Reel Piracy: The Effect of Online Film Piracy on International Box Office Sales

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Abstract:

Hollywood films are generally released first in the United States and then later abroad, with some variation in lags across films and countries. With the growth in movie piracy since the appearance of BitTorrent in 2003, films have become available through illegal piracy immediately after release in the US, while they are not available for legal viewing abroad until their foreign premieres in each country. We make use of this variation in international release lags to ask whether longer lags – which facilitate more local pre-release piracy – depress theatrical box office receipts, particularly after the widespread adoption of BitTorrent. We find that longer release windows are associated with decreased box office returns, even after controlling for film and country fixed effects. This relationship is much stronger in contexts where piracy is more prevalent: after BitTorrent's adoption and in heavily-pirated genres. Our findings indicate that, as a lower bound, international box office returns in our sample were at least 7% lower than they would have been in the absence of pre-release piracy. By contrast, we do not see evidence of elevated sales displacement in US box office revenue following the adoption of BitTorrent, and we suggest that delayed legal availability of the content abroad may drive the losses to piracy.

Introduction

Intellectual property piracy is an issue of large and growing concern to the software, music, and movie industries. Recent years have seen both an explosion of piracy activity (both over the Internet and in traditional copying) and a related swell in research on piracy. To date, most of the empirical research on piracy has concerned music, largely because the music industry faced the piracy threat earlier. The comparatively small size of music files has made file sharing over the Internet an extremely effective means for unpaid music distribution.

While a typical song file is 4 megabytes – downloadable via broadband in 30-60 seconds – the most compressed high resolution movie files remain roughly 700 megabytes, making direct downloading much slower. The development of BitTorrent in 2003 made possible much faster file sharing of movies. By basing a user's allowable download speed on the amount he offered in uploads and by allowing the downloader to simultaneously obtain different parts of a single file from different sources, BitTorrent harnessed the power of individuals' unused upload bandwidth that had been unutilized in other networks (Cohen 2003). The technology caught on rapidly. By the end of 2004, BitTorrent, the most popular movie file sharing protocol, reportedly accounted for as much as 30% of all Internet traffic, with a very large portion of this dominated by video files (Cachelogic 2005). Indeed, the advent and subsequent adoption of BitTorrent is akin to an experiment for testing what happens when movies can be obtained via the Internet without payment. And in this paper we make use of this event to ascertain the effect on international box office revenue.[1]

The question of how free availability of intellectual property content affects paid demand is not as obvious as it may appear at first blush. Theory predicts that piracy may have a negative,

[1] Zentner (2010) makes use of a related "experiment," asking whether broadband adoption depresses movie revenue more after BitTorrent's adoption.

zero, or even positive effect on sales. Existing research on music piracy largely suggests that music piracy does displace music sales. However, a burgeoning literature on movie piracy finds a wide range of effects from no sales displacement to one-for-one displacement of sales by pirated downloads. Our goal is to help resolve this tension using market data and a unique identification strategy.

Like many other researchers, we face difficulty in observing illegal activity – unpaid movie consumption - directly. Our strategy in this paper is not to measure it but rather to measure its indirect determinant, based on the timing of movie releases across countries. A movie is typically available online within a week of its US release. We show that the degree of availability and the number of illegal downloads increases rapidly with time. A key feature of online supply is that it is international. Online supply available anywhere is equally available everywhere else.

In contrast to the ubiquitous unpaid supply, offline supply – in the theaters – is released at different times in different countries. Hollywood movies are typically first released in the US, then only later in France (say 4 weeks later), the UK (say 8 weeks later), and so on. By the time a movie typically arrives in Australian theaters, there is abundant online supply, and a large number of people have obtained the movie illegally online. The basic way we ask whether downloading reduces box office returns is to ask whether the time between the US release and a foreign release – which indirectly proxies the amount of unpaid consumption that has occurred before the foreign release – affects box office receipts in various foreign countries. Of course, time since US release can affect receipts for many reasons. Our basic measurement strategy makes use of the difference between the effect of the release lag before and after the adoption of BitTorrent, asking whether the lag since US release has a larger depressing effect on local box office receipts after the adoption of BitTorrent than before. We also use another approach based on the movie genres differing in their a priori tendency to be pirated, asking whether the increased effect of lag on, say, science fiction and action movies (which are the most heavily pirated) is greater after the adoption of BitTorrent than before.

We find that the longer the lag between the US release and the local foreign release, the lower the local foreign box office receipts. Importantly, this relationship is larger after widespread adoption of BitTorrent than before: a movie released 8 weeks after the US premiere has lower returns by about 22% in a given country in 2003-2004 but by nearly 40% in 2005-2006. In 2003-2004, the relationship between length of release lag and box office returns is no larger for science fiction and action movies than for others, but in 2005-2006, each week of lag decreases returns for science fiction and action movies by an additional 1.3% per week over any decrease for other genres. Using this 1.3% reduction per week as our estimate of the effect of pre-release piracy on box office sales, we estimate that international box office returns in our sample were at least 7% lower than they would have been in the absence of such piracy.

Our paper proceeds in 5 sections. Section I describes the industry and the process and timeline of movie piracy. Section II discusses theoretical predictions of the effect of piracy on the sale of media goods and then reviews the relevant empirical literature. Section III describes the data used in the study. Section IV details our empirical approach and offers model estimates. A brief discussion follows in Section V.

I. The Film Industry and Piracy

In 2004, the year after BitTorrent's release, studios grossed 45 billion US dollars worldwide, up from 32 billion in 2000 and 8.5 billion in 1980 (all in 2004 US dollars). The source of revenues has changed dramatically over time. Box office receipts accounted for over half of studio revenues in 1980 but only 17% of revenues in 2004. Hollywood movies are released in the box office and later on DVD. The time between box office release and DVD release is often termed the DVD release window. During this time, the films are typically released in box offices in only a few countries at first and then released in other countries on a staggered schedule anywhere from one or two weeks to fifteen or twenty weeks later.

Studios employ staggered release schedules for three major reasons. First, the cost of film prints is high (Silver and Alpert, 2003). Print costs per movie range from $750 to $1200 per print, with average duplication and delivery costs per movie making up 3.5% of the total cost to create and distribute a movie (Husak 2004). It is generally less costly to make a small number of prints to be reused around the world as the films premiere abroad. While the growth of digital cinemas (which do not require prints) will ultimately obviate this lag rationale, this is a more recent phenomenon, and by the end of our study in 2006, fewer than 1000 screens in the US and 100 international screens used digital technology.[2] Second, there is an abundance of movie theaters in the US but a scarcity abroad. Elberse and Eliashberg (2003) document that US releases can act as a filtering mechanism, allowing relatively scarcer foreign theaters to allocate their screens only to films that have proven successful in the US. Finally, industry executives have suggested that a large part of promoting films abroad involves the presence of the films' stars, which must naturally be staggered. Thus there is often a lag between the US release of a film and its release in other countries. During this time, pirates make copies available online.

Movie piracy predates Internet distribution. Stolen prints or bootleg recordings made in the theater were copied to forms of media such as VCD's or VHS tapes and then mass-

[2] Statistics collected from various reports at www.screendigest.com. We discuss digital cinema further in our conclusion.

distributed on the black market very inexpensively. But individuals who wanted to obtain pirated copies still had to leave their homes and pay a street vendor. Computers and the Internet decreased the cost of obtaining illegal copies. Increasing Internet access speeds and advances in movie compression algorithms removed some of the limitations to online film piracy, but it was not until the introduction of the BitTorrent protocol that movie piracy truly took off. BitTorrent technology made much more efficient use of free bandwidth, significantly decreasing the transfer times of movies. While a high quality version of a movie might once have taken days to download, BitTorrent allowed popular movies to be readily downloaded in just a few hours not long after (and sometimes before) their release in the theaters (Thompson 2005). Our empirical strategy presumes that longer lags reflect greater illegal availability and pirated consumption, and we can provide evidence for this assumption. Once someone makes the movie available digitally in one or a few locations, they have become the first "seeder" for a movie – someone who is offering a full copy. Employing the BitTorrent protocol, all users who are downloading a movie are also concurrently sharing/uploading whatever parts they have. When they have finished downloading, they by default become seeders of the full copy until they choose to close their BitTorrent application. The result is that Hollywood films are often available shortly before or after their worldwide premiere, and the number of people supplying the movie – as well as the number of times it has been downloaded – grows very rapidly.

We see this directly in case studies of two movies. Figure 1A shows the number of seeders and leechers over time of the popular film "Music and Lyrics" as tracked by torrentspy.com, one of the most widely used indexing sites. Figure 1B shows the same for another popular film "Bridge to Terabithia." The former premiered in the US box office on

February 14, 2007 while the latter premiered on February 16, 2007.[3] One week after their US premieres, each movie was available at over 1000 leechers/seeders, meaning that these films were readily available through BitTorrent and that at least 1000 people were currently supplying or downloading the films. As these case studies indicate, popular films are quickly available to consumers through BitTorrent. Both the ease of getting a pirated copy as well as the number of copies pirated grows over time.[4] This leads naturally to our question, whether this movie downloading from the Internet depresses box office sales.

II. Background: Theory and Relevant Literature

Theory does not give us an unambiguous prediction for how online piracy should affect ticket sales. Not all unpaid consumption displaces paid consumption. When an individual values a film below the ticket price, then if she downloads it, her downloading does not displace a legal viewing in the theater. Unpaid viewing simply creates consumer surplus in this case. On the other hand, when an individual's valuation of viewing the film exceeds the ticket price, then her downloading can displace a ticket sale. This transfers surplus from producers to consumers at a rate of one to one. In principle, piracy can also stimulate box office demand. Shapiro and Varian (1999) argue that free samples of information products can stimulate paid consumption, either by allowing potential consumers to determine their valuations of those products or by generating "buzz" around a product.

Research on piracy is inherently difficult because the behaviors in question are illegal or at least stigmatized. Empirical researchers have in general pursued one of three strategies. The

[3] Note that piracy for Bridge to Terabithia begins two days prior to its worldwide premiere – sometimes, high quality copies of films appear on piracy networks several days before their release.
[4] The fact that the number of leechers seems to level off and remain constant is a clear indicator that the number of pirated copies is growing because leechers either log off or become seeders once they have obtained a full copy.

first approach is to examine time series data at the geographic level, asking whether places and times with greater piracy (by some measure) have lower sales of the media in question. Zentner (2005) follows this approach to test the effect of music piracy on CD sales, instrumenting for piracy with measures of broadband penetration in each country since music piracy and sales might be positive correlated by general taste for music. Hui and Png (2002) also use international panel data and some indirect measures of piracy to study illegal music downloading. Peitz and Waelbroeck (2004) apply a first differences approach to country level data on music sales and the number of music downloaders across 16 countries. All three of these papers find some displacement of music purchases by illegal downloads. Liebowitz (2008) studies the relationship between piracy and music sales in 99 US designated market areas and finds that the entire decline witnessed in the music industry can be attributed to piracy. Finally, Smith and Telang (2010) study the effect of broadband penetration on DVD sales in a similar set of market areas. They find that broadband penetration increases sales but acknowledge that the positive effects of broadband such as at-home purchasing may mask any displacement caused by piracy.

A second strategy is to use individual-level survey data to ask whether persons who engage in more unpaid consumption engage in more or less paid consumption. Rob and Waldfogel (2004) conduct a survey of university students to determine whether students who pirate more music purchase it less. Zentner (2006) uses a similar approach with a cross-section of 15,000 Europeans from 2001. He instruments for piracy using levels of internet sophistication as well as connection speed. The previously mentioned Rob and Waldfogel (2007), Bai and Waldfogel (2010), and Bounie et al. (2006) studies on movie piracy also use individual surveys.

Finally, other researchers examine product-level data, asking whether products that are downloaded more are purchased more or less. Or the time-series analogue: when products are downloaded more, are they purchased less? In most cases, researchers require substantial ingenuity to develop measures of unpaid consumption activity. Oberholzer-Gee and Strumpf (2007) monitor an online service to develop product-specific measures of downloading activity over time. They use instruments such as file size or German school holidays in order to deal with the potential positive correlation due to unobserved heterogeneity, finding no displacement of music sales by piracy. Danaher et al. (2006) also use this approach to study piracy levels of 75 different television series before and after they were removed from Apple's iTunes store, causing a shock to the legal supply of these series. They find that lack of legal availability drives growth in piracy. Our study falls into the third category.

There is an emerging consensus in the literature on music piracy that unpaid consumption depresses paid consumption, although the rate of sales displacement is far less than one-for-one. There is, as yet, no consensus on the effects of file sharing on movies. At one extreme, Rob and Waldfogel (2007) find roughly one-for-one sales displacement but a low rate of unpaid movie consumption among students at a US university. But other studies find a wide range of estimates: Bounie et al. (2006) find that piracy has a strong negative impact on DVD purchases among a sample of French students but no effect on theater attendance. Bai and Waldfogel (2010) find no evidence of sales displacement among a sample of Chinese consumers. Using data on revenue, Smith and Telang (2010) find that cable broadcasts of movies stimulate DVD sales, but that the availability of those films through piracy channels (or lack thereof) does not moderate this effect. De Vany and Walls (2007) find large losses for one blockbuster film in the US box office attributable to piracy. Using a panel of countries, Zentner (2010) finds that the spread of broadband has depressing effects on video sales but not theatrical box office following BitTorrent. The effect of piracy on movie revenue remains unsettled.

III. Data

The data used in this study consist of the weekend box office returns for the top 10 movies each weekend in each of 17 countries during the years surrounding the adoption of BitTorrent - July 2003 to July 2006.[5] Only Hollywood movies are included – observations for foreign films are dropped in order to ensure that the worldwide premieres of all films in our data occur in the US. This leaves 678 films in our data and 19,518 movie-by-weekend-by-country revenue observations. The dataset contains the studio distributing each film, the genres associated with each film, and the total box office returns each film earned. We also observe the foreign release dates of the films, allowing us to code the amount of time between the world premiere and a specific country's premiere, or the length of the movie's "release lag" in that country. The US box office data were collected from the Internet site Boxofficemojo.com while the international data were collected from ScreenDaily.com. These sites, in turn, have acquired their data over the years from various news sources or studio consortiums in each of the countries studied.[6] Finally, movie genres were found on IMDB.com, the Internet Movie Database.

Table 1 presents descriptive statistics for the data. In the US, the average film lasts 3.6 weeks in the box office until its returns are low enough to drop out of our dataset. Hollywood films are nearly always released first in the US. Some countries – the UK, Switzerland, and

[5] Given skewed distribution of returns, the top 10 movies in any weekend account for the vast majority of revenue. For example, boxofficemojo.com shows that for the weekend of August 12-14, 2001, the top 10 movies accounted for 87% of total box office returns.

[6] For more information, see the websites in question. Looking up the weekend box office returns in any country also returns, at the bottom of the chart, the source of the data for that country.

Australia – receive US movies relatively soon after US release, with median lags of 4-5 weeks. Others – such as Denmark, Finland, Italy, Poland, and Turkey – wait longer, with median lags of 8 weeks or more. Hollywood films clearly have the highest total weekend box office returns in the US, with the mean film grossing \$53 million. Sample films experience an average of \$46 million in revenue across the rest of the countries in our data, reflecting the well-known importance of the international box office.

IV. Empirical Strategy and Results

One clear feature of box office revenue is its concentration in early weeks of a film's release. A regression of log revenues on film and country fixed effects and dummies for weeks since release (excluding the opening week) shows sharply declining revenue in the weeks elapsed since release. See column (i) in table 2. Second-week revenues average 28% below opening week revenues, third-week revenues average 52% below, and so on. By the ninth and tenth weeks, revenues average 90% below opening week.

Our basic empirical strategy asks whether this return profile is shifted lower by factors reflecting heightened levels of piracy. We estimate a model showing the relationship between the box office returns for a given movie in a given country and the amount of time between the premiere of that movie in the given country and its US/world premiere.

$$LW_{ijt} = \beta_0 + \beta_1^{\tau} EW_{ij\tau} + \beta_2 WLAG_{ij} + X_{ijt}\phi + \mu_i + \nu_j + \varepsilon_{ijt}$$

where LW_{ijt} represents the log of box office returns for film i in country j at time (weekend) t. $EW_{ij\tau}$ is a dummy indicating that this movie was released τ weeks ago in country j, $WLAG_{ij}$ is the lag measured in weeks between country j's premiere and the US premiere for movie i, X_{ijt} includes any other film, country, or time controls which may affect box office performance (for example, season), μ_i is a film-specific fixed effect, ν_j is a country-specific fixed effect, and ε_{ijt} is an idiosyncratic week-movie-country shock. Note that we also include year dummies in these regressions to allow for a flexible overall time pattern in box office revenue.

While it is tempting to interpret the coefficient on WLAG as an effect of piracy, it is important to realize that returns might be lower for movies appearing later in foreign countries for reasons unrelated to piracy. For example, distributors might bring movies first to the countries where the movies are expected to earn greater returns. Hence, we don't interpret the coefficient on WLAG as direct evidence of the effect of piracy.

Bearing this in mind, columns (ii) and (iii) in Table 2 report regressions of log box office returns on dummies for weeks elapsed since release, film, country, and year fixed effects, and measures of the time elapsed between country release and US release. Column (ii) includes a direct measure of the release lag. The coefficient is -0.023 and statistically significant, indicating that movies released with an additional week of lag earn 2.3% less. In column (iii), we include flexible dummies for each week of the release lag as the association may not be linear. The results indicate that a film released in a country one week after US release experience 12 percent lower returns, while films released abroad 10 weeks after US release experiences 52 percent lower box office revenue than films released simultaneously in the US and abroad.[7] We cluster standard errors at the movie-country level, as revenue realizations are not independent across weeks for a movie's release in a particular country.

Our test for whether online piracy cannibalizes box office returns proceeds by asking whether the lag coefficients are more negative in contexts where online piracy is more prevalent.

[7] We explored month dummies to control for seasonality. While many were significant at the 5% level, they did not materially affect the other coefficients. In our analysis, we dropped all observations where elapsed weeks were greater than 10, but the results are robust to other specifications, such as increasing the maximum elapsed weeks to 15 or dropping all observations where WLAG is greater than 10 or 20.

We have two strategies along these lines. First, we ask whether the coefficient changes following the widespread adoption of BitTorrent. If so, the coefficient on WLAG should be more negative following 2004. We estimate the following equation:

$$LW_{ijt} = \beta_0 + \beta_1^{\tau} EW_{ij\tau} + \beta_2 WLAG_{ij} + \beta_3 WLAG_{ij} * z_t + X_{ijt}\phi + \mu_i + \nu_j + \varepsilon_{ijt}$$

This model is the same as before except that in this case, z_t is simply a dummy variable that is 1 for 2005-06 and 0 earlier. The coefficient of interest in this case is β_3, indicating whether the negative association between release window length and box office returns is different following 2004.[8]

Columns (i) and (ii) of Table 3 report estimates along with their standard errors. Column (i) reports a linear specification; the WLAG coefficient increases from 0.020 for the earlier period to 0.031 for the later period, and this increase is statistically significant. Column (ii) reports the full release lag dummies interacted with the later period dummy. For movies premiering from 2003-2004, movies with one week of release lag have 3% lower returns; in the later period, movies with one week of release lag have almost 20% lower returns, and the difference between these is statistically significant. While the differentials for two, four, and five and nine weeks are statistically indistinguishable from zero, all other differentials are negative and significant. For movies with release lags of 7 weeks or more, returns are 10-20% lower in the later period.[9] The coefficients on the interactions between the WLAG dummies and the post dummy are jointly significant at the 99% confidence level (p-value from Wald test = 0.007).

[8] We also tried allowing the other covariates (such as the country fixed effects and the elapsed week dummies) to vary by period (early and later) by interacting them with the later period dummy. While some of these interactions were statistically significant, this had no impact on the coefficients of interest in this model.
[9] We examined a more flexible specification in which we interacted the WLAG variable with a dummy for each of the years. This revealed that the coefficient on WLAG was only slightly more negative for 2005 than for 2004 (and the difference is statistically insignificant). The difference is driven largely by 2006, in which the WLAG coefficient is significantly more negative than for 2003, 2004, and 2005.

Our second strategy is to add a second difference; that is, to examine movie genres that are more likely to be pirated. We can appeal to some evidence on the relative prevalence of piracy in different movie genres that points to action and science fiction as the more heavily pirated genres. First, the MPAA reports that 16-24 year old males are the demographic group most heavily involved in downloading (MPAA 2005). Second, action and science fiction movies appear to be over-represented in online pirate supply. Of the top 20 grossing US films for the weekend of May 18-20, 2007, seven, or 35%, were classified as science fiction or action; however, online complete copies of these seven movies accounted for 61% of the complete copies of all 20 movies available illegally on the Internet. Related, Danaher et al. (2010) document with actual piracy data that piracy of science fiction television programs is more popular than other genres such as drama.

This allows us to include another difference in our approach: if piracy displaces box office returns, then the difference between the returns-reduction for highly downloaded types and less downloaded types should be larger in the later period than the earlier. We estimate the following model III[10]:

$$LW_{ijt} = \beta_0 + \beta_1^{\tau} EW_{ij\tau} + \beta_2 WLAG_{ij} + \beta_3 WLAG_{ij} * SFA_i + \beta_4 WLAG_{ij} * z_t + \beta_5 WLAG_{ij} * SFA_i * z_t + X_{ijt}\phi + \mu_i + \nu_j + \varepsilon_{ijt}$$

In this model, β_3 represents the degree to which the release lag is associated with a penalty in the earlier period that is greater for science fiction and action movies than for other types of movies. The coefficient β_5 reflects the additional penalty of lag to returns for science fiction and

[10] Typically when including a three-way interaction, all of the main effects for each variable as well as each pair-wise combination of the variables should be included. However, because we include movie fixed effects in our model, we cannot include a main effect for sci-fi/action, a main effect for later period movies, or an interaction term between sci-fi/action and the later period. Each of these would be subsumed by film fixed effects.

action movies (over other types) in the later period, over and above the earlier period. We expect β_5 to be negative if piracy is cannibalizing box office sales.

Column (iii) of Table 3 presents an estimate of model III. The coefficient on "Weeks lag" indicates that in the earlier period for non-sci-fi/action movies, each week of lag is associated with a 1.2% decrease in returns.[11] The interaction between weeks lag and later period indicates that for movies which are not sci-fi/action, each week of lag reduces a film's returns by an additional 0.7% in the later period than in the earlier (for a total of 1.9% per week of lag). This is expected because while science fiction and action movies are the most highly downloaded type, all genres experience some piracy, and this increases over time as BitTorrent is more widely adopted. The interaction between weeks lag and the sci-fi/action variable shows that in the earlier period, when piracy is less prevalent, the returns reduction for sci-fi/action movies is no greater than for other types. Finally, the interaction between weeks lag, later period, and sci-fi/action indicates that in the later period, the revenue to sci-fi/action movies over and above the revenue for other movies is an additional -1.3% per week of lag. In other words, in the earlier period, each week of lag is associated with a 1.2% decrease in returns for all movies, science fiction or otherwise. But in the later period, each week of lag is associated with a 1.9% decrease in returns for non-sci-fi/action movies but a 3.2% decrease for sci-fi/action films.

Thus, when piracy is difficult or costly, lagging the release of a romance film is no better or worse than lagging the release of a film like *The Matrix*. But when piracy becomes easy, lagging the release of *The Matrix* hurts returns more than lagging the release of a romance film. This result, a triple-difference, lends credibility to the idea that a larger coefficient on WLAG following BitTorrent's widespread adoption reflects the effect of piracy.

[11] We use a linear specification here for ease of interpreting the triple difference. We obtain similar results with a more flexible specification.

It is important to note that any evidence we have pointing to an effect of piracy on box office revenues is for countries other than the US, since release lag in the US is always zero. In fact, our coefficients would only indicate piracy in foreign countries *over and above* any piracy occurring in the US. This is because the model essentially takes the returns for a movie in the fourth week in, say, Germany and compares it to the returns for that movie in its fourth week in the US. Controlling for the country and film fixed effects, it correlates the difference in those returns with the length of the release lag for Germany. But piracy may already have depressed sales in the US by the fourth week, and we would not observe the "no piracy in the US" counterfactual. Thus, our results may be underestimates of the total effect of piracy on film returns – they measure only the effect of foreign piracy over and above the effect of US piracy. Our data do not provide a clear "experiment" to determine the effect of piracy on US box office sales, but they can shed some light on this relationship.

We have already acknowledged the fact that movies experience declining returns in each country following their local premiere. In the US, piracy could only exacerbate this phenomenon, as in each successive week the movie has been available illegally online for a longer period. We can exploit the longitudinal nature of the data in the same way as before but for the US only. If piracy displaces US sales then the post-premiere decline in US box office returns for movies should be getting steeper as piracy becomes more widespread. We estimate the following model for US observations only:

$$LW_{it} = \beta_0 + \beta_1^{\tau} EW_{i\tau} + \beta_2^{\tau} EW_{i\tau} * z_t + \mu_i + \varepsilon_{ijt}$$

where z_t is a dummy variable indicating whether the movie was released after 2004. If β_2 is negative and significant, then the decline in returns occurs more rapidly after the adoption of BitTorrent.

In columns (i) and (ii) of Table 4 we present OLS estimates for this model. Column (i) includes elapsed weeks and the square of elapsed weeks to allow for a non-linear decay rate; it also interacts these with the later period dummy. Column (ii) includes a full set of dummies for number of elapsed weeks since release and interacts these dummies with the later period dummy. While both specifications show evidence that the returns profile for movies in the US box office is getting steeper over time, these results are statistically insignificant and economically very small. For example, the largest shift we observe is for the fourth week. In 2003-2004 fourth week returns are 77.5% lower than the first week and in 2005-2006 fourth week returns are 79.3% lower – this difference is not statistically significant. If piracy displaced box office sales in the US, we would have expected the slope of the returns profile to shift more significantly as BitTorrent became more widely adopted. In column (i), we cannot reject with 90% or 95% confidence the null hypothesis that the coefficients on "weeks since release * later period" and "(weeks since release)^2 * later period" are jointly equal to zero (the p-value of the Wald test is 0.44). In column (ii) we cannot reject the null that the coefficients on all interactions between the elapsed week dummies and the later period dummy are jointly equal to zero (p-value of 0.90).

We can also add another layer of difference, asking if the returns profile for science fiction and action movies has shifted more than the returns profile for other movie types. We do so by estimating the following model for US observations only:

$$LW_{it} = \beta_0 + \beta_1^{\tau} EW_{i\tau} + \beta_2^{\tau} EW_{i\tau} * SFA_i + \beta_3^{\tau} EW_{i\tau} * z_t + \beta_4^{\tau} EW_{i\tau} * SFA_i * z_t + \mu_i + \varepsilon_{ijt}$$

SFA_i is a dummy variable equal to one if a movie is classified as science fiction or action. If β_4 is found to be negative, then the returns profile for more highly pirated movie genres has shifted more after BitTorrent's adoption than the profile for less downloaded genres. Column (iii) of

Table 4 displays the OLS estimates. While science-fiction and action movies do appear to have a steeper returns profile than other genres, it is no steeper in the later period than the earlier as indicated by the statistically and economically insignificant coefficients on the triple difference terms. We cannot reject the null that the coefficients for “weeks since release * Sci-Fi/Action * later period” and “(weeks since release)^2 * Sci-Fi/Action * later period” are jointly zero (p-value 0.79). Thus, the returns profile has changed very little over time for both less pirated and more pirated genres.

In short, we do not see much evidence that piracy displaces US box office sales in our data, although this result should be taken cautiously as the “experiment” for examining US piracy is less clean than that for international piracy. However, one possible explanation for the discrepancy between our international results and our US results is availability. In the weeks after the US release, it is true that the number of pirated downloads worldwide is increasing. Importantly, the movie is available to US consumers in the theater at this time but not to consumers abroad. Thus, it is possible that consumers in the US who would choose between the box office and piracy choose the box office (and the remaining US pirates had valuations lower than the ticket price) but that international consumers who would consider both options choose piracy due to a lack of legal availability. This explanation is consistent with evidence in Danaher et al. (2010) that the presence or lack of legal channels in which to purchase television content strongly affects the level of piracy of that content. It is also consistent with the Smith and Telang (2010) finding that piracy does not displace DVD sales, as they study movies during the portion of their lifecycle when they are legally available through many physical and digital channels.

V. Discussion and Conclusion

The theoretical literature on piracy yields ambiguous predictions, and empirical studies as yet have not reached a consensus on whether piracy depresses movie revenue. Noting that pirate supply and consumption through piracy grows in the time following US release, we use the 2003 appearance of BitTorrent to ask whether longer release lags give rise to more depressed international box office sales for Hollywood movies. We find that the relationship between release lag and box office returns grows more negative following 2004. Following 2004, an additional week of release lag depresses box office by 1.1% more than in 2003-2004. Moreover, this effect is heightened for movies in genres more likely to be pirated. For science fiction and action movies, the penalty to returns is 2% higher for each week of lag in 2005-2006 than in 2003-2004, but for other genres, it is only 0.7% higher in the later period than in the earlier. Taking this triple-difference as a conservative estimate of the effect of piracy on box office sales, we infer that pre-release piracy causes the foreign box office returns for a movie to decrease by 1.3% for each week of lag between the U.S. release and the foreign release of the movie.

In 2005, we observe that the total weekend box office returns for all movies in each of the 16 non-US countries in our data were $3.28 billion.[12] If we consider each movie-country observation, we can observe the total weekend returns for that movie in that country as well as the length of that movie's release lag in that country. Assuming each week of lag causes a 1.3% reduction in returns due to piracy, we can impute the counterfactual of what that movie would have returned in that country if not for pre-release piracy. We estimate that movies in our data would have returned a total of nearly $3.52 billion if not for piracy, implying that piracy caused films to lose $240 million in weekend box office returns in the non-US countries in our data

[12] In 2005 the MPAA estimated that total international box office returns were $14.3 billion (MPAA 2010). We observe only a fraction of this in our sample for three reasons: first, we observe only weekend returns, not the entire week. Second, we observe only 16 non-US countries (for example, we do not observe China or Russia). Third, we only observe the top ten movies each weekend in each country.

during 2005. Thus we estimate that weekend box office returns in our data were about 7% lower than they would have been in the absence of pre-release piracy. This estimate may be conservative if the actual losses to piracy are greater than those suggested by our triple-difference estimate or if returns in the US box office are also reduced by piracy.

Our findings are potentially important to policymakers choosing policies to combat piracy. Several countries have recently implemented strong legal policies against Internet piracy, such as the graduated response laws in France (HADOPI) and South Korea. These laws are highly controversial, and similar laws have been considered in the US and England. As a first step, policy makers need to know whether piracy is depressing sales, and our results suggest that piracy depresses international box office.

Our finding that the cost of delaying a film's foreign release is increasing has a strategic implication for the movie industry. Studios already appear to be reacting to the increasing threat of piracy: while the average release window was 10.5 weeks in 2004, it had shrunk to 7.5 weeks in 2006. By 2007 the average release window was 6 weeks, and more recently in 2010 the average release window was down to 4 weeks. The rapid growth of digital cinemas in the last 2-3 years has significantly decreased the cost associated with worldwide simultaneous release. Studios should continue to reduce the length of the release lag, particularly for genres that are more heavily pirated such as science fiction and action films.

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Figure 1A: BitTorrent Piracy of "Music and Lyrics" in 2007

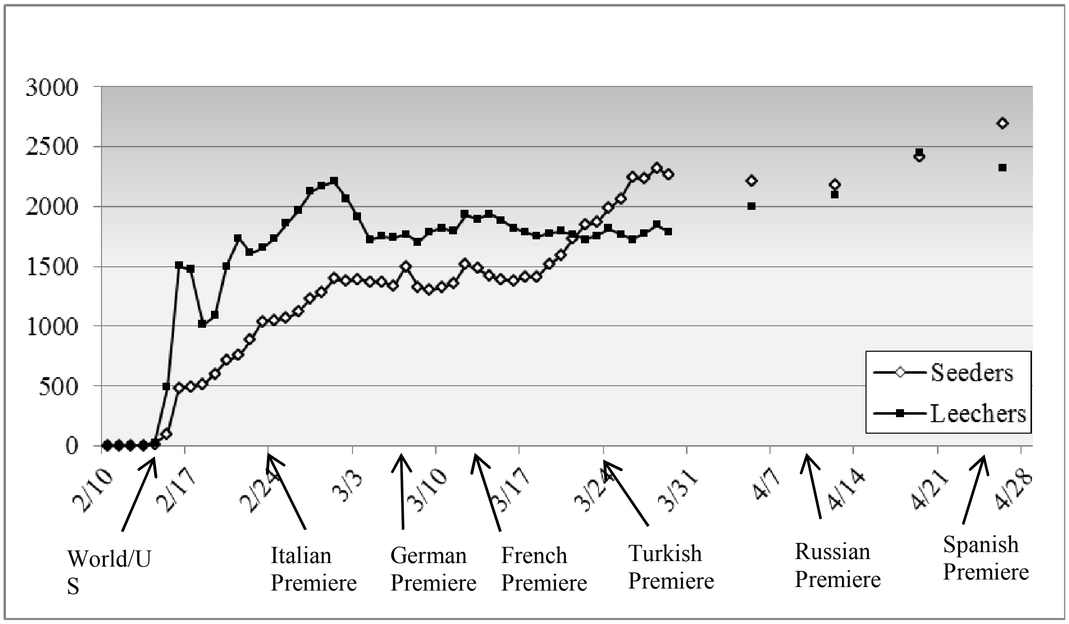

Figure 1B: BitTorrent Piracy of "Bridge to Terabithia" in 2007

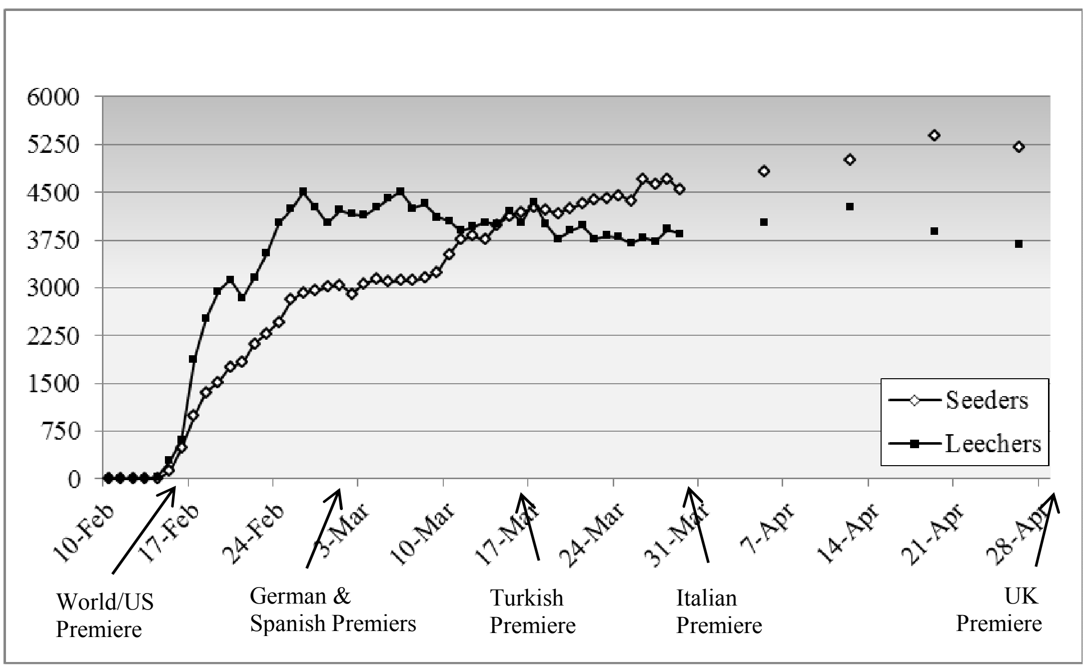

Table 1 – Descriptive Statistics

Country	Number of weekend observations per film		Length of release window		Total weekend box office returns per film (000's)	
	mean	*median*	*mean*	*median*	*mean*	*median*
Argentina	4.2	4	10.3	7	$672	$320
Australia	4.1	4	7.3	5	$4,200	$2,498
Denmark	4.4	4	8.8	8	$1,044	$435
Finland	5.1	4	8.9	8	$513	$222
France	3.2	3	9.2	7	$7,309	$3,439
Germany	3.7	3	9.0	6	$7,137	$2,806
Hong Kong	3.0	3	8.3	6	$774	$305
Iceland	3.7	3	8.2	6	$97	$58
Italy	3.4	3	11.6	8.5	$4,183	$2,085
New Zealand	4.0	4	8.4	6	$793	$384
Norway	4.7	4	8.9	7	$998	$388
Poland	4.2	3	10.8	8	$876	$339
Spain	3.5	3	10.0	7	$4,836	$2,898
Switzerland	4.7	4	6.6	4	$1,403	$742
Turkey	3.8	3	13.7	9	$736	$390
UK-Ireland	3.8	3	6.9	4	$10,700	$5,444
US	3.6	3	0.8	0	$53,200	$34,800
All Countries	3.9	3	8.4	6	$7,260	$917

Table 2 – Weekend Box Office Returns and the Release Window

Dependent variable is log(weekend box office)

	(i)	(ii)	(iii)
2nd week in theater	-0.333*	-0.342*	-0.341*
	(0.009)	(0.009)	(0.009)
3rd week in theater	-0.731*	-0.754*	-0.750*
	(0.012)	(0.012)	(0.012)
4th week in theater	-1.101*	-1.134*	-1.128*
	(0.015)	(0.015)	(0.015)
5th week in theater	-1.425*	-1.470*	-1.463*
	(0.019)	(0.019)	(0.019)
6th week in theater	-1.723*	-1.778*	-1.772*
	(0.024)	(0.024)	(0.024)
7th week in theater	-1.965*	-2.032*	-2.027*
	(0.032)	(0.032)	(0.032)
8th week in theater	-2.121*	-2.204*	-2.195*
	(0.039)	(0.039)	(0.039)
9th week in theater	-2.241*	-2.333*	-2.327*
	(0.052)	(0.052)	(0.052)
10 weeks in theater	-2.343*	-2.433*	-2.429*
	(0.063)	(0.063)	(0.063)
Release lag in weeks		-0.023*	
		(0.002)	
1 week lag			-0.122*
			(0.035)
2 weeks lag			-0.122*
			(0.037)
3 weeks lag			-0.164*
			(0.040)
5 weeks lag			-0.242*
			(0.045)
5 weeks lag			-0.214*
			(0.043)
6 weeks lag			-0.322*
			(0.043)
7 weeks lag			-0.299*
			(0.047)
8 weeks lag			-0.422*
			(0.043)
9 weeks lag			-0.387*
			(0.055)
10+ weeks lag			-0.524*
			(0.037)
Constant	11.748*	11.480*	11.738*
	(0.068)	(0.066)	(0.070)
Observations	19137	19137	19137
# of films	678	678	678
R-squared	0.903	0.907	0.907

Robust standard errors in parentheses, clustered at film-country level
+ significant at 10%; ** significant at 5%; * significant at 1%
Country, film, and year fixed effects are included

Table 3 – Differential Impact of Release Window Legnth
Dependent variable is log(weekend box office)

	(i)	(ii)	(iii)
Release lag in weeks	-0.020*		-0.012*
	(0.002)		(0.002)
Weeks lag * later period	-0.011*		-0.007**
	(0.003)		(0.003)
Weeks lag * Sci-Fi/Action			0.001
			(0.004)
Weeks lag * later period * Sci-Fi/Action			-0.013**
			(0.006)
1 week lag		-0.029	
		(0.051)	
2 weeks lag		-0.123**	
		(0.054)	
3 weeks lag		-0.06	
		(0.054)	
5 weeks lag		-0.184*	
		(0.064)	
5 weeks lag		-0.205*	
		(0.060)	
6 weeks lag		-0.232*	
		(0.059)	
7 weeks lag		-0.132**	
		(0.066)	
8 weeks lag		-0.252*	
		(0.053)	
9 weeks lag		-0.270*	
		(0.062)	
10+ weeks lag		-0.341*	
		(0.045)	
1 week lag * later period		-0.165**	
		(0.066)	
2 weeks lag * later period		0.04	
		(0.068)	
3 weeks lag * later period		-0.138+	
		(0.071)	
4 weeks lag * later period		-0.044	
		(0.084)	
5 weeks lag * later period		0.077	
		(0.076)	
6 weeks lag * later period		-0.079**	
		(0.035)	
7 weeks lag * later period		-0.219*	
		(0.084)	
8 weeks lag * later period		-0.242*	
		(0.080)	
9 weeks lag * later period		-0.107	
		(0.102)	
10+ weeks lag * later period		-0.143*	
		(0.055)	
Constant	11.540*	12.167*	12.079*
	(0.068)	(0.041)	(0.038)
Observations	19137	19137	19137
# of Films	678	678	678
R-squared	0.902	0.906	0.906

Robust standard errors in parentheses, clustered at film-country level
+ significant at 10%; ** significant at 5%; * significant at 1%
Country and film fixed effects are included

Table 4 – Change in US Returns Profile

Dependent variable is log(weekend box office)

	(i)	(ii)	(iii)
Weeks since release	-0.649*		-0.571*
	(0.023)		(0.027)
(Weeks since release)^2	0.030*		0.025*
	(0.003)		(0.003)
Weeks since release * later period	-0.028		-0.04
	(0.033)		(0.038)
(Weeks since release)^2 * later period	0.002		0.003
	(0.004)		(0.005)
Weeks since release * Sci-Fi/Action			-0.231*
			(0.047)
(Weeks since release)^2 * Sci-Fi/Action			0.016*
			(0.006)
Weeks since release * later period * Sci-Fi/Action			0.046
			(0.068)
(Weeks since release)^2 * later period * Sci-Fi/Action			-0.006
			(0.009)
2nd week in theater		-0.558*	
		(0.034)	
3rd week in theater		-1.060*	
		(0.037)	
4th week in theater		-1.497*	
		(0.042)	
5th week in theater		-1.849*	
		(0.050)	
6th week in theater		-2.222*	
		(0.064)	
7th week in theater		-2.408*	
		(0.084)	
8th week in theater		-2.555*	
		(0.113)	
9th week in theater		-2.700*	
		(0.190)	
10th week in theater		-2.974*	
		(0.190)	
2nd week in theater * later period		-0.013	
		(0.046)	
3rd week in theater * later period		-0.001	
		(0.051)	
4th week in theater * later period		-0.081	
		(0.058)	
5th week in theater * later period		-0.095	
		(0.072)	
6th week in theater * later period		-0.044	
		(0.090)	
7th week in theater * later period		0.002	
		(0.119)	
8th week in theater * later period		-0.05	
		(0.159)	
9th week in theater * later period		-0.168	
		(0.234)	
10th week in theater * later period		-0.202	
		(0.376)	
Constant	17.328*	16.693*	17.322*
	(0.027)	(0.016)	(0.026)
Observations	1477	1477	1477
R-squared	0.903	0.903	0.912

+ significant at 10%; ** significant at 5%; * significant at 1%

U.S. observations only. Film fixed effects included.