Association for Information Systems
AIS Electronic Library (AISeL)

ICIS 2007 Proceedings

International Conference on Information Systems (ICIS)

December 2007

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ANALYSIS OF THE IMPACT OF MOVIE BROADCASTS ON DVD SALES AND INTERNET PIRACY

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Abstract

Movie studios have long believed that home video recording damages the market for movies broadcast on free television. This issue has gained renewed importance with the advent of high-definition television, causing movie studios to argue that consumer recording of digital video will result in increased piracy and reduced DVD demand.

In contrast, we find that the dominant impact of movie broadcasts is to stimulate DVD sales by an average of 120% in the week after broadcast. Moreover, this increase in sales appears to derive from the broadcst itself, as opposed to pre-broadcast advertising. However, we also find that movie broadcasts stimulate piracy by between 20-60% in the week after broadcast. Our research highlights both the opportunities and threats facing studios in a digital age.

Keywords: Information goods, Movie broadcasts, Movie promotion, DVD Sales, Broadcast flag.

Introduction

Since the advent of the first VCR, movie studios have believed that the ability of consumers to freely record television broadcasts will significantly harm the marketability of movies that are broadcast on television. The argument is intuitive. Once a consumer is able to make a copy of a movie shown on television, why would they ever consider purchasing a copy of that movie in a similar format?

This concern has gained renewed interest recently with the development of high definition digital television (DTV), which will advance the integration between the television and the computer. Today, DTV conversion devices for computers can be purchased for around $100, and some analysts estimate that 300,000 to 500,000 such cards were in use in computers in 2003 (Godwin et al. 2003).[1]

[1] The industry may also be concerned about the increased penetration of Digital Video Recorders (DVRs), which are more consumer friendly and allow higher quality copies than were possible with analog VCR tapes. Pasztor (2006) quotes from an industry report that estimates DVR penetration of 10% for cable systems and 28% for satellite systems, with estimates of 50% penetration on both systems by 2010.

Thus, while in the analog world of the VCR, consumers could make an imperfect, low resolution copy of the movie, while HDTV allows consumers to make a perfect high resolution digital copy of the movie. Using analog technology it was very difficult for consumers to edit commercials out of their recordings, while the integration between digital video recorders and computers makes it trivially easy for consumers to edit commercials out of their recorded movie broadcasts. Finally, while analog copies of movies were hard to duplicate and share, digital copies of movies can be easily copied and shared, raising the specter of rampant piracy of movies shown on television.

This is not an idle concern for movie studios where media sales, primarily DVDs, made up 46% ($14.9 billion) their total revenue in 2002 (Epstein 2005, p. 20; see also PBS 2005), a little over twice that of theater revenue.[2] Moreover, the studio margins on DVD sales are higher than their margins in many of their other lines of business. Studios only pay 20% of DVD revenues to the various artist and production unions, keeping the remaining 80% for themselves. This "sweetheart deal" was the result of savvy negotiating on the part of the studios early in the development of the DVD standard. Indeed the DVD standard emerged as an enormous boon to the movie industry. For example, Time Warner's library of movies appreciated by $7 billion between the time the DVD was introduced in 1996 to 2004 (Epstein 2005). With this in mind, studios are also concerned about protecting future revenue streams from next generation high definition video player standards such as the Blu Ray and HD-DVD formats, and from emerging digital download services, such as CinemaNow and Apple's iTunes video store.

In raising these concerns, some studio executives have gone so far as to argue that unless copy protection technology is included in over-the-air DTV standards, it will no longer be profitable for them to show their movies on (unprotected) over-the-air network broadcasts. That instead, they will choose to broadcast their content only on cable channels, which currently have basic copy protection for digital television content. For example, in comments before the Federal Communication Commission, Viacom, the parent company to CBS, made the following observation:

> "*Viacom believes that [Digital Television] sales and broadband subscriptions have reached the 'tipping point' at which it can no longer afford to expose its content to piracy. A broadcast flag regime is needed now to protect the value of our important assets or we must withhold our quality HD digital content.*"
>
> Viacom comments before the Federal Communications Commission in the matter of Digital Broadcast Copy Protection, December 6, 2002. (Lucey 2002, page 8)

Similar statements were able made by Disney/ABC (Fox 2002) and NBC (LeBeau 2002). The crux of this argument is that when movies are broadcast in DTV format, it will inevitably lead to increased piracy of these movies through Internet file sharing networks, which in turn, will lead to reduced sales of movies in retail channels — a serious concern for an industry where DVD sales made up 46% ($14.9 billion) of total revenue in 2002 (Epstein 2005, p. 20; PBS 2005).[3] Essentially, the studios are arguing that they can't compete with free copies of movies made available through over-the-air broadcasts and potentially through pirate networks.

However, in spite of these arguments, we believe that it is striking that nowhere does the public record contain any empirical evidence of whether movie broadcasts in general and DTV in particular actually stimulate piracy or reduce DVD sales in a way that might cause the movie studios to find it more profitable to show their content on cable systems versus over-the-air broadcasts.

With this in mind, the goal of this research is to analyze two main empirical questions. First, what impact do movie broadcasts have on DVD sales? And second, what impact do movie broadcasts have on the supply of and demand for pirated copies of movies? These empirical questions are important because they parallel the arguments of the movie studios in advocating the broadcast flag. They also shed light on the incentives of the movie studios to broadcast their content in over-the-air versus cable venues. Finally, they shed light on the impact of movie broadcasts on the subsequent market for movies purchased on DVDs — which is one of four factors used in U.S. copyright law in determining whether a particular consumer use of copyrighted material should be considered an allowable "fair use."

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[2] Free and Pay TV made up an additional 8% and 28% respectively as studios receive between $3-15 million when movies are licensed to play on broadcast or cable channels.

[3] Moreover, the studios' margins on DVD sales are higher than their margins in most of their other lines of business. Studios only pay 20% of DVD revenues to the various artist and production unions, keeping the remaining 80%.

To do this we gather a new dataset including all movies shown on over-the-air television broadcast networks and the four most popular ad-supported cable networks from July 12, 2005 to March 3, 2006 (excluding the Christmas holiday season). For these movies we collect data on sales level at Amazon.com and piracy levels at two major BitTorrent tracker sites. We find that the dominant impact of over-the-air movie broadcasts is to stimulate DVD sales. There is a 120% increase in DVD sales in the week following broadcast, and the increase in sales for broadcast movies is between four to five times larger than the increase in sales from cable movies. We also note that this increase in sales appears to derive from the broadcast itself as opposed to any pre-broadcast publicity. Sales are stable in the week prior to broadcast and the increase in sales in most dramatic in the day after broadcast. However, we also find that movie broadcasts result in a statistically significant increase in the demand for pirated copies of the movies; although this increased piracy appears to come from existing content, ripped from DVDs, as opposed to from HDTV broadcasts.

Literature

In the literature, there is little empirical work on the impact of TV broadcasts on media (e.g. DVD) sales. On one hand, TV broadcast may act as marketing stimuli and generate increased demand. On the other hand, the TV broadcast could satisfy the consumer's desire to see the movie, resulting in decreased demand — a problem made more acute by consumer fair use rights to record broadcasted content and the increasing penetration of high quality DVR devices. TV broadcasts could also decrease demand if they increased the supply of and demand for pirated copies of the content.

Liebowitz (2004) is the only study we are aware of pertaining to the impact of TV penetration on the movie studio revenue. He shows that as TV penetration increased from the 1940's and 50's to the present, box office revenues fell sharply, while revenues from other sources such as movie rental, pay cable have increased substantially. He observes that by opening up new revenue sources from broadcast licensing and downstream media sales, the net impact of TV penetration on the studios was almost certainly positive. However, Liebowitz notes that, owing to data limitations, this analysis is conducted at an aggregate level and cannot establish a causal link between individual movie broadcasts and increased media sales.

Our work also pertains to the literature on the impact of piracy on markets for information goods. Most of the work in this area has focused on software or music piracy, and particularly on P2P file sharing networks and their impact on firm profitability. A prominent trend in the analytic literature has been to show that that piracy need not be bad for firms. Prasad and Mahajan (2003) argue that piracy may be good for a new product if the firm needs to establish initial user base and speed up diffusion. Gu and Mahajan (2005) show that because piracy removes the most price sensitive buyers from the market it can reduce price competition, benefiting sellers. Finally, Peitz and Waelbroeck (2003) show that piracy can act as a free "sample" that increases product awareness.

The empirical work on piracy has focused on estimating the impact of piracy on demand for legitimate content, with mixed results. On one hand, Hui and Png (2003) find that piracy hurts the legal demand for software, and Rob and Waldfogel (2006) find that piracy decreased media consumption by 3.5% in a sample of 500 University of Pennsylvania students. On the other hand, Oberholzer and Strumpf (2004) find that music file sharing on P2P networks has no effect on CD sales. Bhattacharjee et al (2004) find that the impact of piracy depends on the popularity of the music CD, with less popular CDs facing higher piracy risks. Similarly, Blackburn (2004) takes into account the differential impact of piracy and well-known and unknown artists and finds that RIAA lawsuits have resulted in a 2.9% increase in album sales during the 6 month period after the lawsuits were announced.

Analyzing piracy from a policy perspective, Gopal and Sanders (1998) show that government enforcement of intellectual property rights depends on the robustness of the domestic software industry. Finally, analyzing piracy from the perspective of supply, Byers et al. (2003) show that the majority of movies available on file sharing networks originate from studio leaks, as opposed to copies from DVDs or other post-market sources.

We also note that the impact of piracy on product markets is conceptually similar to the impact of used goods markets on new product sales (Ghose, Smith, and Telang 2006), competition between traditional print copies of books and PDF copies of books (Kannan and Jain 2002), consumers' decisions to rent or purchase movies (Knox and Eliashberg 2005), and international movie release windows (Elberse and Eliashberg 2003).

From the perspective of empirical methods, our analysis relates to the growing empirical literature using Amazon's sales rank data to estimate the company's product-level sales. While Amazon.com does not provide product-level

sales information for its products, the company does provide information about the sales ranking of products within a particular product category. Researchers have used this sales rank data to estimate Amazon's sales through direct empirical estimation (Brynjolfsson, Hu, and Smith 2003) and experimental calibration (Chevalier and Goolsbee 2003). Subsequent papers in the literature have used Chevalier and Goolsbee's experimental calibration technique in a variety of contexts (e.g., Chevalier and Mayzlin 2004; Smith and Telang 2004; Ghose and Sundararajan 2005); and Ghose, Smith, and Telang 2006).

Data

Our data were collected from July 12, 2005 through November 23, 2005[4] and from January 1, 2006 through March 3, 2006. We have eliminated all observations during the Christmas holiday season to avoid any potential counter-explanations that might occur during this time period (e.g., increased sales of DVD, reduction in piracy).

Our data consist of information on all movies shown on over-the-air broadcast channels and major ad-supported cable channels. With respect to over-the-air channels, we sampled all movies shown in national broadcasts on ABC, CBS, NBC, FOX, UPN, and WB networks. We used only national broadcasts because local affiliates have the option of slotting movies that will only be shown in a local region. We determined that a broadcast was national if it was shown in both the New York City and Los Angeles affiliates during the same time slot. We use the national (as opposed to local) broadcast as a partial control for audience size.

We also collected data from the four most popular advertising supported cable networks: TBS, TNT, USA, and Lifetime (hereafter ad-cable). We selected these four networks based on Nielsen Media Research viewership estimates (as reported by TelevisionWeek magazine) for the six-month period from March to August 2005. The four most popular channels were the same whether we considered total daily viewers or prime time viewers.

We collected data for each of these movie broadcasts from three primary sources. We collected broadcast information — broadcast date and time, broadcast duration, movie name and description, and whether the movie was shown in high definition format — from TitanTV.com. We used TitanTV because it is easily searchable and provided a 14-day advance notice before a movie's broadcast date. This advance notice allowed us to obtain a baseline level of sales and piracy before broadcast. We used the Internet Movie Database (imdb.com) to obtain information on the theatrical release date, rental revenue, gross revenue, gross budget, and IMDB user star rating for each of the movies in our study.

Finally, we collected information about DVD characteristics and sales (rank) for each version of the movie available at Amazon.com. Many movies have separate wide screen, full screen, and in some cases special edition, or unrated editions.[5] For each of the DVD versions, we collected product characteristics including list price, release date, MPAA rating, aspect ratio, number of discs, and sound quality (e.g., Stereo, Dolby Surround, Dolby THX). We also collected Amazon marketplace information including the Amazon price, the lowest used price, the Amazon users' star rating of the movie, and the movie's sales rank. This information was collected hourly for two-weeks before and after the movie was shown, and daily thereafter (for parsimony we average the data at a daily level). We do not include observations that occur after the second showing of a movie in our data, to focus our attention on the sales gain from the first showing. Our final sample contains 522 broadcast movies and 759 DVD titles. The summary statistics for our sales data are shown in Table 1.[6]

Table 1: Sales Data Summary Statistics

[4] November 23, 2005, is the day before Thanksgiving, the traditional start of the Christmas shopping season. Our results are not sensitive to this choice of dates. For example, eliminating all observations from November 1, 2005 to January 1, 2006 would result in a slight (and statistically insignificant) increase in the sales gains reported here.

[5] We did not collect data on box sets that contain multiple different movies, even if one of the movies in the box set was present in our sample.

[6] This table includes all data from 14 days before broadcast date through 28 days after the broadcast date consistent with our regressions below.

Variable	*Obs.*	*Mean*	*St. Dev.*	*Min*	*Max*
Amazon Rank	39013	12,853	13100	2	97459
Amazon Price	39013	12.95	4.06	4.98	39.99
IMDB Star Rating	39013	5.95	1.24	1.8	8.8
Broadcast Duration (Hours)	39013	2.21	0.41	1.35	5
High Definition Format	39013	0.13	0.34	0	1
Broadcast Network	39013	0.18	0.38	0	1
Number of Discs in DVD	39013	1.10	0.36	1	5
Ln(Gross Revenue ($ Million))	31974	17.36	1.32	10.53	20.2
IMDB User Votes	39013	12,103	19987	1	191,707
No of Viewers (in millions)	38629	2.04	1.97	0.28	9.5
Minutes Edited from Broadcast	39013	9.9	10.5	0	90

We use the DVD sales rank as a proxy for the number of products sold at Amazon. Amazon.com lists the rank of products sold in each product category, with 1 corresponding to the highest selling product, 2 to the second highest selling product, and so on. Following Brynjolfsson, Hu, and Smith (2003) and Chevalier and Goolsbee (2003) we assume that the relationship between sales and sales rank follows a Pareto distribution:[7]

$$Quantity = \beta_1 Rank^{\beta_2} \qquad (1)$$

This relationship can be parameterized using either direct observation of sales and ranks for select titles, typically obtained from product suppliers (see Brynjolfsson, Hu, and Smith 2003) or by means of an experiment (see Chevalier and Goolsbee 2003). Lacking supplier data, we apply Chevalier and Goolsbee's experimental technique, by finding 2 DVDs with high rank (low sales) and observing their rank over the course of several weeks to estimate the number of daily sales. We then ordered 7 copies of the DVDs in an hour, observing the initial and final rank. This allows us to obtain two points on the curve, which we can then use to determine the slope (β2) of equation (1) in log-log space. We performed this experiment on July 1 and July 8, 2004 for two separate DVDs and found the estimated β2 parameter was equal to -1.61 in both cases. We performed this experiment again on February 8, 2006 for two additional DVDs, and found estimated β2 parameters of -1.76 and -1.81 respectively. We use the average of the four β2 estimates (-1.70) in our subsequent calculations.

[7] This technique has also been applied in a variety of other studies, including Chevalier and Mayzlin (2004); Ghose, Smith, and Telang (2006); and Ghose and Sundararajan (2005).

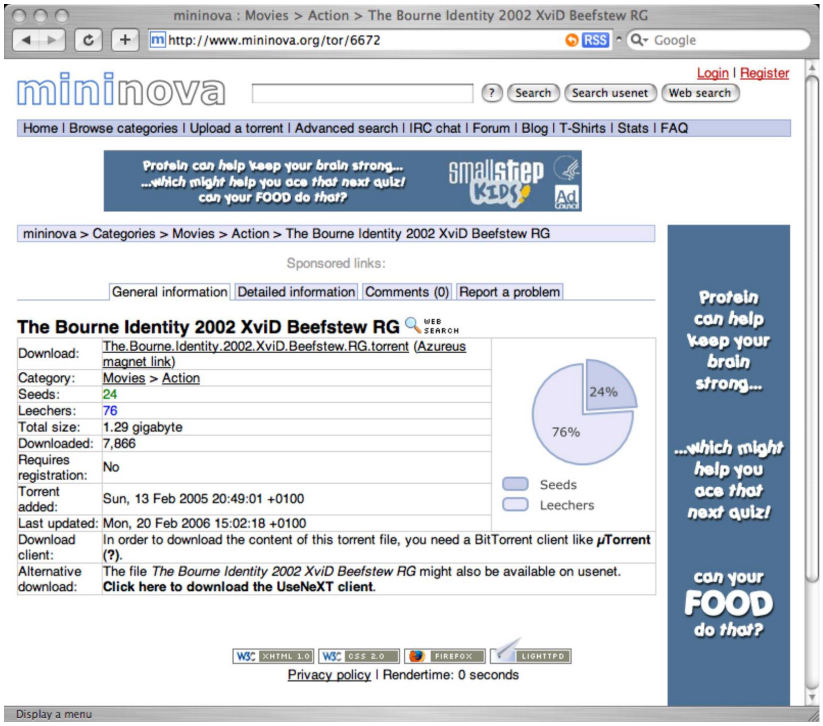

Figure 1: Mininova.org Screen

Our piracy data comes from piratebay.org and mininova.org, two public tracker sites for the BitTorrent protocol. We selected BitTorrent to track piracy for two reasons. First, BitTorrent is currently the most popular protocol for sharing large files, such as movie files. Second, the design of the BitTorrent protocol is such that all nodes participating in a file download report their status to the tracker every 20 seconds. Thus, tracker sites such as piratebay and mininova know, in (near) real-time, the number of users providing the entire file (a.k.a. seeds), the number of users actively downloading the file (a.k.a. leechers), and the number of cumulative downloads. We selected piratebay and mininova as data sources because they were among the most popular BitTorrent tracker sites during our study period,[8] and these sites also list the current number of seeds, leechers, and downloads for each of their trackers. (Figure 1 shows a sample screen from mininova.org.)

Table 2: Piracy Data Summary Statistics

Variable	*Obs.*	*Mean*	*St. Dev.*	*Min*	*Max*
Broadcast Network	22,798	0.44	0.49	0	1
Leechers	22,798	11.61	29.5	0	1070
Seeds	22,798	4.33	13.98	0	485
Daily Downloads	21,826	4.27	13.81	0	467

For each of the movies in our dataset, we search for trackers matching the movie title and general description at both piratebay and mininova both before and after the broadcast date. For all matching trackers we collect the date the tracker was added to the respective tracker site, the file size and daily observations of the number of seeds, leechers, and cumulative downloads. Our final dataset covers the period of October 28, 2005 through March 3, 2006. As above, we exclude the Christmas holiday period (November 23, 2005 through January 1, 2006) to avoid the

[8] For example, Gil (2006) lists both piratebay and mininova among the five most popular BitTorrent tracker sites.

possibility that piracy levels are systematically different during this time period. We collected data on about 210 trackers. The summary statistics for our piracy data are shown in Table 2.[9]

It is important to note that DVDs are typically released 3-6 months after the end of the theatrical release (Epstein 2005) and first shown on television 18 months to 3 years after the DVD release. Which will influence the number of daily downloads per trackers and will also suggest that our measured increase in piracy will be conservative.

Results

DVD Sales Results

To estimate the effect of movie broadcasts on DVD sales, we create a set of weekly time dummy variables that control for the sales levels before and after the broadcast. For notational simplicity, the dummy variable D(x) will be equal to one for x weeks after the broadcast (or before if negative). Thus, D(-1) equals 1 for the time period from one week before until the time when broadcast started on the east coast of the United States. D(1) equals 1 for the first week since the start of the broadcast at the east cost.

Table 3: Impact of Movie Broadcasts on Sales Rank (Fixed Effects)

Broadcast		*Ad Cable*		*HD*	
lnrank	*Coeff. (t-stat)*	*lnrank*	*Coeff. (t-stat)*	*lnrank*	*Coeff. (t-stat)*
Price	0.129** (11.3)	Price	0.090** (20.4)	Price	0.086** (6.3)
D(-1)	0.000 (0.3)	D(-1)	0.000 (0.3)	D(-1)	0.001 (1.3)
D(1)	-0.008** (14.1)	D(1)	-0.012** (20.2)	D(1)	-0.008** (12.4)
D(2)	-0.005** (7.8)	D(2)	-0.002** (2.0)	D(2)	-0.004** (6.4)
D(3)	-0.002** (3.4)	D(3)	0.000 (0.3)	D(3)	-0.001** (2.3)
D(4)	0.000 (0.8)	D(4)	0.003** (3.5)	D(4)	0.000 (0.4)
Cons	6.567** (40.9)	Cons	7.825** (38.5)	Cons	7.226** (37.8)
N	1738 (53 movies)	N	14551 (678 movies)	N	1325 (40 movies)

The dependent variable is ln(sales rank). t-statistics are listed in parenthesis; ** and * denote significance at 0.01 and 0.05, respectively. All models use DVD-level fixed effects.

We then estimate a model with DVD-level fixed effects to examine how sales change before and after a movie is broadcast on over-the-air television or cable. A fixed effect model ensures that sale changes are captured within a DVD. An unfortunate characteristic of fixed effect estimation is that we cannot include variables that are constant within DVD (and therefore collinear with the DVD fixed effect). We will relax this requirement using random effects models below. The fixed effect model we estimate is

$$Ln(Rank_{it}) = \xi\, Price_{it} + \delta\, D_t + \varepsilon_{it} \qquad (2)$$

where i indexes a movie and t indexes time. ξ and δ are the vectors of coefficients to be estimated, where δ captures the effect of movie broadcast on DVD sales, our variable of interest. Note that we start observing sales rank two weeks before broadcast, and we eliminate any observations 4 weeks after broadcast (to avoid conflating our results with natural declines in sales due to product life-cycle issues). Thus, the left out variables in this regression is the sales level two weeks before broadcast. Since the number of viewers differs significantly across movies and across channels, we interact our dummies D_t with the number of viewers (in units of 100,000). Thus, the impact D_t of should be interpreted as the change in rank in week t per 100,000 viewers. Our results for this regression are shown in Table 3.

[9] Our summary statistics only include observations from 14 days before broadcast to 7 days after broadcast consistent with our regressions below.

The crucial variables in our model are the dummy variables on time. The left out category is the time period two weeks prior to broadcast. First note that D(-1) is insignificant. Thus a week prior to the movie broadcast, there is little change in the rank. D(1) is negative and highly significant. A week after the movie is shown, the rank decreases (sales increase) significantly for all three channels. Similarly, D(2) and D(3) are also negative and significant though the magnitudes are decreasing (except for ad-cable where D(3) is not significant). Thus the sales in week2 and week3 are also higher though they are not as high as in week 1. Finally the estimate on D(4) is small, positive and insignificant (except for the ad-cable results). Thus by week 4, the sales reach the same level as they were two week prior to the broadcast. In summary, we find that the sales in the first 3 weeks after the broadcast are higher for all three broadcast types. Amazon price is also consistent and significant. An increase in price leads to lower sales (higher rank).

Based on the estimates, we can quantify the % increase in sale due to movie broadcast. To interpret the values of the dummy variables in terms of changes in sales, recall that Ln(Sales) = β * Ln(Rank) where β = -1.70. It is straightforward to show that the percentage increase in sales resulting from a coefficient δ_i is

$$\Delta Sales = e^{\beta\delta_i} - 1$$

Recall that our estimate is normalized to 100,000 viewers. Since we have the viewership numbers for each movie, we can calculate the % increase in weekly sales due to the movie broadcast. The following table presents these results.

Table 4: % Increase in weekly sales due to Movie broadcast

Time Since Movie Broadcast	Over The Air (no of viewers: 5.6 mil)	Ad-Cable (no of viewers: 1.2 mil)	HD (no of viewers: 5.9 mil)
Week before - D(-1)	-1.44%	-0.26%	-8.14%
First week- D(1)	118.91%	27.19%	118.59%**
Second week- D(2)	55.83%	3.19 %	51.54%**
Third Week- D(3)	21.48%	0.45%	16.04%**
Fourth week - D(4)	4.86%	-3.70%	-2.55%

From Table 4, we can see that movies shown on over-the-air broadcast experience about a 120% increase in DVD sales in week 1, about a 52% in week 2 and about a 16% in week 3. By week 4, return to their levels that are statistically the same as the levels before the movie was broadcast. HD movies show the same trend (in our sample, most of the HD movies are shown on over-the-air). The weekly sales increase in ad-cable is significantly lower. Notice that almost all of that is attributed to the fact that far fewer viewers watch movies on ad-cable (viewership on ad-cable is almost 1/5th of over-the-air). Notice that in Table 3, the estimate on D(1) for ad-cable is also quite large (even larger than over-the-air and HD). However, since fewer viewers watch the movies, the actual sales increase is significantly smaller.

To include additional DVD-level controls, we need to estimate a random effects model. The random effects model assumes that the DVD-level effects incorporated into the random effects error term are uncorrelated with the explanatory variables. If this assumption does not hold, the random effects coefficients are inconsistent. We use a Hausman test to evaluate this assumption, comparing the baseline regression results under the fixed and random effects model. This test fails to reject the null hypothesis that the random effects assumptions hold at any reasonable confidence level.

We report the random effects regression results in Table 5. Estimates on the dummy variables are virtually identical to the estimates with fixed effects. Thus, there do not seem to be movie specific unobserved effects. The estimates on the other variables are not as significant for over-the-air as they are for ad-cable. This could be due to the smaller sample of over-the-air movies. The estimate on gross revenues is negative (for both channels) and significant (for ad-cable). Thus, as expected more popular movies tend to have lower rank (higher sales). Similarly, movies rated highly on the Internet Movie Database have a higher level of sales. Movies with more discs also have high level of sales, possibly reflecting the ability of DVD extras to differentiate purchased content from broadcast content.

Table 5: Impact of Movie Broadcasts on Sales Rank (Random Effects)

Over-the-air Broadcast		*Ad-Cable*	
Log(rank)	*Coeff. (t-stat)*	*Log(rank)*	*Coeff. (t-stat)*
Price	0.126** (11.2)	Price	0.098** (22.1)
D(-1)	-0.001 (0.81)	D(-1)	0.000 (0.2)
D(1)	-0.009** (15.01)	D(1)	-0.011** (17.9)
D(2)	-0.005** (8.83)	D(2)	-0.002* (1.9)
D(3)	-0.003** (4.07	D(3)	-0.001 (1.2)
D(4)	-0.001 (1.77)	D(4)	0.001 (1.5)
Log(gross_rev)	-0.574 (1.79)	Log(gross_rev)	-0.089** (2.9)
imdb_rating	-0.099 (0.47)	imdb_rating	-0.390** (11.1)
duration	0.472 (1.45)	duration	-0.172 (1.6)
min_edited	0.035 (1.53)	min_edited	0.000 (0.0)
discs	-0.727** (-2.22)	discs	-0.493** (5.1)
constant	17.48 (3.4)	constant	12.3** (25.6)
N	1696 (52 movies)		12085 (583 movies)

The dependent variable is log(sales rank). t-statistics are listed in parenthesis; ** and * denote significance at 0.01 and 0.05, respectively.

In total, our results suggest that both cable and over-the-air movies experience a large, statistically significant increase in sales immediately following their broadcast, and this increase in sales typically persists for 3 weeks, before returning to its baseline level. Our findings show that the benefits of DTV broadcast through promoting media purchases far outweigh any potential cannibalization effect.

Piracy Results

In the second part of our analysis, we examine how TV broadcasts affect the piracy of movies on file-sharing networks. The models we estimate are of the form

$$\{download_{it}, lechers_{it}, seeder_{it}\} = \lambda D_t + \beta\, tracker\_age + \varepsilon_{it} \quad (3)$$

where our dependent variables include separately the daily download rate, the number of seeders, and the number of leechers for each movie tracker on each day. Our independent variables include time dummies for weeks after broadcast, and the age of the tracker measured in days since it was first posted on the BitTorrent sent. In many cases, the tracker data was not available 2 weeks prior to the broadcast. Therefore, a dummy before broadcast and 4 dummies for each week following the broadcast were included. The dummy D(-1) is the omitted variable in this case. Viewership figures were available for only about half the trackers. Therefore, we do not use viewership data directly in the regression. We first estimate the impact of over-the-air broadcast.

Table 6: Impact of Movie Broadcasts on Piracy (Fixed Effects) for Broadcast Channels

daily_download	*Coeff. (t-stat)*	*Leechers*	*Coeff. (t-stat)*	*Seeds*	*Coeff. (t-stat)*
D(1)	4.80** (6.5)	D(1)	2.66** (2.2)	D(1)	2.03** (3.9)
D(2)	4.74** (6.4)	D(2)	5.21** (4.3)	D(2)	2.94** (5.6)
D(3)	5.49** (7.3)	D(3)	2.37* (1.9)	D(3)	1.73** (3.3)
D(4)	4.31** (5.6)	D(4)	-1.24 (0.9)	D(4)	0.24 (0.4)
constant	1.97** (3.2)	constant	12.3** (12.1)	constant	4.23** (9.8)
N	4327 208 trackers	N	4594 212 trackers	N	2335 90 trackers

The dependent variable is daily downloads (column 1), number of leechers (column 2), and number of seeds (column 3). Standard errors are in parenthesis; ** and * denote significance at 0.01 and 0.05, respectively. All models use tracker-level fixed effects.

Our results in Table 6 show a significant increase in piracy immediately after movies are broadcast on over-the-air channels. Daily downloads, number of lechers, and number of seeds increase over the next 3 weeks after the broadcast. By week 4, the levels return to the original levels (except for daily download which show an increase in week 4 as well).

From these estimates, we can quantify the magnitude of these changes. The baseline weekly downloads, leechers and seed activities were 7.8, 13.7, 4.6 respectively. The following table calculates the % increase in piracy levels.

	% increase in daily downloads	*% increase in leechers*	*% increase in seeds*
D(1)	61%	20%	44%
D(2)	60%	38%	64%
D(3)	70%	17%	38%
D(4)	59%	-9%†	5.21%†

The magnitude of these changes is non-trivial. For example, our results suggest that in the week following a movie is broadcast there is a 60% increase in the number of daily downloads. Similar increases are observed for seeds and slightly lower levels for number of leechers. By week 4, the levels go to the pre-broadcast levels. In summary, there is unambiguous indication in our data that the movie broadcast on the over-the-air channels lead to a significant increase in the level of piracy.

We ran the same models on cable broadcast movies. Our results are shown in Table 7.

Table 7: Impact of Movie Broadcasts on Piracy (Fixed Effects) for Cable Channels

	Daily_Download			Leechers			Seeds		
D(1)	0.31	0.42		Dw1	0.16	0.30	Dw1	0.16	0.12
D(2)	0.98	0.55		Dw2	-0.51	0.40	Dw2	-0.09	0.15
D(3)	1.99**	0.61		Dw3	-0.69	0.45	Dw3	-0.16	0.17
D(4)	1.10	0.66		Dw4	-0.32	0.48	Dw4	-0.10	0.18
tracker age	-0.22	1.21		tracker age	-1.24**	0.55	tracker age	-0.91**	0.23
constant	3.91**	3.19		constant	16.71**	1.26	constant	7.83**	0.61
N	5910, 459 trackers			N	6462, 499 trackers		N	6456,498 trackers	

The dependent variable is daily downloads (column 1), number of leechers (column 2), and number of seeds (column 3). Standard errors are listed in parenthesis; ** and * denote significance at 0.01 and 0.05, respectively. All models use tracker-level fixed effects.

The cable results reveal a slight increase in daily download activity. The number of leechers and seeders seems to change very little; though the sign of the coefficient is negative, the numbers are economically and statically insignificant.

Why are the differences in the over-the-air and Cable results? We believe that these differences can be attributed to differences in the number of viewers in these broadcast channels. In our sample, there were on average 1.6 million viewers for cable movies and 4.9 million viewers of movies on over-the-air (viewership numbers are slightly different from the DVD sample due to a different in the composition of movies available on piracy channels).

In summary, we find that over-the-air movie broadcasts tend in stimulate both DVD sales and piracy, and these increases are substantially higher than they are for cable broadcasts. Further, by analyzing tracker posting dates and the names of trackers, we find no evidence that television broadcasts (whether HD or analog) serve as the source material for pirated content in our sample. Thus there no evidence that television broadcasts of movies serve as the source material for piracy, at least for the movies in our sample.

Discussion

Movie studios have argued that the development of unencrypted over-the-air DTV, combined with the integration of the computer and television and the prevalence of piracy on the Internet, places their content at risk. Their concern is that when a movie is shown in an over-the-air broadcast it will lead to increased piracy of that movie and reduced downstream sales. Indeed several studios have argued that the loss in sales from this piracy will be so great that it will be more profitable for them to show their movies on cable and satellite systems (which have copy protections in place) than it will be to show them in over-the-air broadcasts.

The FCC seemed to rely heavily on these concerns in mandating that all DTV demodulators respect "broadcast flag" copy protection in DTV broadcasts. Their concern may have been driven by the possibility that if studios were to withhold movies and other "high value" content from over-the-air broadcasts it would slow the penetration of DTV, thereby delaying or increasing the cost of the United State's transition from analog to digital TV broadcasts.

However, what is striking in this debate is that neither side has presented any empirical evidence of the size of the piracy problem faced by the studios or the impact of over-the-air broadcasts on DVD sales (either in absolute terms or relative to cable channels). In this paper we have gathered a new data set that allows us to analyze these two questions.

We find that after a movie is shown on broadcast TV there is a strong and immediate increase in sales of the corresponding DVD through Amazon.com, and that the sales increase for movies shown on broadcast channels is four to five times larger than the average sales gain for cable movies.

However, at the same time, we also find that broadcast movies are associated with a statistically significant increase in piracy for corresponding movie files on public BitTorrent trackers, while cable movies show no statistically significant increase in piracy. However, it is important to note that all of this piracy appears to come from existing copies of the DVD rips of these movies. HDTV signal do not appear to be used as the source material for the piracy in our sample.

For broadcasters, our findings suggest that, even in the absence of copy protection, movie broadcasts act as a strong complement to downstream content sales. These gains come on top of the $3-15 million in revenue studios receive when they license a movie to be broadcast on TV. This result should be encouraging for broadcasters who have long feared that the dominant impact of consumer analog and digital recording devices would be reduced demand for subsequent media purchases. Since the introduction of the VCR, movie studios have argued that if a consumer can record and retain a perfect copy of a movie, TV broadcasts of movies will serve as a substitute for subsequent purchases of the movie content. However, in a digital world this argument may ignore the increased opportunities for studios to differentiate their digital media from the content shown over TV. For example, the increased capacity and random-access capabilities of the DVD format allow studios to include extra content such as commentary tracks, deleted scenes, "behind-the-scenes" documentaries, and music videos. It is also possible that the "hassle" consumers face in copying and storing the broadcast content is sufficiently large to make the commercial purchase an attractive option.

The fact that TV broadcasts serve primarily as complements to subsequent media purchases should also be encouraging for studios increasingly looking to monetize their content through digital download services such as the iTunes video store and other similar services. Indeed the immediate spike in media purchases after a movie is shown on DTV suggest there might be an opportunity for in-program promotion of broadcast content.

However, we also find that movie broadcast tend to stimulate piracy. At the same time, we also find no evidence that TV broadcasts are used as the source material for Internet piracy, rather the vast majority of pirated movies available on the Internet originated from "ripped" DVDs and were available long before the movie broadcast.

The fact that few TV broadcasts serve as the source material for Internet movie piracy is not surprising for standard NTSC movies since the broadcast quality of the movie will generally be lower than DVD quality, and DVD movies are typically available long before the television broadcast. However, this is somewhat surprising for high definition movies as the high definition television broadcast has a much higher resolution than the DVD version. It is possible that the sheer size of HDTV broadcasts (8.7 Gigabytes/hour when broadcast in 1080i) is prohibitive for most Internet users. It is also possible that Internet "pirates" don't value the additional resolution of HD broadcasts versus DVD resolution to invest the additional time in downloading HD trackers.

Of course, these factors could change in the future as Internet download speeds increase and as HD displays gain popularity. However, for movie broadcasts to serve as the source material for piracy — the core argument for the broadcast flag — it would have to be the case that equal or superior quality versions of these movies were not readily available through pirate sites at the time of the broadcast. This would be dependent on the ability of the movie industry to minimize leaks of High Definition material prior to TV broadcast, which in turn would involve shutting down studio leaks, leaks through the next generation high definition DVD standard, and leaks through "protected" pay cable channels. The extant literature suggests that the industry will face severe challenges in closing leaks in these channels (see Byers et al. (2003) for a discussion of studio leaks, and Perry (2005) for a discussion of digital rights management in next generation High Definition DVD standards).

For policymakers, our results show that, in spite of piracy, over-the-air movie broadcasts result in substantially higher increases in DVD sales than cable broadcasts do. This suggests that movie studios will not find it profitable to remove their "high value" content from (unprotected) over-the-air channels in favor of (protected) cable channels, an action that could slow the nation's migration from analog to digital TV. Further, as noted above, consumer groups have identified several reasons to believe that implementing the broadcast flag may retard DTV penetration. Thus, policymakers may wish to consider the possibility that implementing the broadcast flag carries a greater risk of delayed DTV adoption than not implementing the flag will.

Finally, we note that there are several limitations of our study. First, our study should not be viewed as a policy impact statement as we do not observe the counter-factual situation of what would happen to DVD sales in the presence of the broadcast flag regime. Second, our findings may change in the future if the environment surrounding piracy changes. It is possible that an increase in penetration of computer-based HDTV cards, PVRs, or high bandwidth Internet connections will change our results. It is also possible that the movie industry will be able to effectively stop HD piracy from other sources such as industry leaks, Blu Ray and HD-DVD content, and cable and satellite systems. If this were to occur, unprotected HDTV content could, in the future, become a more significant source of piracy. Our sample is also limited to Amazon and the results should be interpreted accordingly. A more comprehensive analysis of DVD sales in both traditional and Internet channels would make an interesting area for future research and analysis.

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