The Metric is the Message: How much of the Decline in Sound Recording Sales is due to File-Sharing?

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Abstract: The file-sharing literature has focused mainly on whether file-sharing has decreased record sales, with less attention paid to the size of any decline. Although there is still some contention, most studies have concluded that file-sharing has decreased record sales. What has not been noted is that most estimates indicate that the file-sharing has caused the *entire* enormous decline in record sales that has occurred over the last decade. This heretofore hidden result is due to the lack of a consistent metric that would allow easy comparability across studies. The task of this paper is to provide such a metric, translate the results reported in the literature into that metric, and then summarizes the results from this exercise.

How much of the highly publicized decade-long decline in the sales of authorized sound recordings is due to file-sharing? Although it is generally accepted that a large majority of empirical studies have found that file-sharing has caused a decline in the sales of prerecorded music, it is difficult for someone reading this literature to find a useful summary of the empirical estimates of the decline caused by file-sharing that might provide an answer to this question. This difficulty is due, in large part, to the different metrics of sales decline used in these studies as well as their use of differing empirical methodologies, different time periods and different geographic regions.

Although several articles, such as Connolly and Krueger (2005), DeJean (2009), Liebowitz (2005), and Oberholzer-Gee and Strumpf (2009), offer lengthy literature reviews, most of them, as well as the many obligatory reviews that are contained in studies of file-sharing, are generally focused mainly or entirely on the sign of the results—i.e., whether file-sharing has a negative impact on the sales of sound recordings. That focus may have made sense when the debate was largely about whether file-sharing had any negative effect at all on the sales of sound recordings. Nevertheless, the size of the estimated piracy-induced declines is of interest in and of itself and should be of greater interest than the sign, in part because the size of a coefficient contains more information than its sign, and also because the policy implications of file-sharing are likely dependent on the size of the estimates.

The purposes of this paper are threefold. First, it is to show that differences in the metric chosen to report the effect of file-sharing lead to important differences in the information conveyed. Second, it is to identify a metric that directly informs legal and economic consideration of the consequences of file sharing regardless of the time period or the countries used in the analysis. The final goal is to convert the estimates found in the literature into this metric so as to provide a meaningful comparison of the estimated size of file-sharing's impact on record sales. The metric that I use for this comparison is defined as the share of the sales decline that is due to file sharing over some period of time.

As I show below, when the results of these studies are made comparable in this manner, the estimates from a majority of studies imply that that file-sharing has caused the *entire* decline in sound recording sales that has occurred since the ascendance of Napster.[1] I believe this finding is likely to surprise even those

[1] As documented in Liebowitz (2006), Napster was born in 1999, grew to prominence in 2000, and was shut down in 2001.

who have been keeping up with this literature, since the prevalence of this result seems not to have been previously noted.

I. Candidate Metrics

Most econometric examinations of the issue tend to perform a regression of the form:

$$(1)\ RS = a + bFS + \boldsymbol{cZ}$$

where RS stands for record sales, FS stands for file-sharing and $\boldsymbol{Z}$ is a vector of covariates that are thought to influence record sales.[2] These regressions can be run across geographic regions, individuals, or albums, at a moment in time or as a time-varying panel. The coefficient *b*, which would be negative if file-sharing decreases record sales, represents the extent to which a downloaded song or album replaces the sale of that song or album.

There are at least three potential metrics of a decline in sales that might be proposed.

The most common method of measuring the impact of file-sharing is to create an estimate of the size of the decline in sales that is caused by file-sharing and then form a ratio of this decline as a percentage of overall sales:

$$Metric\ 1 = Share\ of\ Sales\ \equiv \frac{\left(b \cdot \overline{FS}\right)}{RS}$$

Although this is a natural measure and the one most commonly adopted by researchers in the field, it does not allow comparability with other studies using the same measure, in spite of the fact that it is easy to simply compare percentage changes as a matter of arithmetic. The problem with comparing these percentages is that they will change not only as the amount of file-sharing changes but also as the closeness of the substitutability between

[2] In most instances there is no direct measure of file-sharing. Instead, a proxy, such as Internet usage, is often used. This may overstate the impact of organized file-sharing because other uses of the Internet that might reduce record sales (such as exchanging music files using email) cannot be separated from the impact of programs allowing organized and anonymous file-sharing. The results for these studies should probably be understood either to include a wider aspect of sharing files than organized file-sharing systems, or else to indicate an estimated result that is biased upward. Using the Internet, particularly for other forms of entertainment, might also usurp a user's time that would otherwise be used listening to music, causing a different upward bias in the estimated impact of file-sharing, although Liebowitz (2008) has estimated this bias to be quite small.

originals and unauthorized copies, which is a function of the technology in use by consumers.[3] This means that the same degree of file-sharing by the same people at different points in time will have different values for metric 1. This metric will also vary across countries and populations, for the same reasons.

A second metric could be coefficient b from the above equation:

$$Metric\ 2 = "displacement\ rate" \equiv b$$

Rob and Waldfogel, in their 2006 article, are the only authors of whom I am aware that use this particular measure which they label as the "displacement rate." This metric looks at the share of downloaded music that replaces the sale of music ("We find that each album download reduces purchases by about .2 in our sample, although possibly by much more"[4]). The problem with this measure is that translating it into an actual decrease in sales requires knowing how large the illicit download market is relative to the legitimate market. So the .2 reduction found by Rob and Waldfogel (2006) would imply a 20% reduction in sales if the legitimate and illicit markets were the same size but would imply a 40% reduction if the illicit market were twice as large as the legitimate market.[5] The ratio of the sizes of the licit to the illicit market is likely to differ across countries and over time, increasing the complexity of comparisons. It is perhaps for this reason that this metric is so uncommon among the papers on file sharing.

The most striking statistics in the sound recording industry, post-Napster, is the enormous decline in sales, as indicated in Table 1. A common question asked by many industry analysts is the extent to which the current decade-long decline has been caused by file-sharing. Answering this question provides

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[3] The substitutability between originals and copies depends on how easy it is for unauthorized mp3 files to be played on the same audio devices and in the same locations as the legitimate purchased music that was available on CDs. In the early days of file-sharing MP3 files could not be played on most audio systems and converting MP3 files into the WAV files found on CDs required a CD burner which many users did not yet own. Over time, CD and DVD players gained the ability to play MP3 files, CD burners became commonplace, and MP3 players, such as the iPod, became the centerpiece of home and auto audio systems although the timing differed by country. These advances in technology increasingly made illicit downloads better substitutes for purchased originals.

[4] This statement is taken from the abstract of Rob and Waldfogel (2006).

[5] Liebowitz (2006) discusses various estimates of the relative size of the illicit download market (FS) relative to the legitimate market (RS) and concludes that the estimates of relative size are wildly disparate and that many estimates of the illicit market indicate that it is considerably larger than the legitimate market.

the third candidate metric for the impact of file-sharing: the share of any given decline that is due to file-sharing. This can be represented as:

$$Metric\ 3 = Share\ of\ Loss\ \equiv \frac{(b \cdot \overline{FS})}{\Delta RS}$$

This third metric has the advantage of allowing comparisons over time and across regions. For example, as illicitly downloaded files become better substitutes for legitimate versions (because of the growth of MP3 players, say), both the decline in legitimate sales and the decline in sales due to file-sharing will become larger even if the amount of file-sharing were to remain constant. But if the only reason for the decline in sales were file-sharing, then Metric 3 will remain unchanged at a value of 1, indicating that the role of file-sharing in causing the decline has not changed. This is particularly useful in comparing the decline across countries which will experience different diffusions of technologies that influence the substitutability of illicit and legitimate files.

This metric has problems in specific circumstances, however. For example, file-sharing could be harming sales but sales could still be growing. In this case it would be very awkward and probably meaningless to try to use Metric 3 to compare the estimated impacts of file-sharing over time since it would not even be possible to define the share of the decline that was due to file-sharing if there was no decline in sales.[6]

[6] One might generalize this to try to account for a decline from any trendline, not just zero. If the actual growth of sales fell below trend, then even with an increase in sales it would be reasonable to consider the deviation from trend as lost sales and we could then examine the fraction of lost sales, measured in this way, that is due to file sharing. However, because those lost sales are conjectural, I have not recommended that approach here. Nevertheless, as we will see below, it is not unreasonable to encounter an effect of file-sharing that exceeds 100% of the observed decline in legitimate sales, implying that an upward trendline would have continued if not for file-sharing.

Table 1: Decline in sales after the birth of organized file-sharing			
	U.S. Units	U.S. Real Rev	non-U.S. Real Rev
2000	4.8%	5.0%	4.3%
2001	13.5%	11.4%	5.6%
2002	22.5%	19.9%	12.1%
2003	28.3%	26.4%	21.7%
2004	24.8%	25.4%	27.9%
2005	27.5%	28.2%	34.7%
2006	32.5%	33.6%	39.8%
2007	38.4%	41.5%	44.6%
2008	47.7%	54.0%	43.9%
2009	52.7%	59.9%	45.4%
Units = all full length albums and digital downloads divided by 10. Revenues include ringtones but exclude performing rights. U.S. Unit Data from RIAA; Revenue data from 2010 IFPI "Recording Industry in Numbers" page 5			

Table 1 indicates the size of the decline in the U.S., in both units and real revenues and real revenues for the non-U.S. portion of the world (labeled "non-U.S.").[7] Fortunately, U.S. and worldwide record sales have fallen in an almost monotonic fashion since the appearance of Napster. Further, Liebowitz (2007) provides evidence that each of the top markets has experienced a severe decline in sales so that Metric 3 can be used for the markets that have been empirically examined by economists.

Table 1 also shows that unit declines are slightly less in the U.S. than are revenue declines (columns 1 and 2), indicating a small fall in prices since 1999. The non-U.S. revenues (column 3) decline more slowly in the first few years but then catch up and surpass U.S. losses by 2004, although the U.S. losses become larger again in 2008.

Because of the ease of comparisons across time and geographies, and because Metric 3 directly answers the question as to the importance of file-sharing in the recent industry decline, Metric 3 will be the one I choose as the common denominator with which to compare all results. With this metric chosen as the common denominator, comparisons can be made across the various types of studies to see how similar or dissimilar the results are from one another. First, however, I wish to illustrate how mixing different metrics has led to unfortunate confusion in the literature.

[7] The U.S. data on unit sales come from the RIAA website. Revenue statistics, both for the U.S. and non-U.S., come from the IFPI document "2010 Recording Industry in Numbers." Values for the non-U.S. portion of the world are dominated by the dozen or so leading markets.

II. Some Inconsistent Uses in the Literature

Regrettably, there are in the literature some inconsistent nomenclatures regarding metrics measuring the impact of file-sharing. For example, Rob and Waldfogel are not the only economists to use the term "displacement rate" when discussing possible metrics for the impact of file-sharing on sales. Oberholzer-Gee and Strumpf (2009), which intends to be a summary of the literature, also uses the term "displacement rate" but its use of the term is different from that of Rob and Waldfogel. Further, Oberholzer-Gee and Strumpf, although they have a specific definition of "displacement rate," do not use it consistently when addressing the literature. Here is portion of a paragraph from Oberholzer-Gee and Strumpf (2009) that illustrates multiple inconsistent uses of the term that make the comparisons uninformative:

> The majority of studies find that file sharing reduces sales, with estimated *displacement rates* ranging from 3.5% for movies (Rob and Waldfogel, 2007) to rates as high as 30% for music (Zentner, 2006). …Liebowitz (2008)… reports a *displacement rate* of more than 100% for a selection of U.S. music markets…A typical estimate is a *displacement rate* of about 20%. One implication of these results is that developments other than file sharing must have had a profound impact on sales…Rob and Waldfogel (2006) find an average *displacement effect* of 20%.[8] [My italics]

The first usage of "displacement rate" in the above quote mentions both a 3.5% value from Rob and Waldfogel (2007) and a 30% value from Zentner (2006). The 3.5% figure (for video) used in the Rob and Waldfogel article is an instance of Metric 1, a measure of reduced video sales due to file-sharing (although overall video sales actually increased), whereas Zentner's 30% figure measures the reduced probability of purchasing music and does not fit into any of the three metrics presented above.[9] Although comparing measured values for movies with music might seem a questionable exercise, comparing two completely different metrics to supposedly provide a useful range of estimates is a far more serious error.

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[8] See Oberholzer-Gee and Strumpf (2009) page 35. I have included a portion of their footnote 17 in the text of the quoted paragraph placed where the footnote occurred.

[9] In their abstract (page 379), Rob and Waldfogel state "Our analysis indicates that unpaid consumption, which makes up 5.2 per cent of movie viewing in our sample, reduced paid consumption in our sample by 3.5 per cent." Zentner states in his abstract on page 63: "The results suggest that peer-to-peer usage reduces the probability of buying music by 30 percent." He then creates a "back of the envelope" metric equivalent to Metric 1 (having a value of approximately 8%) that he suggests is more informative.

Oberholzer-Gee and Strumpf's next usage of the term "displacement rate" concerns Liebowitz (2008) who used Metric 3 in his article, or the share of the decline in music sales due to file-sharing. The third usage of the term found in the quoted paragraph concerns a "typical" estimated displacement rate of 20% that Oberholzer-Gee and Strumpf claim to have derived in some manner. Interestingly, the metric that Oberholzer-Gee and Strumpf claim to be using appears to be Metric 3. For example, in the sentence following this third usage they suggest that a rate of 20% implies that other factors must have had "a profound impact on sales" which is a logical implication only if they are using Metric 3 (among the metrics discussed) because it would imply that 80% of the decline would be due to something other than file-sharing. Further, a few pages before the above copied quote (page 20), Oberholzer-Gee and Strumpf summarize their results by stating "…many studies conclude that music piracy can perhaps explain as much as one-fifth *of the recent decline in industry sales*" (my italics). Given that in the next sentence they then refer to this decline as a "displacement" and that the amount is identical to the 20% "typical value" found in the paragraph reproduced above, it seems clear that their term "displacement rate" is supposed to measure the extent to which piracy can explain the recent decline in sales, or in other words, Metric 3. At least it would seem clear, except for the fact that they use the term "displacement rate" in so many incompatible ways.

Their final usage of the term "displacement rate" (labeled a displacement "effect") in that paragraph refers to results from the same Rob and Waldfogel (2006) article which I discussed as the leading, and perhaps only, example of Metric 2. Thus Oberholzer-Gee and Strumpf use four different and incompatible metrics as examples of "displacement rate" within this single paragraph. It is not surprising, therefore, that the "typical" 20% figure suggested by Oberholzer-Gee and Strumpf will be seen to bear no relationship to the actual average displacement where displacement is consistently defined as the share of the decline due to file-sharing (Metric 3).

Notice how much this confusion about the metric can affect the message. If file sharing caused a 20% decline in sales (Metric 1), that would likely be a very large share of the sales decline in the years shortly after Napster's introduction. By conflating the metrics used, however, an observed decline of 20 percent of sales might be reported as a "20% displacement" (defined as Metric 3), leaving the reader with the impression that the actual sales reduction due to file-sharing was quite small relative to the overall decline, with other factors playing a much larger roll. Unfortunately, this is exactly the presentation made

by Oberholzer-Gee and Strumpf that leaves the reader with the impression that the impact of file-sharing is smaller than it actually was estimated to be.

III. Applying the Metric to the Literature

The point of this section is to compare the results of papers finding that file-sharing caused harm (in the next section I discuss papers that do not find harm). The published papers of which I am aware are Hong (2007, forthcoming), Liebowitz (2006, 2008), Michel (2006), Peitz and Waelbroeck (2004), Rob and Waldfogel (2006), Waldfogel (2010) and Zentner (2005, 2006). Two unpublished papers of seemingly similar quality to those that are published are Blackburn (2004) and Zentner (2009).

In order to compare the results of these papers to one another, I translate the amount of file-sharing-induced decline that these papers find into a percentage of the decline in sound recording sales that had occurred at the time of their measurement. Naturally, there is going to be some imprecision within many of these original estimates and that imprecision will necessarily carry over to the translated results. For one thing, many of these papers have multiple point estimates. In such cases, I take the one preferred by the authors when their preference seems justified, or, if none is listed as 'preferred' I use the average of the proffered estimates. Even with just a single point estimate, however, these papers use different years and different countries for their analyses and Table 1 makes clear that there are differences in sales declines depending on which years and which countries are used as the basis of analysis. Also, there are confidence intervals around the point estimates, although I ignore those in this analysis.

Table 2 lists alphabetically the results from ten published articles (listed first) and two unpublished studies (listed last) finding some degree of harm due to file-sharing (the details of the calculations underlying Table 2 are found in the Appendix). Seven of these studies have results indicating that the entire decline in sales is due to file-sharing. Another study has two results, with one of those results consistent with the full decline being due to file-sharing and the other result about a third of the decline. Two other studies indicate that file-sharing is responsible for either about half or two thirds of the decline and one study finds the smallest result, between 20% and 40% of the decline.[10] It is clear that

[10] The reader should be aware that Professor Hong, in his forthcoming article prefers a result of 20% although he found that the overall result after trying to control for compositional changes

the average of these studies is not the 20% "typical estimate" claimed by Oberholzer-Gee and Strumpf since only one of the twelve studies has a result as low as 20%.

Table 2: Results of Studies Using Metric 3				
Published/Unpublished Studies	Share of Decline due to File-sharing	Original Metric	Final Data Year	Geography
Hong (2007)	>100%	1	2002	U.S.
Hong (forthcoming)	20%-40%	3	2002	U.S.
Liebowitz (2006)	100%	3	2005	U.S.
Liebowitz (2008)	>100%	3	2003	U.S.
Michel (2006)	45%	1	2003	U.S.
Peitz and Waelbroeck (2004)	>100%	1	2002	World
Rob and Waldfogel (2006)	35% or >100%	1	2004	U.S.
Waldfogel (2010)	65%	2	2009	U.S.
Zentner (2006)	>100%	1	2001	7 European
Zentner (2005)	100%	1	2002	World
Blackburn (2004)	>100%	1	2003	U.S.
Zentner (2009)	75%	3	2008	World

In summary, and allocating partial results from studies with mixed results, 7.5 of the 12 studies find that file-sharing explains the entire decline.[11] The average estimated value of Metric 3, for the other 4.5 studies that do not find that the entire decline is due to file-sharing, is 50% of the decline. When the raw numbers from all these studies (found in the Appendix) are averaged, the mean value of Metric 3 is slightly over 100%, further indicating that file-

in his data was 40%. His preference for the 20% value is based in large part on the fact that when he subdivides his population data into cohorts, some of the coefficients are statistically insignificant even though their values still imply an overall 40% decline. He chooses to set these insignificant coefficients to zero, thus lowering the overall impact to 20%. But having less than typical statistical confidence in a result does not imply that a result of zero is more appropriate than the measured coefficient. Thus I list both numbers.

[11] Professor Hong, in correspondence, suggested that his 2007 result not be given equal consideration to those from his forthcoming paper because he did not try to control for compositional changes in his 2007 paper (although his 2007 paper appears to be written after his forthcoming paper). Because he has not withdrawn or repudiated his 2007 paper, however, and because we cannot know whether he has truly been successful in controlling for compositional changes in his forthcoming paper (he uses propensity scores and not actual variables on individual characteristics), I include the paper in Table 2. Even if his 2007 paper were removed from the Table, however, it would merely lower the share of papers finding that the entire decline was due to file-sharing from 63% (7.5/12) to 59% (6.5/11). Also, the average value of Metric 3 for all papers would still be over 100%.

sharing has been estimated to be responsible for more than the entire decline in sales.

The Metric 3 values greater than 100% probably need a word of explanation. Many of the studies have Metric 3 values of greater than 100% and as seen in the Appendix, some values are as high as 200%. A value this large may seem odd at first glance, but such a seemingly high number is not necessarily unreasonable once properly understood. This is best illustrated through the use of a simple example.

> Example: Assume that a firm sells 10 CDs in year 0, whereupon file-sharing begins. By year 5, sales have dropped to 8 CDs, a 20% decline. Assume as well that in the absence of file-sharing that sales would have increased by 4% per year, leading to counterfactual sales in year 5 of 12.17 units. The apparent decline, the one reported by the record companies and appearing in RIAA-type statistics, is 2 units (10-8). The actual decline, determined from a perfect econometric examination, is 4.17 units (12.17-8). Metric 3 would state that 208% of the measured decline was due to file-sharing (4.17/2). This is close to what Liebowitz (2008) found, where a counterfactual growth rate of 3.6% was sufficient to explain his Metric 3 result of 200%. A sound recording yearly growth rate of 3.6% in the U.S. was a very typical growth rate during the three decades prior to the advent of file-sharing, indicating that a value of 200% for Metric 3 is well within the realm of reasonableness.

The results from a majority of studies—that file-sharing is responsible for the entire decline in sales—is also consistent with the evidence from proposed alternative hypotheses to explain the decline in sound recording sales. Liebowitz (2004) and Liebowitz (2006) carefully examined these alternative explanations and found that they were largely lacking in empirical support and the intervening years have only strengthened that conclusion.[12] With no support for other possible explanations for the decline in record sales, logical consistency would lead to a conclusion that file-sharing was responsible for the

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[12] For example, the leading alternative explanation (that Liebowitz 2006 did not completely discount) was the purchase of prerecorded video, which did show an increase after 1999 (although it seemed to begin in 1997 and was small compared to the increase in the 1980s when record sales saw robust increases). More recent evidence, however, indicates that sales of prerecorded movies fell after 2004 and were back to their 1999 level by 2009 although sound recording sales showed no such return to their old levels. Similarly, videogame sales, which had been rising since 1996, stopped rising in 2002 whereupon they remained largely unchanged until 2007 at which point there was a sudden and enormous increase, a pattern quite unrelated to the pattern of sound recording sales.

entire decline, which is what the majority of economic studies have found, once the proper metrics are used.

IV. What about the papers that do not find harm?

There are no published articles in academic journals that find a positive impact of file-sharing on sound recording sales, although there is a study (Andersen and Frenz, 2007), conducted for a Canadian Ministry, which concludes that file-sharing has a positive impact on sound recording sales.[13]

The two published studies that do not find that file-sharing harms sales are Oberholzer-Gee and Strumpf (2007) and a revised version of the Canadian government study using the original data, Andersen and Frenz (2010). Obviously, when studies find no impact of file-sharing on sound recording sales there is no need to discuss metrics, since all of the metrics will be zero.

This short list of papers with benign results may appear rather puzzling to those who have read the literature review in Oberholzer-Gee and Strumpf (2009), because Oberholzer-Gee and Strumpf provided a considerably longer list of studies with zero or positive impacts of file-sharing. For example, Oberholzer-Gee and Strumpf claim that "[w]hile the majority of papers reports some sales displacement, the four studies using actual measures of file sharing find that file sharing is unrelated to changes in sales" and the Andersen and Frenz study is not even included in this group. The studies that Oberholzer-Gee and Strumpf reference in this quote (in addition to their own 2007 article) are: Bhattacharjee et al., (2007), Tanaka (2004), and Smith and Telang (2008). The reader may ask why I am not including these three studies in the list of studies not finding harm from file-sharing. A few words are in order.

First, I did not include Bhattacharjee et al., (2007) because, contrary to the claims of Professors Oberholzer-Gee and Strumpf, that paper does not conclude that the impact of file-sharing on sales is benign. This is not just a case of my interpretation of the paper differing from their interpretation. Here

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[13] I do not consider the results found in the 2007 report of Andersen and Frenz (2007) to be plausible. This report estimated that each illicitly downloaded song increases sales by slightly less than half a unit (.44). If extrapolated to the economy, this estimate implies that if file-sharing did not exist, there would have been no sales of prerecorded music at all in Canada, a completely unbelievable notion. Further, this estimation was run for only those individuals in the sample who engaged in file-sharing. When the full sample, including both downloaders and non-downloaders was used, the result was that file-sharing hurt record sales by an amount about equal in size (but the opposite sign) to their favored result.

is what Dr. Bhattacharjee said when a reporter asked him whether Professor's Oberholzer-Gee and Strumpf properly characterized his paper:

> "It is not correct to say that our work shows file sharing is unrelated to changes in sales," said the Management Science paper's lead author, Sudip Bhattacharjee, in an e-mail message to The Chronicle. "The paper did not look directly at sales, only at chart longevity, also known as chart survival." And "we did report a decrease in survival over all" said Mr. Bhattacharjee… [Glenn 2010].

Second, I chose to exclude Tanaka (2004) from the list not because it is a working paper but because the paper is very clearly not a completed working paper. Tanaka lists the paper as version "0.1". His conclusion begins "This research is very preliminary because we have not yet tried sufficient instrumental variables." Since his main econometric technique is based on instrumental variables and he does not discuss the properties of the instruments that he uses, this appears to be a major problem. Finally, Dr. Tanaka has stated in correspondence that his paper will never be finished nor submitted to a journal whereas the two unpublished papers listed in Table 2 have both been completed and submitted to journals. I invite readers to examine Dr. Tanaka's paper and judge for themselves.

Finally, I leave Smith and Telang (2008) out of the current analysis because that paper attempts to measure the impact of file-sharing on video sales of older movies when they are rebroadcast on television. Because the literature that I examine in this paper is focused on audio, not video, and on the overall impact of file-sharing, not a partial impact on one non-current segment of the market, the Smith and Telang result, interesting though it might be, did not seem relevant.

Therefore, the only one of the four studies listed by Oberholzer-Gee and Strumpf as finding a benign impact of file-sharing while using actual measures of file-sharing, is Oberholzer-Gee and Strumpf (2007), a paper that I consider to be unreliable in many ways.[14] Oberholzer-Gee and Strumpf list one more

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[14] See Liebowitz (2007) and Liebowitz (2010) which seriously criticize the analysis and factual claims found in Oberholzer-Gee and Strumpf (2007). In my view Oberholzer-Gee and Strumpf (2009) paper has similar problems (besides those mentioned in the text). For example, they claim that concert revenue increases have more than made up for losses in sound recording sales (as of 2007), although this result is due to their excluding the impact of inflation (real record plus concert revenues fell 33% from 1999 to 2007) along with starting their time period in 1997, three years before file-sharing became important. They also sum the sales of iPods, concerts, and sound recordings, to putatively show a relatively large increase in revenues to the

paper, Gopal and Bhattacharjee (2006), as finding a positive impact of file-sharing on record sales but I believe they mischaracterize this paper's conclusions.[15] Thus, Oberholzer-Gee and Strumpf (2007) and Andersen and Frenz (2010) are, to my knowledge, the only two published articles that find a benign impact of file-sharing.

If the two papers that actually claim a zero impact of filesharing are included in the sample of studies when calculating average values of Metric 3, it is still the case that a majority of studies finds that the entire decline is due to file-sharing and the average value of Metric 3 is still a very high 89%.[16]

V. Conclusion

Although there have been numerous literature reviews discussing empirical estimates of the impact of file-sharing on sales of sound recordings, none have successfully compared the results on a consistent basis. I have endeavored to fill this lacuna by proposing a simple metric—the share of the sales decline that is explained by file sharing—and translating the empirical results of the literature into that metric. That translation allows a useful comparison of the many efforts to identify the effect of file sharing.

The results indicate that the majority of all studies support a conclusion that the entire decline in sound recording sales can be explained by file-sharing. Even those studies that do not find that file-sharing caused the complete decline usually find that it was responsible for a large share of the decline.

Because this type of comparison has not been previously made, I believe that there has not been a recognition that the literature points to such a strong result. I believe that many interested individuals, many researchers in the area, and even many members of the industry are likely to be surprised that a

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"industry" although iPod revenues do not accrue to the sound recording industry and are, in large part, likely to have replaced the sales of other audio equipment.

[15] Gopal and Bhattacharjee (2006) find that the act of 'sampling,' by itself, has a positive impact on sales but they do not claim that the impact of file-sharing, although it may contain a sampling component, is positive. This judgment is directly supported by their statement "This [positive sampling result] has major implications for the music industry, in that the industry can potentially reverse the effects of online audio piracy." This quotation makes it clear that Gopal and Bhattacharjee (2006) believe that piracy is likely to have an overall negative impact on the industry that might be overturned if the industry would try to encourage sampling in various venues (although one does have to read the paper fairly carefully to understand some of its conclusions).

[16] This value is calculated using the raw results found in the Appendix.

majority of econometric studies find that the entire decline in sound recording sales that has occurred is due to file-sharing.

Appendix: The Creation of Metric 3 for various studies

Below is the version of Table 2 that gives more information about the exact results from calculations of Metric 3. A brief description of the calculations for each paper then follows. I tried to contact each of the authors to make sure I understood and fairly represented their papers. I heard back from all but Peitz and Waelbroeck and Blackburn.

Published/Unpublished Studies	Share of Decline due to File-sharing	Metric Used	Time Frame	Geography
Hong (2007)	110%	1	1997-2002	U.S.
Hong (forthcoming)	20% - 40%	3	1997-2002	U.S.
Liebowitz (2006)	100%	3	2005	U.S.
Liebowitz (2008)	200%	3	1998-2003	U.S.
Michel (2006)	45%	1	2003	U.S.
Peitz and Waelbroeck (2004)	125%	1	1998-2002	World
Rob and Waldfogel (2006)	35% or 140%	1	2003/4	U.S.
Waldfogel (2010)	66%	2	2008/9	U.S.
Zentner (2005)	40%-160%	1	2002	World
Zentner (2006)	190%	1	2001	7 European
Blackburn (2004)	>115%	1	2003	U.S.
Zentner (2009)	58%-92%	3	1997-2008	World

Hong (2007): He looks at the impact of the Internet on several activities, including purchases of sound recordings. Col 2 of his Table 4 directly measures the percentage change in sound recordings due to the Internet, which he finds to be 26%. At that time (2002) U.S. sales units had fallen by 23%, as can be seen in Table 1 above. The leads to the ratio of 26/23.

Hong (forthcoming): This is discussed in footnotes 10 and 11. He adjusts his initial estimates to control for the possibly changing composition of the populations used in his difference-in-difference estimates. When he makes this adjustment he finds an overall decline of 40% due to file-sharing. He then tries to separate these results into subcategories of users/households and although the overall results do not change, the statistical significance for some subsets of the population does change and he sets the results from the insignificant groups to zero, lowering his overall result to 20%. As I explain in the footnotes, I do not believe that setting these values to zero is an appropriate action. He

then, as an additional test, mixes two inconsistent data sets and gets results similar to 20%.

Liebowitz (2006): The approach in this paper was to examine whether alternative hypotheses could explain any of the decline. He concluded that no alternative explanation held up very well with most being completely rejected by the data. New evidence has further confirmed this conclusion. Thus the entire decline is attributed to file-sharing.

Liebowitz (2008): Liebowitz discusses his results in terms of Metric 3 but only to indicate that more than the entire decline is due to file-sharing (or somewhat more precisely, that Internet activities that promote piracy, which may overstate the effect of organized file-sharing narrowly defined). In Table 1 overall album sales fell by .58 units. In Table 5, line 5, file-sharing is claimed to have led to a decline of 1.19 units. This works out to almost exactly 200% as the share of the decline that file-sharing was responsible for. Liebowitz calculated that the growth rate in sales implied by his results, in the counterfactual world without file-sharing, was 3.6%, which seemed reasonable given the historical growth of sales in the prior three decades.

Michel (2006): He uses U.S. data through 2003. He found a decline of 13% that he attributes to file-sharing although the cause is likely to be somewhat broader since he doesn't measure file-sharing per se. Unit sales had fallen by 28% at that time, leading to a value of 45% for Metric 3 (13/28).

Peitz and Waelbroeck (2004): They used data for 16 large markets from 1998 through 2002. They find a 20% decline in unit sales. Assuming that an average of the U.S. and non-U.S. (based on revenues) would mimic somewhat their sample of countries implies a decline in sales of 16%. This leads to a value for Metric 3 of 125% (20/16) although there is some uncertainty in this construction. Still, their estimate is almost certainly over 100% since the U.S. had an early and very high drop in units the first few years after Napster and its decline was just slightly greater than 20%, giving slightly under 100% as the low end estimate of Metric 3.

Rob and Waldfogel (2006): Although the text discusses their results in terms of Metric 2, they also present a result in terms of Metric 1 in which their OLS estimate translates to a 9% decline in sales in the 2003/2004 period (this can be found on their page 53 ("downloading reduced purchases by individuals in the sample by about 9 percent"). The average sales decline in those two years is about 26% so that Metric 3 is 35% (9/26). Their instrumental variable approach provides an estimate that is four times as large, which thus becomes

140%. They conservatively lead with their OLS result but always mention both, so I included both as well. Their results are based on a sample of students that is likely to overstate the impact of file-sharing.

Waldfogel 2010: He uses Metric 2 and finds that the share of each downloaded song that replaces a purchased song averages 27%. From his Table 2, the size of the illicit market is 6.7 relative to the legitimate market's 5.5, giving a ratio of 122%. Multiplying 27% by 122% indicates an overall decline due to file-sharing of 33%. The average 2008/2009 decline in the U.S. was about 50%, giving a Metric 3 value of 66%. His results are based on a sample of students that is likely to overstate the impact of file-sharing.

Zentner (2005): He uses 2002 IFPI world unit sales across countries. The average of the 6 coefficient in his Table 2 is 15.5. In 2002, according to Table 1, the worldwide decline in real revenue was about 16%. This gives a Metric 3 value of about 100%.

Zentner (2006): using 2001 survey data from 7 European countries, found that without file-sharing sales would have been 8% higher, or, in other words, that file-sharing appeared to decrease sound recording sales by roughly 7.4%. European unit sales were down by 3.8%, although there are more European countries than his seven. Nevertheless, the Metric 3 value is 195% (7.4/3.8).

Blackburn (2004): In his Table 7, a 40% reduction in file-sharing leads to a 17% increase in sales and a 50% reduction leads to a 26% increase. Since U.S. units sales had fallen by 23% in 2003 and a 100% decrease in file-sharing would have a larger impact than a 50% decrease, the implication is that Metric 3 would be considerably larger than 115%.

Zentner (2009): Since Zentner uses Metric 3 in his paper one merely needs to read his discussion surrounding his Table 3. The range he presents is 58% to 92%.

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