Piracy or Promotion?
The Impact of Broadband Internet Penetration on DVD Sales

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ABSTRACT

The Internet provides copyright holders with new sales and promotional channels for their content, while also providing consumers with new opportunities to illegally obtain free copies of this content. Unfortunately, disentangling these two effects is extremely difficult.

In this paper we attempt to disentangle these two effects by applying fixed effects and first difference models to a new dataset quantifying changes in broadband Internet penetration and DVD sales at a local level from 2000 to 2003. We then compare our results to those reported in Liebowitz (2008), who uses similar models in a similar time period on a similar product category: music CDs.

Unlike Liebowitz, who finds a strong negative impact of broadband penetration on music sales, our results show that increased broadband penetration leads to a significant *increase* in DVD sales. Using the most conservative results, 9.3% of the $14.1 billion increase in DVD sales during our study period can be attributed to increased broadband penetration. One interpretation of these results is that the difference arises from differences in the ability to pirate these two types of content: while Internet music piracy was easy and rampant from 2000-2003, Internet movie piracy was difficult and of generally low quality in this time period. If this interpretation is true it would suggest that, in the absence of piracy, the Internet has an overall strong positive impact on media sales.

JEL Codes: D69, L86, O30

Keywords: *Information goods, Internet penetration, movie promotion, DVD Sales.*

1. Introduction[1]

> "There are days where I really wish Al Gore hadn't invented the Internet."
> *Stephen Soderbergh, 60 Minutes Interview with Leslie Stahl, November 1, 2009. (CBS 2009)*

> "The moat that has slowed a wide-spread assault on movies in digital form is the languor with which American computer-homes have valued broadband access… But that moat will gradually be drained as broadband grows, both in its speed-power and in the deployment of broadband to homes. Once that happens…all barriers to high-speed takedowns of movies will collapse… It is the certainty of that scenario which concerns every moviemaker and distributor in the land."
> *Jack Valenti, testimony before the Senate Committee on Foreign Relations, February 12, 2002. (Valenti 2002)*

Digital computer networks represent a disruptive technology, with the potential to create or destroy economic value in established industries. These opportunities and challenges are particularly apparent in the movie and music industries, whose business models are driven by the ability to extract revenue from what are essentially information goods.

On one hand, digital networks can create new and lower cost channels for media companies to promote, sell, and distribute their content to paying customers. Having high speed access to the Internet might allow consumers to collect and exchange more information about content they are interested in, might allow access to products that would not have been available in brick-and-mortar channels (Brynjolfsson, Hu, and Smith 2003), and might allow companies a more targeted channel to promote content of interest to consumers.

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On the other hand, digital networks could harm media companies economically. For example, broadband Internet access could create new entertainment outlets for consumers, crowding out the time they would have spent watching movies or listening to music. For example Williams and Shapiro (1985) found that in-home entertainment resulted in decreased theater attendance. More importantly, broadband Internet access creates new opportunities for unscrupulous users to illegally obtain free copies of media files through pirate websites and peer-to-peer file sharing.

However, while the dual possibilities of broadband access driving Internet promotion and Internet piracy have been well known, it is difficult to disentangle these two effects because of the inherent simultaneity in their application. The goal of this research is to attempt to disentangle these two effects by comparing the impact of broadband Internet access on sales of DVDs to the results in Liebowitz (2008) documenting the impact of broadband Internet access on music CDs. These two papers use similar models in similar timeframes and on similar products. One notable difference, however, is that while Internet piracy for music CDs was easy and rampant from 2000 through 2003, movie piracy, owing to its relatively larger size, was much harder during this same timeframe. Moreover, the pirated movie content that was available was of a much lower quality relative to the competing DVD goods than were comparable pirated music files to the competing CD content. While our identification strategy derives from the comparison between these two results, as opposed to a direct comparison within the data, we believe it provides suggestive evidence of the potential benefits and potential harm from broadband Internet access.

As such, this research has both managerial and policy importance. From a managerial perspective, our results shed light on the degree to which broadband Internet access supports the media industries when separated from the cannibalizing effect of digital piracy. For the movie

industry, a loss in DVD sales due to piracy is a significant concern because DVD and other media sales comprised 46% ($14.9 billion) of total revenue in 2002 (Epstein 2005, p. 20; see also PBS 2005). Moreover, studios' concerns about piracy are not without empirical and anecdotal support. A recent study found that in 2005 Hollywood studios lost $1.3 billion in the United States due to piracy (McBride and Fowler 2005). Of this, $447 million was attributed to Internet piracy (with the remaining amounts coming from physical copies of movies sold by professional bootleggers ($335 million) and illegal copies made by individual consumers ($529 million)).

However, while piracy is a significant concern for media companies, focusing solely on the potential for increased piracy may serve to obscure the potential positive benefits broadband Internet access brings to the movie industry. For example, broadband Internet access may provide consumers with new ways to access movie information through sites such as IMDB.com and Yahoo movies. Further Internet retailers can provide a substantially larger variety of movies for sale on their websites than brick-and-mortar retailers can. Finally, the impact of piracy may be smaller than initially expected if the individuals illegally downloading movies would not otherwise have purchased a legitimate copy of that movie.

From a policy perspective, our results may shed light on the degree to which governments should regulate new Internet technologies to protect established industries, relative to more focused efforts to reduce piracy on these networks. For example, representatives of the recording industry in the United Kingdom have argued that the government should impose a 4 Euro per month tax on broadband Internet access to reimburse rights holders in the movie and music industry for anticipated losses due to piracy (Orlowski 2006). One could argue that while this approach may provide a short-term revenue boost, if it forestalls the use of broadband Internet connections it could also harm sales down the road.

Thus, our research contributes to the literature by addressing this question: what has been the net impact of increased broadband Internet penetration on DVD sales during a period where it was difficult to pirate movies, relative to the net impact of broadband Internet penetration on CD sales reported in Liebowitz (2008) for the same time period — a period where music piracy was easy and widespread.

While the dual impacts broadband Internet access on promotion and piracy of media content has been much discussed in the literature, there have been no studies attempting to disentangle these two effects. It seems likely that this is because of two estimation challenges. First, studies of the impact of piracy on sales are complicated by obvious endogeneity issues: unobserved popularity impacts both the left hand side sales variable and the right hand side piracy variable. Second, disentangling the impact of broadband Internet access on promotion and piracy of media content is complicated by simultaneity issues: Internet access typically impacts both factors at the same time.

To address the first problem, instead of focusing on individual DVD sales, we use the aggregate sales of DVDs at a local level as our unit of analysis.[2] We have obtained DVD sales data from Nielsen Videoscan for 99 Designated Market Areas (DMAs) for the years 2000, 2001 and 2003. We have matched this data with broadband Internet penetration data for these same regions. Our broadband penetration data comes from a U.S. Government current population survey (CPS) of more than 60,000 U.S. Households conducted in 2000, 2001, and 2003. The CPS one of the most reliable and detailed data source used by government policy makers and academics. The use of

[2] We do not measure the DVD rental market because DVD rentals do not represent a source of additional revenue to the movie industry. Under the first sale doctrine, once a rental company purchases a DVD, they can rent that physical copy of the media out to its consumers without further reimbursement to the rights holder. While studios have recently entered into agreements with rental companies, such as Netflix, to provide them with priority access to some new titles in high demand, in exchange for licensing fees, these agreements were not in place during our study time period.

panel data is critical to our study. A purely cross-sectional analysis of broadband penetration and DVD sales would again be subject to spurious correlation. With a longitudinal dataset across a large number of local areas, we can estimate a first difference model to overcome these limitations. The intuition is that by running a regression of changes in DVD sales on changes in broadband penetration over time (after controlling for local area characteristics), we can obtain an unbiased estimate of the impact of broadband penetration on DVD sales.

To address the second estimation issue — disentangling the impact of broadband Internet access to promotion of media content and piracy of media content — we compare our results in the context of DVDs to a similar study (Liebowitz 2008) in the context of CDs. In this comparison, we employ the fact that the empirical methods and timeframe are very similar between these two papers. Moreover the broad products categories are generally similar in nature. However, one difference between the DVDs and CDs in the 2000 to 2003 timeframe, is that while digital music piracy was easy, fast, and of high quality relative to a CD purchase, digital movie piracy in this timeframe was still in its nascent stage: it was relatively difficult, generally slow, and the media files obtained were generally of low quality relative to DVD purchases. Thus, any differences in results between these two product categories may shed light on the impact of broadband Internet access on media sales where piracy options are and are not easily available.

Under this setup we find that, contrary to Liebowitz (2008), increased broadband Internet penetration leads to a large and statistically significant increase in DVD sales. This increase is robust to a variety of different specifications. Using the most conservative results, we find that 9.3% of the $14.1 billion increase in DVD sales during our study period can be directly attributed to increased broadband Internet penetration. This corresponds to a $1.3 billion increase in DVD revenue to the movie industry, and a $630 million increase in profits to Hollywood

studios. Moreover, while this is not an ideal identification strategy, we believe our results still suggests that — in the absence of piracy alternatives — the Internet can have a strong positive impact on sales and marketing strategies in the media industries.

The remainder of this paper proceeds as follows. In Section 2, we review the relevant literature on piracy and its impact of media sales. In Section 3, we present a brief theoretical treatment of the possible impacts of increased broadband Internet penetration on DVD sales. Sections 4 and 5 present our empirical estimation models and data. Section 6 presents our results. We close with a discussion of the implications of our results in Section 7.

2. Literature

Our research is most related to the literature on the impact of piracy on markets for information goods. Most of the work in this area has focused on music "piracy," and particularly on P2P file sharing networks and their impact on firm profitability. Much of the analytic literature, has argued that piracy does not have to be harmful for firms if it helps to establish an initial user base that can be monetized later (Prasad and Mahajan 2003), if it reduces price competition (Gu and Mahajan 2004), or if it provides information to consumers that can later be monetized through sales (Peitz and Waelbroeck 2003). However, most of the empirical work on piracy has found that piracy reduces music sales. The literature has found this to be true in international markets from 1994 to 1998 (Hui and Png 2003), among European consumers in 2001 (Zentner 2006), among U.S. consumers in 2003 (Blackburn 2007), and among a sample of University of Pennsylvania students in 2003 (Rob and Waldfogel 2006). In contrast, Oberholzer and Strumpf (2004) find that piracy has no effect on CD sales, Bhattacharjee et al. (2004) find that the impact

of piracy depends on the popularity of the particular music CD, with more popular CDs facing higher piracy risks.

Our research also relates to a small, but growing, literature analyzing piracy in the context of legitimate sales and consumption of movie and television content. In this literature, Rob and Waldfogel (2007) use survey data and find that unauthorized viewing replaces paid content, Danaher and Waldfogel (2008) find that online movie piracy harms international box office revenue, Smith and Telang (2009) find no impact of piracy on DVD sales for catalog titles, and Danaher et al. (2010) finds a strong substitution between legitimate digital channels and illegitimate piracy channels for television content.

However, we are not aware of any studies that have analyzed the net impact of digital networks on sales of DVDs and other digital media. Studying only the impact of piracy effectively ignores positive impacts digital networks can have on DVD sales. Digital networks can have a strong positive impact on media sales in a variety of ways, such as the availability promotional information on movies or the increased product variety available through online markets (Brynjolfsson, Hu, and Smith 2003). For example Anderson (2004) notes that while a typical Blockbuster video rental outlet carries around 75 documentaries on DVD, Amazon.com carries 17,061. Similarly, Anderson (2006) notes that, DVDs outside the 1,000 most popular titles at any given time sell three times more titles through the Internet than they do through brick-and-mortar stores. However, disentangling these two effects — piracy and promotion — is difficult because of the obvious simultaneity issues.

3. Theory of the Impact of Broadband on DVD Sales

Increased penetration of broadband digital networks can have either a positive or negative impact on sales of information goods such as DVDs. In terms of negative impact, broadband digital networks may reduce the amount of time consumers have to watch DVDs by increasing the availability of other entertainment options such as online gaming, consumer generated content sites, and online communities.[3] More insidiously, broadband Internet access could increase movie piracy. Liebowitz (2008) and Boorstein (2004) made similar arguments when they used Internet penetration as a proxy for music file sharing. While movie file sharing has not received as much press as music file sharing, it is still a significant phenomenon, as highlighted above. The sheer numbers of movies downloaded and shared is in millions. The movie industry has recognized this and a recent industry study finds that losses due to illegal online movie file sharing are in the range of $450-550 million (see LEK 2005 and McBride and Fowler 2006). However, and importantly to our study, while digital music piracy was easy and rampant from 2000 to 2003, digital movie piracy was still in its infancy during this time period.

On a broader level, the impact of file sharing itself has been a controversial topic with differing conclusions and opinions. File sharing can act as a substitute where a copy freely available online substitutes for a legally available content and thereby hurts and interest of original copyright holders. However, there is an alternative argument put forward, namely sampling. Pirated content available online can make users aware of the availability of certain movies and artists and eventually lead to purchases by users. This argument suggests that file sharing

[3] Note that broadband connections could also lead to a substitution effect as DVD consumers choose instead to buy digital content through the online channel. However, in our timeframe there were no significant legitimate digital download channels for movies. While Movielink.com and Cinemanow.com began online movie download services in 1999 and 2002 respectively, neither gained any significant market penetration. Likewise, the iTunes store was not a factor during our timeframe. iTunes began selling music in April 2003 and movies and videos in October 2005.

networks can actually reduce search costs for users and can make them aware of more obscure and less advertised movies, leading to an increase in DVD purchase. There is significant empirical work for music file sharing and how it has impacted the recording industry. However, as noted above, there is no consensus in the literature on the magnitude of file sharing's impact on media sales.

Independent of file sharing, access to broadband Internet networks may stimulate DVD sales. Recent work by Brynjolfsson et al. (2005) and Brynjolfsson et al. (2003) argues that increased product variety and decreased search costs for product information in Internet markets has made is easier for users to find niche products that offer a good fit for their individual tastes. The availability of increased product variety and increased product information could be particularly important for DVDs where typical brick-and-mortar retailers carry fewer than 1,000 of the more than 40,000 DVDs in print. Given that advertising and promotional costs are very high in these markets, broadband networks may help lower promotional costs for niche titles. This conjecture is also consistent with Bhattacharjee et al.'s (2005) finding that peer-to-peer networks can help sales of less popular music titles.

In summary, the increased penetration of broadband digital networks might hurt media sales through "crowding out effects" on consumers' time or cannibalization due to piracy. On the other hand, increased broadband penetration might help media sales through access to increased product variety, lower search costs for product information, the ability to sample product content, and the ability to better promote and market DVDs.

The majority of the extant literature has focused only on the impact of piracy. In this study we focus on the impact of broadband digital networks on economic activity in the market for DVDs.

We attempt to disentangle the promotion and piracy by comparing our results for broadband penetration's impact on DVD sales to the results reported in Liebowitz (2008) on the impact of broadband on music sales, noting that while our papers use similar models in a similar timeframe on similar product categories, Internet music piracy was easy and rampant from 2000 through 2003 while Internet movie piracy was difficult and generally of a low quality.

4. Model

Our econometric model to estimate impact of broadband Internet penetration on DVD sales correlates local changes in Internet broadband penetration with local changes in DVD sales, following a methodology similar to Boorstein (2004) and Liebowitz (2008). However, our data sources are somewhat different with additional measures, and include better controls for demographic characteristics.

We use an aggregate approach, because measuring the impact of file-sharing on DVD sales at an individual movie level is notoriously tricky due to a serious simultaneity problem: DVDs that have higher sales also tend to have higher levels of piracy. This makes estimation very difficult unless one can find good instruments, a non-trivial problem. Analyses at the individual level can also ignore trends at the industry level: while an individual movie may suffer from piracy, the industry as a whole may not suffer as much (or at all).

Our approach with aggregate data avoids these problems by estimating the impact of file sharing on aggregate sales rather than individual products. Moreover, by using panel data, we can avoid the simultaneity problem as well, as explained below.

Specifically, we first estimate the following model using both DMA- and year-level fixed effects:

$$Sale_{it} = \delta 0 + \delta 1 * bband\_penetration_{it} + \delta 2 * X_{it} + \xi_{it} \quad (2)$$

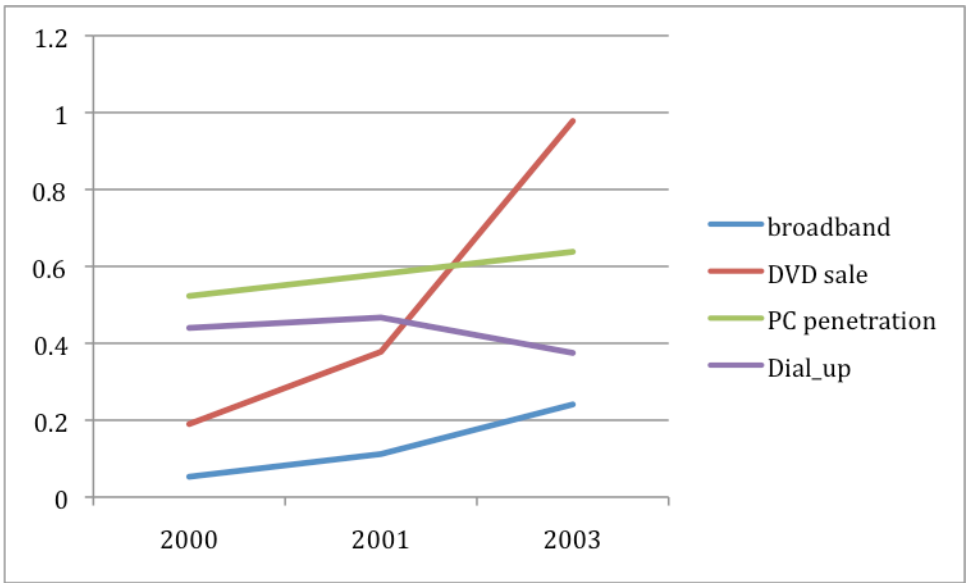
where i indexes each DMA, t indexes each time period, *Sale* is the sale of DVDs, *bband_penetration* is broadband penetration, and X is a vector of other exogenous factors that may affect DVD sales. For our individual year regressions, these exogenous factors include demographic characteristics and the number of Wal-Mart stores in the DMA. In our pooled regressions, we also add yearly indicator variables as controls.

The essence of simultaneity bias is bias resulting from an unobserved factor that impacts both the right-hand side (in our case broadband penetration) and left-hand side (in our case DVD sales) variables. For example, a more urban DMA or a younger DMA will probably see more broadband penetration as well as higher DVD sales. Our empirical approach overcomes simultaneity bias by collecting a longitudinal data set allowing us to use fixed effects — essentially a separate identifier variable for each DMA and each time period. This controls for both DMA and time specific unobserved effects that might be correlated with both broadband penetration and DVD sales (for example affluence, technological sophistication) and factors that would be common to the entire industry (for example changes in the DVD release window over time).

Finally, one of the shortcomings of the panel data is that error terms can be autoregressive. As broadband penetration and DVD sales are generally increasing over time, we also explicitly control for autocorrelation in our estimation. Specifically, in (2) we allow $\xi_{it} = \rho\xi_{it-1} + z_{it}$, and control for potential autoregressive error structures following Baltagi and Wu (1999).

5. Data

Our data consist of DVD sales, broadband penetration, broadband use for media consumption, demographic characteristics, and market characteristics for the 99 largest media markets in the United States from 2000 to 2003. This is an important time period because 2000 was the beginning of the large-scale rollout of Internet broadband access in the United States. Between 2000 and 2003, broadband penetration increased from about 5% to 25%, as shown in Figure 1. The econometric challenge is that DVD sales and high technology penetration (e.g., personal computer sales) also increased significantly during this period. Thus, the goal of our estimation is to capture the large variation in broadband penetration, DVD sales, and technology penetration across years, and disentangle the causality between these variables through the use of local-level observation.



Source: Nielsen

Figure 1: Changes in Broadband Penetration, Dialup Penetration, DVD Sales, and PC Penetration (2000-2003)

We obtain our DVD sales data from Nielsen VideoScan. Nielsen captures aggregate sales of DVDs through both Internet and brick-and-mortar channels within DMAs.[4] A DMA is typically defined as a large media market and its surrounding areas. For example, the Philadelphia DMA includes more than 450 zip codes and includes areas from Philadelphia to some parts of Reading, PA and some zip codes in Delaware. Our data cover the 99 largest DMAs in the United States (about 83% of the total U.S. population). The data provided by Nielsen quantifies unit DVD sales in these DMAs for the years 2000, 2001, and 2003. We convert this to per capita DVD sales using census data for each DMA.

Our broadband penetration data was collected from the Current Population Survey (CPS), a monthly household survey conducted by the Bureau of the Census for the Bureau of Labor Statistics. The Current Population Survey provides a comprehensive body of information on the Nation's population, classified by age, sex, race, and a variety of other characteristics. The CPS covers a representative sample of approximately 130,000 individuals nation-wide and asks a multitude of questions regarding employment, income level, etc. The CPS is one of the most comprehensive and reliable data source and these data are used by many government and research organizations to inform policy decisions (www.bls.gov/cps).

The CPS also periodically issues "Internet use" supplements, and some of the questions on this survey are whether a user has a broadband connection (typically defined as a speed of 200 kilobits per second one way) and what type of broadband connection is used (e.g., DSL, Cable, Satellite, Fiber Optic. With these questions, the CPS data allow researchers to know the proportion of users within a geographical area who have an Internet broadband connection, and to have a limited idea of how these connections are being used.

[4] Note that Internet sales are allocated at the customer's location, not the retailer's location.

The CPS aggregates its data by Metropolitan Statistical Area (MSA), which are smaller in size than DMAs. Broadband data is available for the 241 largest MSAs in the country, covering 82% of the U.S. population. The CPS provides broadband information as un-weighted raw number as well as weights for the number by households and the number of persons. We use person-weighted data (PWSSWGT) as it is the standard weight used for demographic calculations.[5] Further details on the CPS data and weighing scheme can be found (http://www.bls.census.gov/cps).

Our demographic data was collected from Sourcebook America for the 2000 and 2003 for each DMA.[6] For 2001 we extrapolated data from 2000 and 2003 and used available data from the MSA level. Our demographic data include control variables for the population of the MSA; and for the median age, median income level, proportion of whites, proportion of males, and proportion of the population between the ages of 15 and 24 for each DMA. These variables are included as controls, and also have a theoretical basis, particularly in the case of 15 to 24 year old males. According to a recent study conducted by LEK Consulting for the Motion Picture Association, 16 to 24 year olds and males made up 71% and 58% respectively of active Internet downloaders in 2004 (LEK 2005).

One remaining challenge is to match our DMA-based DVD sales data to the MSA-based broadband usage and demographic data. In previous work (e.g. Boorstein 2004), this mapping was based on the assumption that if the largest zip code in an MSA was contained in a DMA, then the whole MSA was mapped into that DMA. This approach, while reasonable, can create problems as DMAs typically encompass a larger area than MSAs do.

[5] Household weights give similar results, but person-weighted data are better suited to our disaggregate analysis.
[6] Note that the Sourcebook America data are compiled by ESRI (www.esri.com).

In an attempt to map MSAs into DMAs more precisely, we create a mapping based on the individual zip codes for each MSA and DMA, along with the population of each zip code obtained from the U.S. census.[7] We then match MSAs into DMAs using zip codes. Not every zip code of a DMA is matched into an MSA; however, our mapping is still quite good. On average, we can map about 88% of a DMA into one or more MSAs. For larger and more urban DMAs almost 100% mapping is achieved (for example New York or Philadelphia). However, there are a few DMAs where coverage is less than 50% (for example the Johnstown-Altoona DMA). Thus, while imperfect, we believe this mapping is accurate for our analysis and represents an advance of techniques in the extant literature. Below, we perform sensitivity analysis to verify how robust our results are to DMA coverage.

Using this mapping to measure broadband penetration level at a DMA level, we weight the MSA-level broadband penetration by the proportion of MSAs that belongs to a DMA. For example, if 30% of MSA-A's zip codes (mapping fraction of MSA) and 70% of MSA-B's zip codes map into DMA-1, we first calculate per capita broadband penetration at the MSA level, weight them by the mapping fraction, and sum them up to calculate per capita broadband penetration at DMA level.

With regard to market data, one shortcoming on the Nielsen DVD sales data is that it does not include Wal-Mart sales. In our sample time period, Wal-Mart accounted for approximately 29% of all DVD sales in the United States (Alexander and Associates, cited in Mortimer 2006), a share that seems to be increasing over time. For example, Wal-Mart notes that in 2006 it was "Hollywood's biggest customer, accounting for 40% of [Hollywood's] DVD sales" (Wal-Mart,

[7] http://mcdc2.missouri.edu/websas/geocorr2k.html, last accessed April 11, 2009.

2006).[8] However, because of the absence of Wal-Mart sales in our data it is important to control for changes over time in the number of Wal-Mart outlets in the DMAs we analyze. To do this, we obtained a list of all Wal-Mart locations in the United States, their address (including zip code), the type of store (Superstore, Wal-Mart, local store), and their opening date.[9] We use this data to construct a variable for the number of new Wal-Mart retail stores in each DMA that opened since the baseline 2000 year. Table 1 presents summary statistics for our data.

Table 1: summary Statistics

	Year 2000		*Year 2001*		*Year 2003*	
	Mean	*Median*	*Mean*	*Median*	*Mean*	*Median*
Per capita DVD sales (pc_sale)	0.19 (0.09)	0.185	0.38 (0.17)	0.37	0.978 (0.243)	0.982
Per capita broadband usage (pc_bband)	0.046 (0.03)	0.044	0.112 (0.05)	0.107	0.241 (0.07)	0.255
Population (in 000)	2,424 (2,754)	1,580	2,454 (2,785)	1,595	2,516 (2,846)	1,643
Median income (in 000)	40.92 (6.0)	41.05	42.26 (6.3)	42.15	44.93 (6.95)	44.6
Median age (in years)	35.8 (2.4)	35.7	36.06 (6.05)	36.0	36.56 (2.6)	36.45
Proportion of Males	49% (0.68)	48.9%	49.03% (0.67)	48.93%	49.08% (0.64)	49%
Proportion of Whites	79.85% (11.4)	82.7%	79.55% (11.7)	82.45%	78.96% (11.7)	82%
Age between 15 and 24	14.07% (0.01)	14.1%	14.14% (0.01)	14.1%	14.28% (0.015)	14.2%
No. of new Wal-Marts per DMA since 2000			1.01 (0.76)	0.0	1.93 (2.93)	1.0
N	98	98	98	98	98	98
DMA_Coverage_factor	0.76 (0.21)	0.83				

6. Results

As mentioned above, our analysis is conducted at the DMA level and our dependent variable is per capita DVD sales. Our key explanatory variable is per capita broadband penetration. We also

[8] Similarly, a 2005 story in Variety placed Wal-Mart's sales at 37% of total Hollywood output (Learmonth 2005).
[9] We eliminate "local stores" from this is data as discussions with Wal-Mart public relations staff suggested that these stores typically sell very few DVD titles. Our results are not sensitive to this assumption.

use various control variables for demographic characteristics and the number of new Wal-Mart stores opened in 2001 and 2003. We first estimate a fixed effect specification as in (1). The fixed effects estimates control for any unobserved DMA-level (and time-level in models 2 and 3) effects even if they are correlated with broadband penetration. When controlling for autocorrelation we relax the assumption that the error terms are not auto-correlated.

Table 2: Fixed Effect Regressions

Indep. Vars.	Fixed Effect (1)	Fixed Effect with Time Dummies (2)	Fixed Effect with Time Dummies and Autoregressive Errors (3)	Fixed Effect with Time Dummies, Autoregressive Errors, Coverage >0.75 (4)
Per Capita Broadband Penetration	1.08** (0.21)	0.61** (0.21)	0.58* (0.22)	0.68** (0.34)
Log(Population)	-0.56 (0.87)	-0.70 (0.71)	-1.95 (1.04)	-3.13* (1.4)
Median Income	0.08** (0.013)	0.06** (0.012)	0.07** (0.017)	0.05** (0.025)
% Whites	-0.21** (0.057)	-0.17** (0.05)	-0.19* (0.06)	-0.20* (0.078)
% Males	-0.20** (0.13)	-0.23** (0.10)	-0.36** (0.14)	-0.57* (0.48)
Median Age	0.09** (0.024)	0.03 (0.03)	0.04 (0.05)	-0.12 (0.13)
% 15-24 Year Olds	0.20** (0.06)	0.20** (0.06)	0.26** (0.02)	0.23 (0.13)
Wal-Mart Supercenters	0.01 (0.05)	0.002 (0.005)	-0.001 (0.006)	-0.011 (0.007)
Time Dummies	No	Yes	Yes	0.313
Autoregressive Errors (AR1)	No	No	0.37	Yes
Constant	25.874 (18.4)	28.9** (15.07)	53.83** (12.8)	89.0** (26.5)
No. of Obs.	294	294	196	114
R^2 (Within)	0.94	0.95	0.94	0.95

The dependent variable is per capita DVD sales. Standard errors are listed in parenthesis; ** and * denote significance at 0.5 and 0.10, respectively. All models use DMA-level fixed effects.

The results are presented in Table 2. In Column 1 we present the results of our model using only DMA-level fixed effects. In Column 2 we add controls for year-level effects. And in Column 3, we add controls for autoregressive errors as outlined above. As noted in the body of the text, one of the issues with our data is the DMA coverage factor. While overall MSA-DMA mapping is fairly comprehensive (with a mean matching of 0.77 and median of 0.83) some of the DMAs are

not precisely matched. To address the possibility that mapping errors are driving our results, in column (4) we re-estimate the model for only DMAs with coverage > 0.75.

The effect of broadband penetration is large, positive, and statistically significant in the fixed effects regression (column 1). Adding additional controls for time effects and autocorrelation reduces the magnitude of this coefficient, but it remains large, positive, and statistically significant in both the time effects (column 2, p=0.01) and autoregressive (column 3, p=0.10) results. Note that controlling for autoregressive errors reduces the number of observations, which impacts the standard errors and resulting significance in column 3. The results in Column 4 are very similar to the main regression, suggesting that our results are not sensitive to including DMAs with lower coverage.

We also note that the signs of the control variables are consistent across specifications[10] and that the (suppressed) time dummies in specification 2 are highly significant indicating that controlling for time effects is important. The autoregressive coefficient ($\rho = 0.31$) in column 3 is not particularly large. However, including it does have a significant impact on the magnitude of broadband penetration. Characteristic of fixed effects regressions, the fit of the model is excellent across specifications.

An alternate way to estimate this model is through the first difference method. In first differences, instead of running a regression of Y_{it} on X_{it}, we run the regression of Y_{it}-$Y_{i(t-1)}$ on X_{it}-$X_{i(t-1)}$. When T =2, fixed effects and first difference produce the same results. When T > 2, the models are different. In particular, first differencing allows the error term to be auto-correlated. In fact, if the autocorrelation is high, then first differencing will produce more efficient

[10] Note that the coefficient on Log(Population) is statistically insignificant in each specification.

estimates. We re-estimate our model using first differencing method and present the results in Table 3.

Table 3: First Difference Estimation

Indep. Vars. (with differencing)	Estimates
Per Capita Broadband Penetration	0.25** (0.10)
Log(Population)	0.03 (0.44)
Median Income	0.03** (0.01)
% Whites	-0.10** (0.03)
% Males	-0.17** (0.05)
Median Age	0.02 (0.02)
% 15-24 Year Olds	0.12** (0.03)
Wal-Mart Supercenters	-0.01 (0.01)
Time dummy	-0.02 (0.02)
Constant	0.12** (0.03)
No. of Obs.	196
R^2	0.62

The dependent variable is per capita DVD sales.
Standard errors are listed in parenthesis; ** and * denote significance at 0.5 and 0.10, respectively.
All models use DMA-level fixed effects.

As before, the estimate on per capita broadband penetration is large and statistically significant. It is also quite similar in magnitude to the coefficient in the autoregressive results in Column 3 of Table 2. The other control variables have the same signs as the fixed effects results. Thus, we conclude that per capita broadband penetration has a positive and statistically significant impact on DVD sales, and that this result is robust across a variety of different specifications.

Finally, it is possible that the broadband variable is serving as a proxy for a DMA-level technological sophistication as opposed to purely measuring broadband Internet access. Ideally, we would be able to address this concern by including a closely related technology variable, such as DVD player penetration. Unfortunately, neither Nielsen, nor any other company we contacted, tracked DVD player penetration at a DMA-level during our study period. However, as a

substitute, in Table 4 we re-estimate our model controlling for DMA-level PC penetration. These results are consistent with the results reported above: after controlling for PC penetration, broadband penetration still has a strong, positive impact on DVD sales. The coefficient on PC penetration is negative, but is only statistically significant at the .10 level.

Table 4: Fixed Effect Regressions with Controls for PC Penetration

Indep. Vars.	All DMAs (1)	DMAs with Coverage > 0.75
Per Capita Broadband Penetration	0.63** (0.22)	0.79** (0.39)
PC Penetration	-0.35* (0.19)	-0.68* (0.36)
Log(Population)	-0.75 (0.70)	-1.63 (0.79)
Median Income	0.06** (0.012)	0.05** (0.02)
% Whites	-0.17** (0.07)	-0.15** (0.06)
% Males	-0.22** (0.11)	-0.33 (0.31)
Median Age	0.04 (0.05)	-0.12 (0.13)
% 15-24 Year Olds	0.21** (0.05)	0.23 (0.13)
Wal-Mart Supercenters	0.001 (0.01)	0.002 (0.01)
Constant	29.95* (15.21)	53.78* (26.74)
No. of Obs.	297	171
R^2 (Within)	0.94	0.95

The dependent variable is per capita DVD sales. Standard errors are listed in parenthesis; ** and * denote significance at 0.5 and 0.10, respectively. All models use DMA-level fixed effects and time dummies.

What is the economic significance of a positive and significant estimate on per capita broadband? If we take the most conservation estimate of 0.23 (Table 2, Column 3), this suggests that a unit increase in per capita broadband penetration has caused an increase of about 0.23 units in per capita DVD consumption. From year 2000 to 2003, the average per capita penetration of Internet broadband access increased from 0.046 to 0.25 or about 0.204 units (Table 1). Since β = 0.23, this suggests that this increase in broadband penetration accounted for a per capita increase in DVD sales of 0.23*0.204 = 0.047 units. From Table 1, note that during this time period per capita DVD sales increased from 0.19 units to about 0.697 units.

Thus, our results indicate that 9.3%[11] of the increase in DVD sales from 2000 to 2003 is directly attributable to increased Internet broadband penetration. In dollar terms, given that DVD sales increased by $14.1 billion during our study period (MPA 2004), this corresponds to a $1.3 billion increase in DVD sales that is directly attributable to increased access to broadband digital networks. In terms of profit, previous studies have found that the wholesale price of DVDs is approximately 60% of the retail price (Mortimer 2006), and conversations with industry executives suggest that 80% of studio revenues on DVD sales translate into direct profit. Thus, the $1.3 billion in increased revenue translates into $630 million of increased profit to studios directly attributable to increased broadband penetration from 2000 to 2003.

7. Discussion

Increased broadband Internet penetration may impact media companies and the economy in a variety of ways. On one hand, broadband Internet penetration may facilitate piracy, reducing media sales. On the other hand, broadband Internet penetration may improve consumers' ability to discover and evaluate media products and may increase media firms' ability to target their promotions to the right consumers. In this light, some might argue that media companies have focused disproportionately on the first concern, to the exclusion of the second opportunity.

In our research we attempt to disentangle these piracy and promotion effects. To do this, we start by compiling a dataset that quantifies broadband Internet penetration and DVD sales at a regional level. We analyze this data with both fixed effects and first difference statistical models, allowing us to avoid simultaneity bias.

[11] I.e., 0.047 / (0.697 – 0.19)

Our results show a large, statistically significant, positive impact of increased broadband penetration on DVD sales, a result that is robust to a variety of specifications. Using our most conservative estimates, we find that increased broadband penetration accounts for 9.3% of the $14.1 billion increase in DVD sales over our study period — representing $1.3 billion in increase revenue and $630 million in increased profit to the studios.

We then compare these results to Liebowitz (2008) who uses similar econometric models, during essentially the same time frame, on a similar product category: music CDs. In contrast to our results, Liebowitz finds that increased broadband Internet penetration had a strong negative impact on CD sales. We note that in spite of the similarities between our models, timeframe, and products there is one significant difference between Internet music and movie availability that may explain these contrasting results: While music piracy was easy, of a relatively high quality, and widespread from 2000 to 2003, movie piracy was still relatively difficult, of low quality, and limited during this period. If differences in the ease of piracy were to explain the difference in broadband's impact on CD and DVD sales it would suggest that, absent piracy, the Internet represents a significant sales and marketing opportunity for media companies.

As discussed in the theory section, we believe there are several possible reasons why broadband Internet access could increase sales. First, it is possible that having access to broadband digital networks lowers the search costs for users to find information about media content, leading to an increase in sales. Many of the most popular sites on the Internet are primarily associated with providing consumers information about media content (in the context of movies, these would include the Internet Movie Database, yahoo movies, MSN Entertainment, Apple movie trailers, Rotten Tomatoes, Moviefone, Hollywood.com, Fandango.com). It is reasonable to suggest that

allowing consumers to easily access such multimedia information about movies through broadband connections could lead to increased DVD sales.

A related candidate explanation for the broadband digital networks leading to increased DVD sales is that digital networks allow movie studios great flexibility to target advertisements to their consumers. These dual explanations of increased access to advertising and decreased search costs for product information resonated with a representative of a major Hollywood studio who, being shown our results, commented:

> "Fundamentally, people buy DVDs when they really like a movie, and want to watch the movie (or the special features) again and again, either now or at some point in the future…So marketing/advertising, either via [broadband] or TV, doesn't over-expose these people to the movie, it just reminds them how much they like it and want to own it..."

In conjunction with increased access to product and advertising information, broadband digital networks also provide consumers with access to an increased variety of DVDs than what could be found in brick-and-mortar stores. Typical brick and mortar video stores sell fewer than 1,000 titles, and Wal-Mart superstores typically sell fewer than 500 unique titles. In contrast, Amazon.com sells nearly all of the more than 30,000 DVD titles in print — and consumers seem to have strong demand for these niche titles. Anderson (2006) reports that DVD titles ranked below 1,000 sell three times as many copies online as they do in brick-and-mortar markets.

It is also possible that having a broadband connection may spur the purchase of related equipment, such as laptop or desktop computers, which allow users to watch DVDs in new settings, thus increasing DVD sales. However, whatever the specific explanation, it is clear from

our results that the dominant impact of increased broadband penetration is increased sales of DVDs, not decreased sales as previously feared by the movie industry.

Finally, we note that our results are conservative in two important respects. First, the fact that the proportion of DVDs sold at Wal-Mart (which is not represented in our sales data) is increasing over time, should have the effect of reducing any observed increases in DVD sales in our data *ceteris paribus*. Second, any increases in broadband speed over time are unobserved in our data and will have the effect of increasing piracy and reducing DVD sales in our data. In each case, these unobserved effects will bias our results away from finding that increased broadband penetration leads to an increase in DVD sales, making our reported results conservative.

Our results are not without limitations, however. First, it would be ideal have an identification strategy that does not rely on comparing results across two different product categories and studies. Second, it is possible that the increase in DVD sales during our time period is unrelated to the Internet's promotional impact on sales, for example direct substitution between CDs and DVDs. Third, even though we control for DMA-level fixed effects, finding an instrument for broadband penetration would be ideal and would remove any potential bias of time varying unobserved effects that may be correlated with changes in broadband penetration. In spite of these limitations, we believe our study provides insight into an important managerial and policy question by highlighting both the risks and rewards of increased Internet penetration for consumers, media companies, and society.

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