MARKETING SCIENCE
Vol. 29, No. 6, November–December 2010, pp. 1138–1151
ISSN 0732-2399 | EISSN 1526-548X | 10 | 2906 | 1138

informs

DOI 10.1287/mksc.1100.0600

Converting Pirates Without Cannibalizing Purchasers: The Impact of Digital Distribution on Physical Sales and Internet Piracy

Brett Danaher
Wellesley College, Wellesley, Massachusetts 02481, bdanaher@wellesley.edu

Samita Dhanasobhon, Michael D. Smith, Rahul Telang
Heinz College, Carnegie Mellon University, Pittsburgh, Pennsylvania 15213
{sdhanaso@andrew.cmu.edu, mds@andrew.cmu.edu, rtelang@andrew.cmu.edu}

The availability of digital channels for media distribution has raised many important questions for marketers, notably, whether digital distribution channels will cannibalize physical sales and whether legitimate digital distribution channels will dissuade consumers from using (illegitimate) digital piracy channels. We address these two questions using the removal of NBC content from Apple's iTunes store in December 2007, and its restoration in September 2008, as natural shocks to the supply of legitimate digital content, and we analyze the impact of this shock on demand through BitTorrent piracy channels and the Amazon.com DVD store.

To do this we collected two large data sets from Mininova.com and Amazon.com, documenting levels of piracy and DVD sales for both NBC and other major networks' content around these events. We analyze these data in a difference-in-difference model and find that NBC's decision to remove its content from iTunes in December 2007 is causally associated with an 11.4% increase in the demand for NBC's pirated content. This is roughly equivalent to an increase of 48,000 downloads a day for NBC's content and is approximately twice as large as the total legal purchases on iTunes for the same content in the period preceding the removal. We also find evidence of a smaller, and statistically insignificant, decrease in piracy for the same content when it was restored to the iTunes store in September 2008. Finally, we see no change in demand for NBC's DVD content at Amazon.com associated with NBC's closing or reopening of its digital distribution channel on iTunes.

Key words: Internet; piracy; digital distribution; distribution channels; cannibalization
History: Received: April 29, 2009; accepted: June 16, 2010; processed by Duncan Simester. Published online in *Articles in Advance* October 20, 2010.

We can't compete with free. That's an economic paradigm that doesn't work.—James Gianopulos, Co-Chairman, Twentieth Century Fox (quoted in Thompson 2003)

You'll never stop [piracy]. What you have to do is compete with it.—Steve Jobs, CEO, Apple Inc. (quoted in Goodell 2003)

1. Introduction

The development of digital distribution channels has raised many important questions for marketers. For television and movie studios, two of the more important questions are (1) can paid digital distribution channels serve as an attractive alternative to consumption through ("free") digital piracy channels, and (2) will digital distribution cannibalize DVD box set sales?

With respect to the first question, the quote above from James Gianopulos, co-chairman of Twentieth Century Fox, is representative of many in the industry who claim that it is difficult, if not impossible, to successfully use paid digital distribution channels to compete with a free (albeit illegal) piracy channel. On the other side of this argument, Steve Jobs, CEO of Apple Incorporated, claims that digital distribution channels, such as Apple's iTunes video store, offer studios the best opportunity to compete with piracy channels by mimicking the ease and convenience of pirated channels at a competitive price point.

With respect to the second question, there is ample evidence in the business press that DVD retailers feel that studios' distribution through digital channels will significantly cannibalize sales of DVDs. For example, in late 2006, after Disney finalized a deal to distribute its movies through iTunes, press reports claim that a Walmart executive visited Hollywood Studios to tell them that "it will retaliate against them for selling movies on Apple's iTunes [store]" (Arango 2006). This report goes on to note that Walmart, which makes up an estimated 40% of studios' DVD sales, made good on this threat by sending "'cases and cases' of DVDs back to Disney" (Arango 2006). Similarly,

Target, which makes up an estimated 15% of DVD sales, sent a letter to studios threatening them not to follow Disney into digital distribution (McBride and Marr 2006) and, reportedly after sending this letter, "ordered its stores to take down a multitude of internal signs steering customers to Disney products" and replaced Disney's endcap promotional displays with displays for Disney's competitors (Menn 2006).

However, whereas these questions have received much discussion in the industry and in the press, we are not aware of any empirical studies that address the degree to which digital distribution of media content affects demand for physical content and demand for Internet piracy. The goal of this paper is to analyze these questions through a quasi-experiment that occurred on December 1, 2007. During August of 2007, NBC expressed dissatisfaction with the Apple iTunes store's pricing policy. Whereas NBC (and other media companies) wanted more flexibility in pricing, Apple was enforcing a one-price-fits-all policy across nearly all television episodes for sale on iTunes. When negotiations broke down, NBC announced that it would remove all of its content from iTunes on December 1, 2007, a significant move since NBC reportedly supplied 40% of all video content on the iTunes store.[1] In response, Apple refused to offer NBC's fall 2007 season for sale starting in September 2007, and on December 1, 2007, Apple removed all older NBC content from iTunes.

In our analysis, we use this event as an exogenous shock to the legal digital supply of all older seasons of NBC television. This content was generally available for sale on DVD, on iTunes (prior to December 1), and through piracy, and thus we study a market with a physical sales channel, a digital sales channel, and a piracy channel. We account for the possibility of a time trend by comparing changes in piracy and DVD sales two weeks before versus two weeks after December 1 for NBC's competitor networks, ABC, CBS, and Fox (all of which continue to offer their content on iTunes and thus received no shock on December 1). We then contrast this time trend with the change in piracy and Amazon.com DVD sales for NBC, arguing that any differences for NBC content after December 1, over and above the difference for similar television networks, was caused by the removal of NBC content from iTunes. Finally, we ask whether our findings are upheld in a second experiment on September 9, 2008, when NBC restored all of its content to the iTunes store.

We find that the removal of NBC content from iTunes caused an 11.4% increase in piracy for its content, which corresponds to 27 more pirated downloads per day per episode, or about 48,000 total additional pirated downloads per day. This number is nearly twice as large as the daily number of downloads of these episodes on iTunes in the two weeks prior to December 1, implying a fixed cost associated with the decision to pirate: once individuals start to pirate, they pirate more content than they would have originally purchased. This may also imply a spillover effect—that piracy of content on other networks could have increased as a result of NBC's decision to remove its own content from iTunes. Although we cannot positively identify this externality because of the lack of an appropriate counterfactual, our results are consistent with such an effect because non-NBC piracy increased by 5.8% over this time period (and thus the documented 11.4% increase in piracy may understate the true displacement of piracy by digital distribution). Finally, although studying NBC's return to iTunes in September 2008 is complicated by the start of a new season of television, our evidence suggests that the restoration of NBC content to iTunes caused a smaller, statistically insignificant drop in piracy, which is also consistent with a fixed cost to piracy.

In contrast to the strong correlation between legitimate digital distribution and piracy, we find no change in the Amazon.com sales rank of NBC television season box sets in the four weeks surrounding December 1 relative to the baseline change in non-NBC box sets, implying that while customers who cannot purchase digitally may turn to piracy, they do not consider DVD box sets—at least those sold on Amazon.com—as a substitute to digital downloads.

2. Literature Review

As this paper addresses the interaction between legitimate digital and physical distribution channels, as well as the interaction between legitimate and illegitimate digital distribution channels, the paper fits into two main literatures: the marketing literature studying interactions between various distribution channels, and the economics and information systems literature on online piracy of digital goods.

With respect to the piracy literature, most existing studies examine the effect of online piracy on physical media sales. Most of these studies analyze the impact of piracy on music CD sales, with a few recent studies examining the impact of piracy on movie or television revenue. The challenge in this literature is typically identification, as the correlation between physical sales and pirated downloads of each movie or song is predominantly driven by unobserved heterogeneity across goods.

Papers in this literature address the identification issue in several different ways: through cross-country variation, exogenous shocks to demand, or survey results. With respect to cross-country variation, Zentner (2005), Hui and Png (2003), and Peitz

[1] See Msnbc.com (2007).

and Waelbroeck (2004) use international panel data on music sales and pirated downloads, with each study finding that piracy displaces CD sales to some extent. Similarly, Danaher and Waldfogel (2008) examine the impact of online piracy of Hollywood movies on international box office revenue and find evidence of displacement of ticket sales by online piracy.

In the context of exogenous shocks, one of the tests used by Oberholzer-Gee and Strumpf (2007) takes holidays in the German school system as exogenous demand shocks and finds little or no displacement associated with music piracy. Likewise, Smith and Telang (2009) use the television broadcast of a movie as an exogenous demand shock for the DVD and find little or no displacement of DVD sales from piracy for movies broadcast on television.

Finally, in the context of survey data, Rob and Waldfogel (2006) use survey data from a population of college students, asking whether individuals who pirate music purchase less music, including controls such as stated valuations of the albums in question or personal taste for music. Rob and Waldfogel (2007) use a similar approach to study the effect of movie piracy on paid consumption of movies such as theater attendance, DVD rental, and DVD purchase. In both studies, the authors find displacement of paid consumption by piracy.

Thus, the majority of existing empirical studies in the literature find some degree of substitution of unpaid "pirated" consumption for paid consumption,[2] which raises the question of how firms should optimally combat the negative effects of piracy. Recent papers in the literature have examined this question in the context of litigation against pirates, protection of media content through digital rights management (DRM) systems, and purposefully damaging the performance of file sharing networks.

Addressing the effectiveness of the first anti-piracy tool, Blackburn (2004) and Bhattacharjee et al. (2008) examine the impact of the RIAA's legal threats against individual file sharers during the summer of 2003 as a quasi-experiment, with both sets of authors finding that when the threat of litigation is higher, file sharing declines but availability of content is still substantial. In the context of DRM protection, Vernik (2009) and Sinha et al. (2010) argue that the presence of DRM may *increase* piracy by reducing the usability of the purchased files, causing consumers who otherwise would have purchased to pirate instead. In the context of degrading the performance of file-sharing networks, Christin et al. (2005) study the impact of several different "poisoning" strategies on four popular peer-to-peer file-sharing networks and find that the injection of a few replicated decoys can strategically manipulate users' perception of content availability in the network.

However, another important tool that media companies may be able to use to reduce the impact of piracy is directly competing with piracy channels by adding legitimate digital distribution channels. To the best of our knowledge, there are no papers in the literature that examine the interaction between legitimate and illegitimate (piracy) digital distribution channels, and one contribution of this paper is to examine this question.

Our question is also related to the interaction among different distribution channels, which has been widely studied in the marketing literature. For example, Jeuland and Shugan (1983) show that coordination between distribution channels leads to higher profits. Extending this finding, Chiang et al. (2002), Chu et al. (2007), and Webb (2002) develop strategies for firms to manage multiple distribution channels effectively. In the context of direct distribution channels, Balasubramanian (1998) uses analytic models to show that the presence of direct distribution channels, including Internet channels, yields higher returns when the product is well adapted to the channel. Other papers in the marketing literature also note that the more differentiated two channels are, the less likely they are to cannibalize one another (e.g., Friedman and Furey 1999, Viswanathan 2005).

However, there are relatively few papers in the literature that attempt to directly measure the effect of digital distribution on physical channel sales. One exception is Deleersnyder et al. (2002), who use a sample of 85 British and Dutch newspapers that added digital distribution channels and find that when newspapers make their content available online, the online content has only a small impact on physical newspaper sales. Likewise, Biyalogorsky and Naik (2003) find that Tower Records' addition of an Internet distribution channel did not significantly cannibalize its retail sales. With respect to video distribution, Waldfogel (2009) uses survey data to show that authorized YouTube viewing of television content has only a small net displacement effect on over-the-air viewing and may achieve complementarities between the two channels.

In summary, the challenges of identification are significant in this domain. Our paper contributes to the literature by being the first paper, to our knowledge, to use a natural quasi-experiment impacting the supply of legitimate content to address the identification problem. Our paper also contributes to the literature

[2] We note that many analytic papers have found that piracy need not be harmful to the copyright industries. For example, Jain (2008) argues that piracy need not be harmful to the extent that it may serve as a price discrimination device, allowing price-sensitive consumers to pay nothing and reducing price competition among other consumers.

by proposing a technique to collect data documenting piracy levels over time and by being the first paper we are aware of to empirically estimate how legitimate digital distribution channels interact with demand through both physical and piracy channels.

3. Theory

3.1. Digital Distribution and Piracy

Theory does not clearly predict the effect of a digital sales channel on consumption in a digital pirate channel. On one hand, iTunes purchases (by far the dominant legitimate digital channel for video purchases) and pirated downloads are similar in that both provide high-quality, usually fast file downloads that can be viewed on a computer or, with some effort, a television or portable video device.[3]

Given these similarities, one might ask why anyone would purchase through a digital distribution channel if piracy is free. For this to occur, there must be some nonfinancial cost to piracy. There are several possible categories into which that cost could fit:

(i) There may be a cost to learn to use BitTorrent, which would be akin to a fixed cost (especially because BitTorrent is generally considered to be easy to use once learned).

(ii) Individuals may experience moral qualms about pirating, which could have the characteristic of a fixed cost (see, for example, Nagin and Paternoster 1991 in the context of fixed moral costs to committing crimes) or a variable cost.

(iii) Individuals may fear being caught and punished, a cost which is also variable with respect to downloads.

(iv) It is possible that pirated downloads are viewed as less convenient (and lower quality) compared with iTunes consumption (either because of the relative ease of use of iTunes versus piracy sites or the variability in quality through piracy sites). This cost would also be variable with respect to the number of downloads.

Given this information, it is straightforward to analyze how the removal of a digital sales channel might impact piracy. Specifically, consider a standard downward sloping demand curve for media downloads and two cases: one where the decision to purchase instead of pirate is driven solely by the high fixed cost of piracy and one where the decision to purchase is driven solely by the high variable costs of piracy.

If the costs to piracy are largely "fixed" in nature and this fixed cost is sufficiently large, then consumers will forgo investing the fixed cost of piracy and purchase a certain quantity of legitimate digital content. However, once the legitimate channel is removed, some consumers will invest the fixed cost associated with piracy and, owing to the lower marginal costs of piracy, will *increase* their overall level of consumption. On the other hand, if the cost to piracy is variable in nature (i.e., each pirated content imposes a marginal cost) and the marginal cost is constant in the number of pirated episodes, then once the legitimate channel is removed, consumers will *decrease* their level of consumption of pirated content relative to purchased content.

There are, of course, other possible structures for the nonfinancial cost of piracy, including a mix of fixed and variable costs as well as increasing or decreasing marginal cost.[4] However, even in these environments, one can show that when the digital purchase channel is removed, it is possible that an individual would either not turn to piracy, begin to pirate a number of episodes less than or equal to the number of purchases she had been making on iTunes, or even begin pirating more content than she had ever purchased. In short, because of data limitations, we cannot model piracy costs at an individual level; however, we can use the theory outlined above to infer the general nature of piracy costs perceived by consumers by observing changes in piracy after iTunes removal. Specifically, an increase in piracy after iTunes removal that is larger than the preremoval iTunes sales would be consistent with a fixed cost to piracy among a substantial number of users, either through learning or moral costs.

On the other hand, the theory behind the substitutability of iTunes purchases for DVD box sets is less clear than it is for the piracy. It is possible that digital goods cannibalize physical sales. However, unlike the comparison of digital sales to piracy, digital goods do not necessarily have lower profit margins than physical goods do. Moreover, even if digital goods margins are lower, there may be sufficient differentiation between digital and physical goods that they appeal to different customer segments. Finally, even if box sets and file downloads are substitutes for each other, it is possible that individuals who "go digital" will be disinclined to go back to the physical product (indeed, this would be analogous to a fixed cost associated with beginning to download/watch television online).

In summary, iTunes customers may otherwise have been pirates, may otherwise have purchased the box set, or may otherwise not have consumed the content

[3] Pirated files, of course, tend to be easier to share or use on a variety of devices (in large part because of the lack of digital rights management restrictions on playback), whereas iTunes downloads tend to have more consistent quality.

[4] In fact, it is possible to show that if the marginal cost is increasing, then consumers might mix behaviors, pirating some episodes and purchasing others.

at all. We have shown that it is even theoretically possible that the availability of content on iTunes could displace more pirated downloads than the number of episodes being purchased on iTunes.

Following this analysis, we ask the following two major empirical questions:[5]

(i) What happens to the level of piracy of television content when that content is removed from iTunes (and when it is returned)?

(ii) What happens to DVD sales of television seasons sold on the Internet when those seasons are removed from the iTunes store?

The answers to (i) and (ii) also provide evidence of the percentage of iTunes purchases that come from otherwise would-be pirates, the possibility that one network's decision to use (or not use) a digital distribution channel can influence piracy of content on other networks, and the shape of the nonfinancial cost curve associated with piracy.

4. Data

To address these questions, we use panel data on consumption of pirated television content through major BitTorrent tracker sites, and panel data on sales of DVD season box sets at Amazon.com. We describe these data in more detail below.

4.1. Piracy Data

Following Smith and Telang (2009), we use the level of daily downloads of BitTorrent tracker files at Mininova.org as a proxy for piracy activity on the programs in our sample. The website Mininova is a search engine for torrent trackers—the files that allow you to link to other computers and download a specific piece of media content. BitTorrent serves as a useful proxy for video piracy as it was the most popular source of pirated video downloads during our study period (Smith and Telang 2009). Mininova is a useful proxy for download levels through the BitTorrent protocol because it was the most popular BitTorrent tracker site during our study period according to Alexa.com,[6] it posts a large number of television tracker files, and unlike some other sites, it provides information on the cumulative number of downloads for all tracker files downloaded from its site.

Our piracy data set contains the daily number of downloads for 5,200 unique television episodes (corresponding to roughly 75 unique series) starting November 16, 2007. The data include the series name, season number, and episode number of each television program, as well as the number of times that file was downloaded each day. We also added indicators for the network that owns the rights to the show, the genre of the show, and whether the show is a series that is still producing new episodes (such as *Heroes*) or a "catalog" series (such as the original *Star Trek*).

This data set was created from a larger data set we collected monitoring all television trackers posted to Mininova. We collected data at the torrent level starting in November 2007, obtaining roughly 210,000 records per day and yielding a data set of over 68 million observations for 180,000 torrents. We extracted the torrent file names from this data set and interpreted the file names to code the series, season, and episode for our television data. When a file contains multiple episodes of a television show, we counted this as a download for each episode contained in the file. Because multiple files frequently map to the same episode of television (for example, there may be six different torrent files that contain, say, season 1, episode 4, of *Grey's Anatomy*), we then collapsed the data to the episode level by adding the total daily downloads for an episode across all tracker files mapping to that episode. Repeated observations of the same content over a period of a month should minimize any potential measurement errors in our data.

For our analysis, we focus on piracy among television programming for NBC and its subsidiaries (USA and the Sci-Fi Channel (now Syfy)). We also analyze piracy for television programming from the other major television networks—ABC, CBS, and Fox—as a control. We removed all content from the 2007–2008 season from the data because, as noted above, the NBC content being sold on iTunes prior to December 1 only included episodes prior to the 2007–2008 season.[7] Thus, our analysis compares changes in piracy for older "out-of-season" content.

Finally, in our analysis we focus on the time period two weeks before and two weeks after December 1, 2007 (as well as the two weeks before and after September 9, 2008) to best isolate the effect of the removal of NBC content from iTunes on piracy. Our main strategy will be to compare the change in piracy for NBC content after December 1 to the change in piracy for non-NBC content, arguing that any incremental NBC change over and above the non-NBC change is attributable to the removal of NBC content from iTunes.

It is important to note that although December 1, 2007 was the official date of NBC's removal from iTunes

[5] As we discuss in detail in §4, it is important to note that of necessity we are asking these questions in relation to older, off-season content for most of our analysis.

[6] Available from http://www.alexa.com/, accessed April 19, 2009.

[7] This is because, starting in August 2008, Apple did not add any new NBC content to the iTunes store in response to NBC's announcement that they would remove all of their content in December.

and December 2 is the first entire day on which the iTunes store held no NBC content, Apple actually began the removal process on November 30 and continued through December 1. Thus we might expect to see some increase in piracy as early as November 30, but we conservatively remove December 1 from the data and code December 2 as the first day of the "postremoval" period in the data. If, as our data show, piracy began to increase as soon as the removal began, then our selection of this later removal date will lead to an underestimate of the true change in piracy caused by the content's removal from iTunes.

It is also worth noting that past studies on Internet piracy have rarely made use of events or "quasi-experiments" because these events often occur with short notice, and data collection on piracy cannot begin soon enough to match the event. Thus a contribution of our study is the method of data collection, which allows us to track a good index of piracy over time and analyze these data when shocks are observed.

4.2. DVD Sales Data

To analyze the effect of the December 1 experiment on DVD sales, we use panel data on sales ranks of DVD season box sets on Amazon.com for the same date range: November 18 through December 15, 2008. We selected Amazon.com as our reference point for changes in DVD sales following the removal of a digital channel because Amazon.com has an estimated 90% share of online DVD sales in the United States (Netherby 2005), and it seems plausible that users who are no longer able to purchase television content through an Internet channel (i.e., iTunes) would be disproportionately more inclined to purchase DVD box sets from another Internet channel rather than from brick-and-mortar retailers. However, given that Amazon.com is only the fourth largest seller for DVDs in the United States, behind brick-and-mortar retailers Walmart, Target, and Best Buy (DVD News 2006), a conservative interpretation of our results is that they apply only to consumption through Internet DVD channels.

To analyze changes in DVD sales at Amazon.com, we collect daily observations of the price and sales rank for each DVD Amazon sells. We then focus on DVD box sets of television content for the four major networks, capturing the television series, season, and network names.

We interpret the sales rank based on prior work[8] that has shown that the relationship between sales rank and sales follows a Pareto distribution:

$$\text{Quantity} = \alpha \text{Rank}^{\beta}. \quad (1)$$

Thus, following the experiment proposed by Chevalier and Goolsbee (2003), one can estimate the parameters of the relationship between Amazon.com sales rank and actual sales of the product. However, for the purpose of this study, we simply note that this implies that the relationship between price and sales rank is best modeled as an elasticity. Prior research[9] has dealt with the nonlinear relationship between Amazon sales and Amazon sales rank by analyzing the effect of events or explanatory variables on the log of sales rank. If an effect is found, the experimental approach can allow us to translate the coefficient into the actual effect on sales, but this turns out to be unnecessary here as we find no statistical effect.

As in our analysis of piracy, we will compare the change in sales rank of NBC season box sets after December 1 to the change in sales rank of ABC, CBS, and Fox season box sets to determine the effect of the removal of NBC's digital distribution channel.

4.3. Summary Statistics

The simplest possible analysis of this quasi-experiment is a comparison of means before and after the removal of NBC content from iTunes on December 1. So to start, we list some very high-level summary statistics and ask whether if the average number of daily downloads of an NBC episode is greater in the two weeks after December 1 than in the two weeks before. We also test the hypothesis of whether more unique NBC episodes become available through piracy when NBC content is removed from iTunes. Table 1 displays these summary statistics.

In rows 1, 2, and 3, we report the mean download statistics for NBC and non-NBC shows. During our study period, the average number of daily downloads for NBC episodes increased by 28, whereas the average for non-NBC shows decreased slightly. Table 1 provides a basic trend for our results that NBC downloads have increased compared with the control panel. We use a balanced panel to construct these statistics and use this in our subsequent regressions; i.e., we only use episodes that were available both before and after the event. If a new episode appears, then it is a supply-side shift, and we ignore it to avoid the bias in the demand-side shift. This approach is conservative as ignoring new episodes made available on piracy after the removal of NBC content from iTunes should, if anything, introduce additional competition for interest among the other episodes in our sample.

In rows 4, 5, and 6, we outline the supply sides of the effect of content removal from iTunes. In the two weeks after December 1, there were a net 129 more unique NBC episodes available for piracy than

[8] See Chevalier and Goolsbee (2003), Brynjolfsson et al. (2003), and Ghose et al. (2006)

[9] See Smith and Telang (2008).

Table 1 Piracy Data Summary Statistics, November 18 Through December 15, 2007

	NBC networks	Non-NBC networks
1. Mean daily downloads before 12/1 (balanced panel)	237	405
2. Mean daily downloads after 12/1 (balanced panel)	265	397
3. Change	28	−8
4. No. of unique episodes available before 12/1	1,683	3,400
5. No. of unique episodes available after 12/1	1,812	3,383
6. Change	129	−17

in the previous two weeks. A more detailed analysis shows that 147 new NBC episodes became available through pirated channels in the two weeks after December 1, and 18 episodes ceased to be available. In contrast, for non-NBC content, we do not observe any new episodes becoming available, and we observe 17 episodes ceasing to be available. The number of new NBC episodes is striking, because we would expect older content to simply become less popular (and, as a result, less available) over time.

Examining the newly available episodes, we discover that entire seasons of some less popular NBC content—seasons that were not available on Mininova before December 1 but were available on iTunes—become available on Mininova after December 1. These series include, for example, a number of seasons of *Saved by the Bell* and *Xena*: *Warrior Princess.* None of these seasons had new or updated box sets released or new syndication deals during the time period of the study, supporting the inference of causality with NBC's removal from iTunes. In short, it is striking that these entire seasons of older NBC television shows became available for piracy immediately after the removal of the iTunes channel, whereas no new non-NBC content became available. We conjecture that increased demand for these shows through piracy allowed a sufficiently large piracy swarm to exist after the content was no longer available on iTunes.

However, these simple statistics only tell a partial story as they do not control for important episode-level heterogeneity nor do they reflect an appropriate model of the actual relationship between digital distribution and piracy. Thus, we turn to regression models for our main empirical analysis.

5. Results

5.1. Impact on NBC Piracy

First, we provide evidence in support of our identifying assumption: that non-NBC piracy is a good counterfactual for NBC piracy. As evidence, we test whether non-NBC piracy and NBC piracy have similar time trends before NBC content was removed from iTunes. Because the raw data are very noisy, we provide a statistical test and then provide a plot of the fitted values to outline the trends in piracy. We utilize a longer time frame (from November 15 to December 24) for the plot. We first estimate the following difference-in-difference model:[10]

$$\log(\text{Downloads}_{it}) = \alpha_i + \sum_{t=\text{Nov15}}^{\text{Dec24}} \beta_t D_t + \sum_{t=\text{Nov15}}^{\text{Dec24}} \gamma_t D_t \times \text{NBC}_i + \varepsilon_{it}, \quad (2)$$

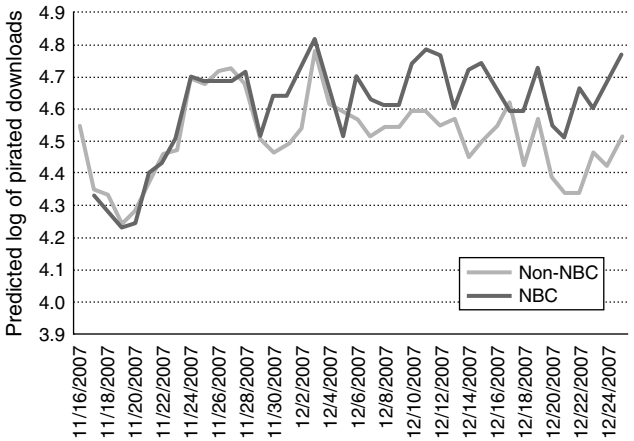
where NBC_i is an indicator variable equal to one if episode i is broadcast on NBC, D_t is a vector of date fixed effects for each day (from November 15, the first date in our data through December 24), α_i is a vector of episode-level fixed effects, Downloads_{it} is the total number of pirated downloads of episode i on day t, and γ_t captures the differences in NBC piracy over the non-NBC piracy on any day t. If non-NBC episodes are a good control for NBC episodes, then we would expect γ_t to be zero for dates before the event. Thus we test if $\gamma_t = 0$ for all t from November 15 to November 30. Second, assuming that non-NBC piracy is an adequate control, we can visually analyze what happens to NBC piracy relative to non-NBC piracy in the period after removal.

We plot the resulting coefficients in Figure 1, where non-NBC piracy levels are given by $\bar{\mu}_j + \beta_t$, and NBC piracy levels are given by $\bar{\mu}_i + \beta_t + \gamma_t$, where $\bar{\mu}_j$ and $\bar{\mu}_i$ are the average baseline piracy for non-NBC and NBC episodes, respectively.

If non-NBC piracy is a good control for NBC piracy, then we would expect γ_t to be equal to zero for all dates before the treatment. One can see from the chart above that non-NBC piracy tracks NBC quite well until November 30, which is the first date that NBC began removing its episodes from iTunes. More formally, a Wald test of the null hypothesis that all γ_t are jointly equal to zero for all t before December 1 could not be rejected at the 5%, 10%, or even 20% levels. Conversely, it is quite clear from the graph that NBC piracy increases beyond non-NBC piracy immediately following the removal from iTunes and, for all but a few dates, remains at this increased level for the 25 days following the removal of NBC content from iTunes. The t-statistics for nearly all γ_t for times after December 1 indicate that the difference between NBC piracy and non-NBC piracy is significant at the 5% level and suggest that NBC piracy increased

[10] Note that we do not include a main effect in this equation for the NBC dummy. This effect cannot be identified, as it would be subsumed entirely by the episode fixed effects.

Figure 1 NBC vs. Non-NBC Piracy Surrounding December 1, 2007



significantly relative to non-NBC piracy after iTunes removal.

Although Figure 1 provides strong evidence that the removal of the digital distribution channel increased piracy—and that this increase was maintained for at least the time period of our data—it does not conveniently allow us to measure the overall average increase in piracy caused by the event. To avoid holiday effects, we use data from November 18 to December 15, which gives us two weeks before and two weeks after the event. Given this information, we next run the following regression as a standard difference-in-difference model to estimate the aggregate effect of the removal of NBC content from iTunes:[11]

$$\log(\text{downloads}_{it}) = \alpha_i + \beta D_t + \gamma \text{NBC}_i \times D_t + \varepsilon_{it}. \quad (3)$$

This model is similar to model (2), except that here, D_t is a single indicator variable equal to one if the observation occurs in the two weeks after December 1, 2007 and equal to zero if it is in the two weeks before that date. Thus γ captures the average effect of the event on NBC's piracy relative to the control group's piracy. A positive value indicates that NBC piracy has increased by about $100^*\gamma$ percent in the period after removal relative to the piracy of non-NBC channels. As before, we include episode-level fixed effects in the form of α_i and daily-level fixed effects in the form of D_t. We also estimate a specification with date fixed effects where we use a dummy for each day similar to (2).

We use a log specification of our dependent variable for several reasons. First, the download data are heavily skewed, and hence log transformation provides a better fit.[12] Second, previous papers have extensively used log specifications for album sales and piracy (e.g., Hendricks and Sorensen 2009). Third, a log specification accounts for nonlinearity in the treatment effect. For example, piracy and sales changes may be particularly large for popular episodes, and log specification will capture some of this nonlinearity.

However, by taking logarithms, we implicitly assume that the effect of the removal of the digital distribution channel is proportional. In a linear model, a few large episodes can have a significant effect on our result. Thus, although most of the episodes may show a large proportional increase in piracy, if a few large ones do not increase enough, a linear specification estimate will differ from the log specification. Given the fit of our data and based on prior literature, we use log transformation as our primary specification. However, we also estimate a linear specification and find that our results are robust to using a linear specification (results are discussed in more detail below and in footnote 16).

One might worry that downloads of episodes within a season or series may be correlated. For example, an increase in piracy of episode 1 of the first season of *Heroes* may be correlated with episode 12 of the second season of *Heroes*. Therefore, following Bertrand et al. (2004), we cluster our standard errors at the series level, which allows all episodes within our 76 unique series to be correlated. We also estimate robust standard errors to allow for heterogeneity across series.

The results of model (3) are displayed in columns (i) and (ii) of Table 2. Column (i) reports results for model (3), and column (ii) adds date fixed effects, producing very similar results. The variable of interest in the regression is γ because it indicates the percent change in pirated downloads for NBC over and above any change for non-NBC programs.

The coefficients from the regressions in columns (i) and (ii) show that whereas non-NBC piracy increased by 5.8% during this time period, NBC piracy increased by an additional 11.4% over and above this level. Thus, the removal of NBC content from iTunes caused an 11.4% increase in piracy over and above the change in the non-NBC "control group." This shows a significant substitution between legitimate digital distribution and piracy channels. Based on 95% confidence intervals computed using the clustered standard errors, the removal of NBC's iTunes channel caused an increase in piracy between 3.4% and 19.4%.

[11] Observations occurring on December 1 are removed from the data as NBC was in the process of removing episodes on this date. Including these observations would not materially impact our results.

[12] We also ran a Box-Cox test on the model to determine the best-fitting transformation of downloads—the test produced a $\theta = 0.04$, indicating quite strongly that the log transformation produces the best fit to our data.

Table 2 Ordinary Least Squares Regressions of Log of Daily Downloads, November 18 Through December 15, 2007 and 2008

	2007		2008	
	(i)	(ii)	(iii)	(iv)
After 12/1	0.058†		0.337**	
	(0.029)		(0.029)	
After 12/1 × Removed	0.114**	0.115**	−0.055	−0.052
	(0.041)	(0.041)	(0.058)	(0.059)
Constant	4.513*	4.314*	4.296*	3.806*
	(0.011)	(0.027)	(0.013)	(0.109)
Date fixed effects	No	Yes	No	Yes
No. of episodes	6,005	6,005	6,376	6,376
Observations	161,784	161,784	170,556	170,556
R^2	0.028	0.16	0.15	0.37

Notes. The dependent variable is ln(total pirated downloads before or after September 9). *t*-Statistics are listed in parentheses. Regressions include episode-level fixed effects with standard errors clustered at the series level.
*Significant at 0.01, **significant at 0.05, †significant at 0.10.

In columns (iii) and (iv) we run the same models for the same time period but for 2008 (i.e., November 18 through December 15, 2008), when there was no event or treatment at iTunes.[13] In these regressions, γ is negative and insignificant, indicating that the increase in NBC piracy over and above non-NBC piracy is not somehow typical during this time of year—further evidence of a causal relationship between the 2007 increase and the removal of NBC content from iTunes.

The increase in non-NBC piracy observed here could, however, be derived from some other outside factor or be a general time trend for all piracy during this period, in which case the difference-in-difference model is an accurate estimation of the effect on NBC piracy. However, we have not been able to determine any outside factors during this time frame that might result in an increase in television piracy demand unrelated to NBC's iTunes decision.

An alternate explanation, and one that is derived from §3, is that removing the digital distribution channel could have a spillover effect if the nonfinancial cost of piracy is largely fixed. Thus the 5.8% increase in non-NBC piracy found in column (i) of Table 2 could be a result of the December 1 NBC treatment and not a general time trend. If this were the case, then our results would understate the displacement of piracy by the iTunes channel, because the change in non-NBC piracy would no longer be an appropriate counterfactual to predict what should have happened to NBC piracy in the absence of the December 1 event. However, although the evidence is consistent with the possibility of a spillover effect, this study cannot identify this effect precisely because of the lack of an appropriate counterfactual. In fact, the results above show a significant increase in non-NBC piracy during the same time period in 2008. Also, a linear specification for the 2007 event shows a small decrease in non-NBC piracy, because a few extremely popular non-NBC episodes experienced large decreases in piracy (while the majority of non-NBC episodes experienced an increase).

Table 3 Ordinary Least Squares Regressions of Log of Daily Downloads by Genre, November 18 Through December 15, 2007

	Drama	Action	Comedy	Sci-fi
After 12/1 × NBC	0.011	0.112†	0.223*	0.213*
	(0.062)	(0.060)	(0.092)	(0.064)
Constant	5.050**	3.704**	4.920**	4.210**
	(0.049)	(0.055)	−0.029	(0.076)
Observations	27,378	51,830	40,734	11,738
No. number of episodes	1,014	1,925	1,510	435
R^2	0.21	0.24	0.20	0.27

Notes. The dependent variable is ln(total pirated daily downloads). *t*-Statistics are listed in parentheses. Includes both episode and date fixed effects, with standard errors clustered by series. For this analysis, we dropped several shows/episodes that did not fit into these four major categories.
*Significant at 0.10, **significant at 0.05, †significant at 0.10.

To explore the source of the increase in NBC piracy, in Table 3 we break down our results by type of program and run model (3) for four separate genre groups: drama, action, comedy, and science fiction (sci-fi). Conventional wisdom suggests that comedy, sci-fi, and action programming appeals more to a younger demographic.[14] It is well known that this younger demographic is also more likely to indulge in piracy (Liebowitz 2008). Consistent with this conjecture, our results show that the increase in piracy for comedy and sci-fi is above 20%; for action, the increase is about 11%; and the piracy increase for drama programming is only slightly positive and insignificant.

Returning to our main results in model (3), we note that there are a few ways to interpret the overall percentage change in piracy resulting from the removal of iTunes content. The first is to calculate the implied average unit increase in piracy per episode as the average number of pirated NBC downloads per episode prior to December 1 (237) multiplied by the estimated increase in piracy in our model

[13] In the 2008 regression, there were about 370 more episodes available for analysis than in the 2007 regression (in part because of the additional NBC episodes that appeared after December 1, 2009). However, removing these new episodes from the 2008 analysis produces no material changes to our results.

[14] For example, see the June 2009 Nielsen report with respect to genre preferences in media consumption for teens (Nielsen Company 2009) and the Time Warner 2010 report on media advertising targeting to young males (Time Warner Cable 2010).

(11.4%) to obtain an average increase of 27 pirated downloads per episode attributable to NBC's decision to remove the iTunes distribution channel.[15] Because there were 1,683 NBC episodes available for piracy prior to December 1, and the average episode experienced an increase of 27 pirated downloads, using this method, we would conclude that the removal of NBC content from iTunes caused a total increase of about 48,000 pirated downloads per day of NBC content. The 95% confidence interval around this number is 13,500 to 77,400 pirated downloads per day.

Another way to look at this increase is to compare it with iTunes purchases of NBC episodes before the removal of the content. To do this, we were able to obtain data showing that NBC sold slightly over 320,000 episodes of its content through iTunes in the two weeks prior to December 1, 2007, or about 23,000 episodes per day. Thus, our results suggest that the unit increase in piracy was about twice as large as the preremoval sales on iTunes.[16] This result, although surprising at first, was predicted in our theory section if the fixed cost of piracy were significant. We discuss this in further detail in §6.

Importantly, our model is measuring the increase in piracy across episodes in percentage terms. One practical question is whether the percentage increase that we have witnessed is being driven disproportionately by the most or least popular episodes. To investigate this, we first separated out the top 20% of the most downloaded episodes (the "head") from the remaining episodes (the "tail").[17] Using this split, we ran a triple difference model to examine whether the increase in NBC piracy, over and above non-NBC piracy, was different for the head (the most popular 20% of episodes) than for the tail (the remaining 80%):

$$\log(\text{Downloads}_{it}) = \alpha_i + \beta D_t + \gamma \text{NBC}_i \times D_t + \delta D_t \times \text{Head}_i + \nu D_t \times \text{Head}_i \times \text{NBC}_i + \varepsilon_{it}. \quad (4)$$

In model (4) D_t is again a dummy variable equal to one if the date is after December 1, and Head_i is now a dummy variable indicating whether the episode is in the top 20% in terms of number of downloads. Thus, γ represents the increase in piracy caused by NBC's removal from iTunes for the less popular tail episodes, and $\gamma + \nu$ indicates the increase in piracy for the most popular episodes.[18]

Table 4 Analysis of Piracy Change for Head and Tail Titles

	DVD box sets
After 12/1	0.086* (0.034)
After 12/1 × NBC	0.104** (0.0424)
After 12/1 × Head	−0.110* (−0.044)
After 12/1 × Head × NBC	−0.039 (0.069)
Constant	4.518* (−0.010)
Observations	161,784
No. of episodes	6,005
R^2	0.35

Notes. The dependent variable is ln(iTunes downloads). *t*-Statistics are listed in parentheses. Regressions include episode-level fixed effects with standard errors clustered at the series level.
*Significant at 0.01, **significant at 0.05.

The results in Table 4 suggest that on a percentage basis the change in piracy for the most popular episodes in the head was statistically no different than that for the tail. However, we also note that interpreting these percentage results in light of the unit downloads of head and tail titles on both iTunes and through piracy suggests that iTunes downloads for head titles were far more likely to convert to piracy than iTunes downloads of tail titles were.

This finding also sheds light on the arguments outlined in the theory section regarding fixed versus variable cost to piracy. Specifically, in the results above, our primary argument for a fixed cost to piracy is the fact that the increase in piracy caused by the removal of the iTunes channel was larger than the size of the iTunes market preremoval. A possible objection to this is a story of variable cost: when the iTunes channel is removed, some percentage of iTunes customers turn to piracy. Based on how the BitTorrent protocol works, this additional demand becomes supply and makes download speeds faster, reducing the variable cost of downloading and attracting additional new pirates (who may not have even been iTunes customers).

However, because of the nature of the number of connections maintained in BitTorrent "swarms," episodes with a small number of downloaders will experience a much larger reduction in variable costs (increase in download speeds) from additional downloaders than episodes with a large number of downloaders will. Therefore, if decreasing variable cost is

[15] Although we have explained why the log model is the appropriate specification here, we also tested a linear model. The coefficient on the interaction term between NBC and the after December 1 dummy in the linear model is about 25 downloads per day and is significant at the 95% level. Thus for our coefficient of interest, a linear model produces results similar to those implied by our log model (a unit increase of 25 versus an increase of 27 for the log model).

[16] Although, notably, at the 95% confidence level, we cannot reject the null hypothesis that the increase in pirated downloads was less than the size of the NBC iTunes market before it was removed. This is primarily due to the large standard errors that result from clustering at the series level, as we only observe 88 unique television series in our data.

[17] Our classification follows the widely used "80/20" Pareto principle, although a 90/10 or 70/30 split yields similar results.

[18] As before, several main effects and pairwise combinations of these effects have been left out of the model as they would be subsumed by the episode and date fixed effects.

causing the increase in piracy, we would expect to observe this phenomenon most strongly among less popular episodes. However, this is in contrast to what we observe that, if anything, the increase in piracy for the most popular head shows was larger than the size of the iTunes market for these shows.

To close, we note that the main results reported throughout this section are robust to a variety of alternative specifications. A linear model also shows a similarly sized increase in NBC piracy over and above non-NBC piracy. Changes to the time frame, the removal of the Sci-Fi and USA networks from the analysis, and the inclusion of controls for the age of each episode do not materially impact the results. Coding November 30 as the first day of the "after removal from iTunes" period produces even stronger results, likely because NBC started removing content on November 30. Additionally, one might worry that the early announcement of NBC's removal from iTunes (announced several months before it happened) might have caused people to switch to piracy before the actual removal. If this were the case, piracy would have spiked before December 1, causing our results to underestimate the true effect. Thus, the model appears to produce robust and, if anything, somewhat conservative, results.

5.2. Impact on Amazon.com DVD Box Set Sales

To determine the degree to which the iTunes digital distribution channel displaces purchases of DVD box sets sold on the Internet, we use similar tests to those above. The dependent variable in this case is the Amazon.com sales rank, and thus a decrease in a DVD's rank indicates an increase in sales of that DVD. Table 5 compares means for sales ranks of NBC and non-NBC box sets before and after December 1, 2007.

We see from Table 5 that the mean rank for non-NBC box sets increased by 10%, meaning that fewer non-NBC television series box sets were sold after December 1 than before. The increase in rank for NBC box sets was only 6%, which could indicate that the removal of NBC content from iTunes caused some additional purchases of DVD box sets. However, as with our analysis for piracy, this comparison of means does not account for changes in price that may occur during this time period (especially with the approaching holidays) nor is a linear model appropriate when predicting sales rank because of the Pareto distribution of sales across box sets. Thus, we run a similar difference-in-difference model to the one we ran for piracy, specified as follows:

$$\ln \text{Rank}_{it} = \mu_i + \alpha D_t + \beta \text{NBC}_i \times D_t + \delta \log(P_{it}) + \varepsilon_{it}, \quad (5)$$

where Rank_{it} is defined as the Amazon.com sales rank of season box set i on day t, D_t is an indicator variable equal to one in the two-week period after December 1, P_{it} is the price of box set i on day t, and μ_i is a vector of fixed effects for each season box set. We log transform the Amazon sales rank as well as the daily Amazon price consistent with prior literature and based on the explanation provided in §4. As above, our regressions are conducted on a balanced sample of titles. Indeed, we do not observe any new DVD box set titles added during this time frame.[19]

One may worry that NBC (or Amazon) may change prices of NBC DVDs in response to the event. Our data do not show any unusual price changes for NBC DVDs. We also had a discussion with NBC personnel and do not believe NBC strategically changed the prices. However, inclusion of price data provides a good control for our key estimate, β. Omission of pricing information may lead to omitted variable bias. We present results for this regression in Table 6.

We note that raising price has the predicted effect of decreasing sales, as observed by increased rank. We also observe no significant change in sales rank for NBC box sets relative to non-NBC box sets after December 1. Thus, the removal of the digital sales channel did not seem to increase sales of DVD box sets sold on the Internet.[20] Given the prior marketing literature on channel differentiation (e.g., Viswanathan 2005), this finding could suggest that consumers consider illegal digital downloads a much stronger substitute for legal digital downloads than legal physical purchases are for legal digital downloads. We discuss this result in more detail below.

5.3. NBC's Return to iTunes

The results presented above represent the best experiment we can find to determine the relationship between piracy, digital distribution, and physical sales. However, another experiment occurred on September 9, 2008, when, after reaching an agreement with Apple, NBC restored all of its content to

Table 5 DVD Sales Rank at Amazon.com (Comparison of Means), November 11 Through December 15, 2007

	NBC networks	Non-NBC networks
Amazon.com sales rank prior to Dec. 1	24,553	35,384
Amazon.com sales rank after Dec. 1	26,056	38,785
Change	1,503	3,401
% Change	6%	10%

[19] Discussions with knowledgeable persons in the television industry suggest that almost all DVD box sets are released immediately before the fall television season, which starts in September.

[20] We analyzed DVD box sets at the level of box set sales per day, because price is a significant predictor of sales and changes by box set and by the day. However, if we were to cluster our standard errors at the series level, it would merely inflate them, and thus our results would remain close to zero and insignificant.

Table 6 Ordinary Least Squares Regressions of Ln Sales Rank of Season DVD Box Sets, November 18 Through December 15, 2007

	DVD box sets
ln(Amazon price)	1.727** (0.103)
After 12/1	−0.023 (0.020)
After 12/1 × NBC	0.000 (0.048)
Constant	2.925 (0.338)
Observations	9,555
No. of unique DVD box sets	397
R^2	0.29

Notes. The dependent variable is ln(Amazon sales rank). *t*-Statistics are listed in parentheses. Regressions include DVD-level fixed effects. Adding date fixed effects does not materially change the results.
*Significant at 0.01, **significant at 0.05.

the iTunes store. Unfortunately, this date also coincides with the new fall season of television in 2008, which presents complications for our empirical analysis. The premiere of a new season of television undoubtedly increases demand for older seasons of the same show, causing large day-to-day swings in piracy of older content that correspond to the premieres of new shows and increasing the noise in the data around this period (as evidenced in the large standard errors and low explanatory power reported in Table 7).

However, it still may be valuable to examine the changes in piracy around this time period to see whether our earlier findings are supported. In §5.1 we noted that when NBC removed its content from iTunes, pirated downloads of NBC shows increased by more than the number of iTunes purchases previously made, and we interpreted this as evidence of a fixed cost to piracy. If the nonfinancial cost of piracy is largely fixed, then we would not expect to see as many customers return to iTunes as left when the content becomes available again there.

Table 7 Ordinary Least Squares Regressions of Log of Daily Downloads, August 26 Through September 22, 2008

	(i)	(ii)
After 12/1	0.063	
	(0.049)	
After 12/1 × NBC	−0.077	−0.077
	(0.096)	(0.096)
Constant	4.306*	4.275*
	(0.021)	(0.053)
Date fixed effects	No	Yes
Observations	129,720	129,720
No. of episodes	4,709	4,709
R^2	0.015	0.074

Notes. The dependent variable is ln(total pirated downloads before and after September 9). *t*-Statistics are listed in parentheses. Standard errors are clustered at the series level.
*Significant at 0.01, significant at 0.05, †significant at 0.10.

To explore this possibility, we run model (3) again for the four weeks surrounding September 9, 2008, reporting these results in Table 7. Our results suggest that when NBC content was returned to iTunes, piracy of NBC content was reduced by 7.7% over and above any change for non-NBC content. However, this result is statistically insignificant, and considering the point estimate alone suggests that the unit decrease in piracy when NBC returned to iTunes is much smaller than the unit increase in piracy when NBC left iTunes.

6. Discussion

Our results represent the first test, to the best of our knowledge, we are aware of that quantifies the effect of a legal digital distribution channel on both online piracy and online sales of physical products. As such, they offer decision makers at media firms some much-needed evidence regarding the ability of legal digital distribution channels to compete with illegal piracy channels without cannibalizing physical distribution channels.

Specifically, in this study, we used NBC's decision to remove its content from the iTunes music store on December 1, 2007 as a quasi-experiment and found that the removal of NBC's primary digital sales channel caused an 11.4% increase in piracy of that content over and above any change experienced by competitor networks ABC, CBS, and Fox over the same period. An 11.4% increase in piracy corresponds to about 27 more downloads per day per episode, or 48,000 additional pirated downloads of all NBC content per day. To put this number in perspective, it is about twice as large as the number of daily iTunes sales NBC received in the two weeks before December 1. This estimate is conservative because Mininova piracy, although arguably a good proxy for overall BitTorrent piracy, represents only a portion of overall BitTorrent television piracy.

We note that this large jump in piracy (larger than the size of the iTunes market) is consistent with there being a significant fixed cost to piracy. In other words, our results are consistent with the possibility that iTunes purchasers may avoid piracy because the fixed cost in learning to use BitTorrent (or the fixed moral/stigma cost of illegal behavior) makes piracy less attractive than legitimate purchases through iTunes. However, when the digital sales channel is not available, these individuals turn to piracy, pay the fixed cost, and, owing to the seemingly low marginal costs of additional downloads, begin to consume more content through piracy than they had previously purchased. Moreover, this phenomenon seems most prevalent for the most popular episodes of television, which suggests that it is not driven by a decrease

in the variable cost of piracy resulting from more pirates participating in the BitTorrent swarm.

We note that a fixed-cost effect could even have a spillover effect for other networks that have a digital sales channel, because once the fixed cost is paid for NBC, it is likely paid for, say, ABC as well. Our results are consistent with this possibility—the model shows a 5.8% increase in non-NBC piracy when we might have expected a decrease resulting from decreasing interest. However, this result should be treated cautiously owing to a lack of strong counterfactual evidence for non-NBC piracy. Either way, these results should sound an alarm to content providers, because once the fixed cost of piracy is sunk, it may be difficult to get pirates to return to legal options. Indeed, although the return of NBC content to iTunes presented some analytical challenges as a result of its coinciding with the start of the fall television season, we observed a smaller and statistically insignificant decrease in piracy for NBC content (compared with non-NBC content) when it was returned to iTunes.

Digital distribution's impact on sales of DVD box sets sold through Internet channels presents a different story, however. When NBC removed its archived seasons of television from iTunes, we found no significant change in the Amazon.com sales rank for NBC's DVD sales relative to the trend that we saw for non-NBC box sets. One possible interpretation of this finding is that digital downloads and DVDs are not substitutes in the short term, and thus adding a digital distribution channel does not lead to a short-term displacement in DVD box set sales. A similar interpretation is that there is a fixed cost to digital viewing of television, and once a consumer has "gone digital," she is unlikely to come back.

We note that there are several limitations to our study. First, and most notably, our findings represent a test of short-term elasticity between legitimate digital distribution, pirated digital distribution, and physical distribution channels. The long-term presence of a digital distribution channel likely has a much stronger effect on physical channel sales than those observed here in the short term. However, it is important to note that there is little that media firms can do to forestall the penetration of digital channels given the increased ease, speed, and flexibility associated with obtaining media in digital environments. Rather, our results suggest that media companies would be best served by competing with piracy through digital distribution rather than hoping that the lack of a legitimate digital distribution channel will drive consumers away from the digital channel and back to physical purchases. In addition to this limitation, we also note that the spillover results mentioned above should be interpreted cautiously owing to the lack of an appropriate counterfactual. Further, we note that our results represent a snapshot in time for a single media type. It would be useful for future studies to analyze competition between legitimate and illegitimate digital channels in other settings to confirm our results.

Another interesting potential direction for future research relates to the "moral" cost of piracy. In §3, we argued that the decision to purchase or pirate rests largely on the shape of the nonfinancial cost curve associated with piracy. Although part of that cost may be related to learning or to the (sometimes) diminished quality of the pirated copies, these costs may approach zero in the future as pirates become more sophisticated in their methods, consumers become more technologically savvy, and client software for piracy becomes even more user-friendly. We suspect that a large part of antipiracy efforts in the future may need to rely on the consumer's "moral" cost associated with piracy. To price competitively, digital distribution efforts would benefit from knowing more about the shape of this moral cost. As such, we believe that user studies—whether in the laboratory or in the field—aimed at revealing the nature of the moral cost of piracy for different types of consumers is a fertile area for future research.

Acknowledgments

Authors are listed in alphabetical order. The authors thank Mel Stephens, Lowell Taylor, Joel Waldfogel, Nitin Mehta, the editors of this journal, and workshop participants at the 2009 NBER Summer Workshop on Information Technology and Economics, the 2009 International Conference on Industrial Organization, the 2008 ZEW Web 2.0 Workshop, the 2008 Workshop on Information Systems and Economics, Arizona State University, the University of California at Irvine, Carnegie Mellon University, Cornell University, the University of Maryland, the University of Southern California, Temple University, the University of Texas at Austin, and the University of Texas at Dallas for valuable comments on this research. The authors also thank Guillermo Jose Aguilar, Temi Awofisayo, Salahaldin Hussein, Suganth Pranesh, and Bryan Springer for excellent research assistance. The authors acknowledge the National Science Foundation for generous financial support provided through CAREER Award IIS-0118767 (to the third author) and CAREER Award CNS-0546009 (to the fourth author). R. Telang also acknowledges financial support of Alfred P. Sloan Foundation Industry Studies Fellowship.

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