record sales were statistically larger in the vinyl than cassette era. When vinyl records are compared to the P2P era the difference in mean ranking (17.04) is larger than the LSD statistic (8.86) and indicates that relative record sales were statistically larger in the vinyl record than P2P era. These results support the view that record sales significantly dropped in the piracy friendly cassette and P2P eras when compared to the vinyl record era.

<< Insert Table 4 about here >>

The results have similar implications when CDs are compared to tapes and P2P. The mean ranked difference of CDs and tapes (14.45) is larger than the LSD statistic (10.99) signifying that relative record sales were statistically larger in the CD than cassette era. When CDs are measured against the P2P era the difference in mean ranking (18.33) is larger than the LSD statistic (9.86) and signifies that relative record sales were statistically larger in the CD than P2P era. These results are consistent with the proposition that record sales percentages were lower in the copy friendly cassette and P2P eras than the copy unfriendly vinyl record and CD eras. The finding of equivalent mean percentages within the vinyl record and CD eras as well as the cassette and P2P eras would be consistent with the claim that shifts in record sales accompanied shifts in technology that facilitated home recording.

If pre-recorded music sales are affected by piracy there is no reason to suspect that the mean percentage of record sales to personal consumption during the vinyl record era would differ from the CD era since they were both recording unfriendly, or that the percentages would differ between the recording friendly cassette and P2P eras. The rank difference of record sales to personal consumption for vinyl records and CDs (1.29) is much smaller than the LSD statistic (9.69) indicating that relative record revenues were the same in the two eras. The difference in ranked relative sales percentage for tapes compared to P2P era (3.88), is smaller than the LSD statistic (10.26), indicating no statistical difference in relative record sales between the two eras. Overall, these results support the view that there was no significant movement of record sales purchases within like home recording capability periods. The significant downward shifts in record sales purchases occurred during periods when readily available technology facilitated home recording.

This study finds that as a percentage of personal consumption, recorded music sales were statistically lower in the cassette and digital eras than in the vinyl record and CD eras. It supports the contention that relative record label revenues were lower in piracy friendly cassette and P2P eras than the piracy unfriendly vinyl record and CD eras. The digital (P2P) finding is consistent with previous studies and supports the RIAA's claim that piracy was facilitated due to the ease of illegal distribution of copyrighted songs on the Internet. The reduction of revenues in the cassette era is supportive of the RIAA's piracy contention but differs from Liebowitz' (2004) findings.

4.3 Recreational Goods and Services

A key assumption for the above tests is that absent piracy consumer purchases of prerecorded music as a percentage of personal consumption would have at least remained constant over the period 1972-2009. One way to validate this assumption is to examine the constancy of consumer spending on recreational goods and services, of which prerecorded music is a component. If consumer spending on recreation was constant over time then shifts in spending on prerecorded music could be explained by piracy. However, if significant recreational spending downturns occur on the same cycles as downturns for pre recorded music purchases, then one possible explanation for piracy losses is that they were a component of reduced consumer recreational spending.

As noted in the previous section record sales had peaks in the vinyl record (1972-1983) and CD (1991-1998) periods and troughs in the piracy friendly cassette tape (1984-1990) and P2P (1999-2009) periods. In contrast, consumer spending on recreational goods and services has an ascending trend over the time frame of the study, going from 4.47% of personal consumption expenditures in the record era to 6.62% in the P2P era (Figure 2,

Table 5). It does not appear that downturns in prerecorded music purchases during the tape and P2P eras were part of downturns in consumer spending on recreation.

<< Insert Table 5, Figure 2 about here >>

The Kruskal Wallis test is used to determine if the mean percentage of recreational spending to personal consumption in all four eras is the same. Using the rank sum test, this hypothesis is rejected at the 99% confidence level (Table 6).

<< Insert Table 6 about here >>

As indicated by the raw data, recreational spending has an upward trend over the time frame of the study. There are no dips coinciding with the piracy friendly tape (1984-1990) and P2P (1998-2009) eras, indicating that reduced music purchases in the piracy friendly eras were not part of downturns in recreational spending. The Fisher's Least Significant Difference (LSD) procedure on the ranked recreational spending data confirms this. The null hypotheses that relative recreational spending over the time periods of the study are equal is rejected for all comparisons (Table 7). In all comparisons later recreational expenditures are higher than earlier ones and the difference between the ranked relative recreational expenditures is greater than the LSD statistic when comparing earlier periods to later periods, indicating that recreational expenditures as a percent of personal consumption increased over time. For example when comparing recreational expenditures between the records (1972-1983) and tape (1984-1990) eras, the ranked tape mean (16.00) is greater than the ranked records mean (6.50) and the difference (9.50) is greater than the LSD statistic, indicating that

recreational expenditures were statistically higher in 1984-1990 than 1972-1983. This same principle applies to all periods examined. The data does not support the contention that record label losses ascribed to piracy are a component of downturns in spending on recreational goods and services.

5 Summary and conclusions

The recording industry asserts that the introduction of technology facilitating home recording and file sharing, most notably cassette tapes and peer-to-peer file sharing, has reduced domestic record sales. Most previous studies of the effect of unauthorized digital downloading of music on album sales have confirmed this claim. This study finds results consistent with the RIAA's piracy claims for both the tape and digital eras by comparing relative record sales in periods of home recording friendliness (when music was delivered on cassettes or available through P2P) to periods not amenable to home recording (music formatted on vinyl records and CDs). Using data from 1972 (when piracy prosecution under copyright law was standardized nationally) to 2009 this study finds mean record sales as a percentage of personal consumption to be statistically higher during the vinyl record and CD eras, when sound recording equipment was not widely adopted by consumers, than the cassette tape and peer-to-peer internet song swapping eras, when recording/downloading capability was readily available. This study also finds no significant difference in the mean percentage of record sales to personal consumption during the vinyl record and CD eras, which are both home recording unfriendly, and no significant differences in the percentages in the home recording friendly cassette and P2P eras. These latter results are consistent with the argument that no significant movement of record sales purchases within like home recording capability periods occurred, the significant shifts in record sales purchases occurred during periods when widely available

technology facilitated home recording. This study also confirms that reduced record sales in the piracy friendly eras was not part of a larger phenomenon of changing patterns in consumer recreational spending, eliminating another potential factor that could have explained piracy.

It must be noted that these results must be interpreted with caution. Factors other than piracy may have contributed to downturns in relative record label revenues. Like most previous studies, this study does not attempt to directly measure piracy's effects on recording industry revenues. It simply affirms that the data are consistent with the recording industry's claims.

Appendix: Recreational Goods and Services as Identified by the United States Bureau of Economic Analysis.

Recreational goods
- Video, audio, photographic, and information processing equipment and media
  - Video and audio equipment
    - Televisions
    - Other video equipment
    - Audio equipment
    - Recording media
      - Prerecorded and blank audio discs/tapes/digital files/downloads
      - Video cassettes and discs, blank and prerecorded
  - Photographic equipment
  - Information processing equipment
    - Personal computers and peripheral equipment
    - Computer software and accessories
    - Calculators, typewriters, and other information processing equipment
- Sporting equipment, supplies, guns, and ammunition
- Recreational books
- Musical instruments

Recreation services
- Membership clubs, sports centers, parks, theaters, and museums
  - Membership clubs and participant sports centers
  - Amusement parks, campgrounds, and related recreational services
  - Admissions to specified spectator amusements
    - Motion picture theaters
    - Live entertainment, excluding sports

Spectator sports
Museums and libraries
Audio-video, photographic, and information processing equipment services
Cable and satellite television and radio services
Photo processing
Photo studios
Repair of audio-visual, photographic, and information processing equipment
Video media rental
Gambling
Casino gambling
Lotteries
Pari-mutuel net receipts
Other recreational services

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United States Constitution, Article I, Section 8, United States House of Representatives, Washington DC.

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A&M Records et. al. vs. Napster et. al. United States District Court for the Northern District of California, May, 2000.

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RIAA vs. Diamond Multimedia, United States District Court for the Central District of California. 1998

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RIAA vs. Verizon, United States District Court for the District of Columbia, 2003.

Figure 1. Prerecorded Music Sales as a Percent of Personal Consumption in the United States 1972-2009.

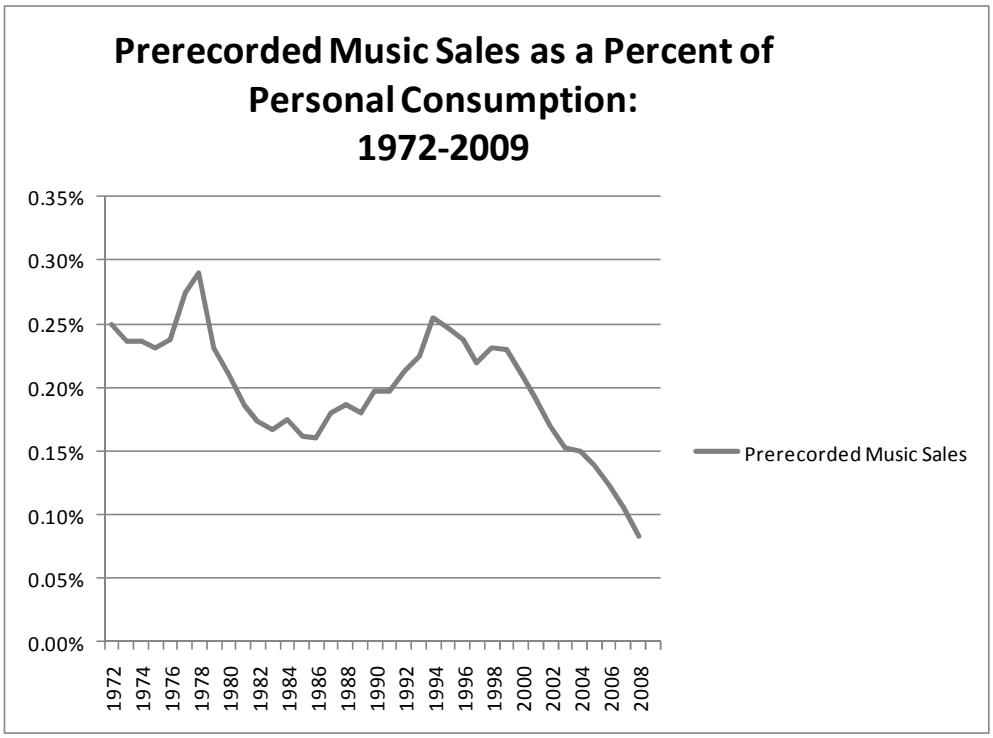

Figure 2. Recreational Goods & Services Spending as a Percentage of Personal Consumption in the United States 1972-2009.

Table 1. Recorded Music Sales, Personal Consumption and Percentage of Pre-recorded Music by Delivery Mechanism: 1972-2009. (Sources: RIAA Market Research Committee *Manufacturers Unit Shipments* various years, United States Bureau of Economic Analysis, National Income and Product Accounts, Table 2.1 Personal Income and Its Disposition, 10/5/2010.

Year	Records	Tapes	CD's	Other	Digital	Prerecorded Music Sales ($ millions)	Personal consumption expenditures ($ millions)
1972	71.9%	28.1%		0.0%		$1,924.0	$770,230.0
1973	71.2%	28.8%		0.0%		$2,016.6	$852,013.0
1974	70.4%	29.6%		0.0%		$2,200.2	$932,932.0
1975	70.9%	29.1%		0.0%		$2,391.0	$1,033,788.0
1976	69.7%	30.3%		0.0%		$2,737.0	$1,151,254.0
1977	69.7%	30.3%		0.0%		$3,500.8	$1,277,823.0
1978	66.2%	33.8%		0.0%		$4,131.4	$1,427,621.0
1979	65.6%	34.4%		0.0%		$3,676.1	$1,591,167.0
1980	66.5%	33.5%		0.0%		$3,682.0	$1,755,826.0
1981	65.1%	34.9%		0.0%		$3,626.0	$1,939,506.0
1982	60.6%	39.4%		1.4%		$3,592.0	$2,075,495.0
1983	51.3%	47.5%	0.5%	0.7%		$3,814.3	$2,288,576.0
1984	42.3%	54.5%	2.4%	0.8%		$4,370.4	$2,501,083.0
1985	35.6%	55.0%	8.9%	0.6%		$4,387.8	$2,717,608.0
1986	26.0%	53.7%	20.0%	0.2%		$4,651.1	$2,896,746.0
1987	17.9%	53.4%	28.6%	0.1%		$5,567.5	$3,096,960.0
1988	11.4%	55.0%	33.6%	0.0%		$6,254.8	$3,350,056.0
1989	5.2%	54.8%	40.0%	0.0%		$6,464.1	$3,594,490.0
1990	2.4%	49.5%	45.9%	2.3%		$7,541.1	$3,835,453.0
1991	1.2%	41.5%	55.8%	1.5%		$7,834.2	$3,980,073.0
1992	0.9%	37.8%	59.5%	1.7%		$9,024.0	$4,236,891.0
1993	0.6%	32.0%	65.3%	2.1%		$10,046.6	$4,483,594.0
1994	0.5%	26.9%	70.6%	1.9%		$12,067.7	$4,750,806.0
1995	0.6%	20.6%	77.0%	1.8%		$12,320.3	$4,987,280.0
1996	0.7%	16.7%	80.7%	1.9%		$12,533.8	$5,273,608.0
1997	0.6%	13.5%	83.3%	2.6%		$12,236.8	$5,570,626.0
1998	0.4%	11.0%	84.8%	3.7%		$13,711.2	$5,918,488.0
1999	0.4%	7.6%	89.4%	2.6%		$14,584.7	$6,342,784.0
2000	0.4%	4.4%	93.3%	2.0%		$14,323.7	$6,830,371.0
2001			93.9%	6.1%		$13,740.9	$7,148,807.0
2002			95.5%	4.5%		$12,614.2	$7,439,191.0
2003			94.8%	5.2%		$11,854.4	$7,804,013.0

Table 1 cont'd.

Year	Records	Tapes	CD's	Other	Digital	Prerecorded Music Sales ($ millions)	Personal consumption expenditures ($ millions)
2004			92.0%	5.7%	2.29%	$12,439.2	$8,285,080.0
2005			85.2%	5.5%	9.29%	$12,342.2	$8,819,002.0
2006			79.3%	4.2%	16.42%	$11,547.7	$9,322,662.0
2007	0.3%	0.0%	72.0%	4.7%	23.01%	$10,372.2	$9,826,438.0
2008	0.7%	0.0%	64.6%	2.6%	32.10%	$8,480.3	$10,129,919.0
2009	0.8%	0.0%	55.6%	2.8%	40.70%	$7,686.0	$10,088,549.0

Table 2. Summary Statistics: Sales of Recorded Music by Media Type as a Percentage of Personal Consumption in the United States 1972-2009.

	records	tapes	CDs	P2P
Prerecorded Music Sales / Personal consumption expenditures	**72-83**	**84-90**	**91-98**	**99-09**
begin	1972	1984	1991	1999
end	1983	1990	1998	2009
n	12	7	8	11
Raw data				
mean	0.2268%	0.1771%	0.2280%	0.1484%
median	0.2336%	0.1798%	0.2279%	0.1501%
std dev	0.0374%	0.0130%	0.0186%	0.0497%
max	0.2894%	0.1966%	0.2540%	0.2299%
min	0.1667%	0.1606%	0.1968%	0.0762%

Table 3. Kruskal Wallis Test of the Rank of Recorded Music Sales as a Percentage of Personal Consumption in the United States by Media Type: 1972-2009. H_0: the average rank of recorded music sales as a percentage of personal consumption by media type is the same across all media type. H_1: the average rank of recorded music sales as a percentage of personal consumption by media type is different for at least one pair of media type.

Kruskal Wallis	records	tapes	CDs	P2P
	72-83	84-90	91-98	99-09
ranking	35	13	20	26
	31	9	23	22
	30	8	25	18
	28	14	36	11
	33	16	34	7
	37	15	32	6
	38	19	24	5
	27		29	4
	21			3
	17			2
	12			1
	10			
sum	319.0	94.0	223.0	105.0
count	12.0	7.0	8.0	11.0
mean	26.58	13.43	27.88	9.55
		SS	4569.5	
		SST	2511.3	
		Error SS	2058.2	
		MST	837.1	
		MSE	60.5	
		F-Ratio	13.8	
		confidence level	99.00%	
		PR > F-stat	0.000005	
			reject H0	

Table 4. Pair wise Fisher's Least Significant Difference (LSD) Tests of the Rank of Recorded Music Sales as a Percentage of Personal Consumption by Media Type. H_0: The rank of all categories are equal. H_1: There are differences in the rank of categories.

Fisher LSD	Prerecorded Music Sales / Personal consumption expenditures				
			LSD stat	difference	conclusion
(records tapes)	72-83 vs 84-90		10.10	13.15	reject H0
(records CDs)	72-83 vs 91-98		9.69	1.29	accept H0
(records P2P)	72-83 vs 99-09		8.86	17.04	reject H0
(tapes CDs)	84-90 vs 91-98		10.99	14.45	reject H0
(tapes P2P)	84-90 vs 99-09		10.26	3.88	accept H0
(CDs P2P)	91-98 vs 99-09		9.86	18.33	reject H0
			t-stat 0.995, 34		
			2.7284		

Table 5. Summary Statistics: Recreational Spending as a Percentage of Personal Consumption in the United States 1972-2009.

	records	tapes	CDs	P2P
Rec Goods & Svcs/ Personal consumption expenditures	72-83	84-90	91-98	99-09
begin	1972	1984	1991	1999
end	1983	1990	1998	2009
N	12	7	8	11
Raw data				
mean	4.4708%	5.2116%	6.0435%	6.6185%
median	4.4632%	5.2517%	6.1267%	6.6165%
std dev	0.0877%	0.2818%	0.3981%	0.0534%
max	4.6901%	5.4937%	6.4882%	6.6993%
min	4.3417%	4.8060%	5.5008%	6.5457%

Table 6. Kruskal Wallis Test of the Rank of Recreational Spending as a Percentage of Personal Consumption in the United States by period: 1972-2009. H_0: the average rank of recreational spending as a percentage of personal consumption by media type is the same across all periods. H_1: the average rank of recreational spending as a percentage of personal consumption by period is different for at least one pair.

Kruskal Wallis	records	tapes	CDs	P2P
	72-83	84-90	91-98	99-09
ranking	1	13	20	33
	2	14	21	36
	4	15	22	28
	10	16	23	30
	11	17	24	29
	8	18	25	34
	6	19	26	32
	5		27	37
	3			38
	7			35
	9			31
	12			
sum	78.0	112.0	188.0	363.0
count	12.0	7.0	8.0	11.0
mean	6.50	16.00	23.50	33.00
		SS	4569.5	
		SST	4246.5	
		Error SS	323.0	
		MST	1415.5	
		MSE	9.5	
		F-Ratio	149.0	
		confidence level	99.00%	
		PR > F-stat	0.000000	
			reject H0	

Table 7. Pair wise Fisher's Least Significant Difference (LSD) Tests of the Rank of Recreational Spending as a Percentage of Personal Consumption by Period. H_0: The rank of all periods are equal. H_1: There are differences in the rank of periods.

Fisher LSD	Rec Goods & Svcs/ Personal consumption expenditures				
			LSD stat	difference	conclusion
(records tapes)	72-83 vs 84-90		4.00	9.50	reject H0
(records CDs)	72-83 vs 91-98		3.84	17.00	reject H0
(records P2P)	72-83 vs 99-09		3.51	26.50	reject H0
(tapes CDs)	84-90 vs 91-98		4.35	7.50	reject H0
(tapes P2P)	84-90 vs 99-09		4.07	17.00	reject H0
(CDs P2P)	91-98 vs 99-09		3.91	9.50	reject H0
			t-stat 0.995, 34		
			2.7284		