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Information Discovery and the Long Tail of Motion Picture Content[1]

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Recent papers have shown that, in contrast to the long tail theory, movie sales remain concentrated in a small number of hits. These papers have argued that concentrated sales can be explained, in part, by heterogeneity in quality and increasing returns from social effects. Our research analyzes an additional explanation: how incomplete information may skew sales patterns. We use the movie broadcast on pay-cable channels as an exogenous shock to the availability of information, and analyze how this shock changes the resulting sales distribution.

Our data show that the pay-cable broadcast shifts the distribution of DVD sales toward long tail movies, suggesting an information spillover from the broadcast. We develop a learning-based movie discovery model to precisely quantify the two mechanisms of movie discovery: word-of-mouth from previous sales and information spillover from broadcast. We use this model to estimate the lost DVD sales due to incomplete information. Our study contributes to the literature by analyzing how information provided in one channel can change the assortment of the same products demanded in another channel.

Keywords: Incomplete information, product discovery, multichannel distribution, movie industry, cannibalization, movie broadcast, DVD sales and rental, long tail, sales distribution

Introduction

"The long tail" is a term coined by Anderson (2004) to describe an environment where digital channels allow firms to promote and sell a larger variety of products than would be possible in physical channels. As a result of this increased product variety made available online, one might expect the distribution of sales to become less concentrated and shift toward a larger variety of products, an outcome that has been demonstrated in the context of books (Brynjolfsson, Hu, and Smith 2003).

However, in the face of this possibility, recent studies have argued that the long tail effect is not observed in important categories of products, notably movies (e.g., Elberse and Oberholzer-Gee 2007). Explanations for the lack of a long tail outcome in these product categories include the fact that movies and music have high fixed costs of production, have

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externalities from the social nature of consumption, and feature significant heterogeneity in quality causing "good" movies to outsell "bad" movies (Elberse 2008).

In this paper we explore an additional explanation for the observed concentration in movie sales: incomplete information about a product's idiosyncratic quality. We do this in the context of movies that are shown on pay-cable channels such as HBO and Showtime. Since our data allow us to fix the supply side, any shift in consumption can be attributed to demand side effects. Figure 1 shows the pay-cable release window in the context of the overall movie life cycle. As shown, movies are first released in theaters and are available exclusively through this channel for 20 to 40 weeks. Movies are then released in DVD, video-on-demand (VOD), and digital channels such as iTunes called as "pay-per-view window." After 20 to 40 weeks in these windows, movies shift into the "pay-TV broadcast window" and are shown on subscription pay-cable channels (such as HBO, Showtime, Cinemax, and Starz). Finally, movies are made available on advertising supported cable and broadcast channels, popularly called the "free-TV" window.

For our study, this setting gives us a unique opportunity to examine how the availability of increased movie information in one distribution channel impacts the total sales and the skewness of the sales distribution for movies in a different channel. In particular, in the life cycle described above, consumers initially become aware of movies that are distributed exclusively through local physical theaters. Because these theaters can only show a small number of movies at any given time, studios have incentives to only promote a small number of popular movies, and consumers are likely to become aware of only a small number of these popular movies. Since consumers only get to consume a small number of popular movies in the theatrical window, they only create word-of-mouth promotion for these movies, and film critics and other reviewers also tend to only write about these popular movies.

However, by the time movies enter the pay-cable broadcast window, channel operators are able to show a much larger variety of movies to their subscriber base than was possible in the theatrical window. Moreover, unlike the prior movie distribution windows that are mainly based on a per-movie fee, after paying a monthly subscription fee, a pay-cable subscriber can sample any movie shown on the network with no additional marginal cost. This may result in consumers viewing, and thus discovering, niche movies they otherwise would not have been able or willing to consume in the theatrical window. Such added discovery opportunities may result in higher sales of less popular and niche movies during their broadcast window, which may in turn affect the skewness of the sales distribution of movies in this period.

The broadcast window has several unique empirical characteristics that allow us to use the movie broadcast as an exogenous shock to the amount of information consumers have about movies, and then analyze how this information changes subsequent sales distribution patterns: First, contracts between studios and pay-cable channels are such that all movies produced by a particular studio (both highly successful and less successful) are included in the license to the cable channel. Second, the cable channel's incentives are such that they broadcast all of the movies available through their license (Andreeva 2011; Becker 2007; Flint 2013; McNary 2013). Third, the institutional details of the movie industry are such that there is significant exogenous variation between the time a movie starts showing in theaters and the time it appears on the pay-cable channel (Frankel 2009). Finally, the timing of the broadcast is such that we can isolate the effect of the broadcast from other changes in distribution that occur during the broadcast window. We examine each of these characteristics in more detail below.

The role of information in the sale of products is an important question for a variety of reasons (Goeree 2008; Hendrick and Sorensen 2009; Jin and Leslie 2003; Sorensen 2007). First, incomplete information represents a welfare loss to consumers who, were they fully informed, would prefer to watch a less popular movie more aligned to their taste than the more popular movie they were aware of. Second, incomplete information about products affects product variety available in the market. Incomplete information may tilt investment toward products with mass-market appeal, rather than niche products, and thus support a limited talent base of artists. Third, incomplete information may result in a loss of potential revenue to producers. For these reasons, mechanisms to provide information to consumers are of great interest to both academic scholars and industry managers.

Our research also answers an important managerial question regarding how different distribution channels interact. Managing diverse channels is a significant challenge to firms as the introduction of a product in one channel may cannibalize product sales in other channels. This has become an extremely important issue for media companies given the introduction of digital distribution channels for media content, and our paper sheds light on how movie broadcasts affect the assortment of product demanded in DVD sales and rental channels.

To test how incomplete information affects the total sales and the skewness of movie sales in the broadcast window, we identified a sample of 314 movies that were shown on the four major pay-cable channels (HBO, Cinemax, Starz, and Showtime) between January 2008 and June 2010, and collected their weekly DVD sales data. We find that, in the first month

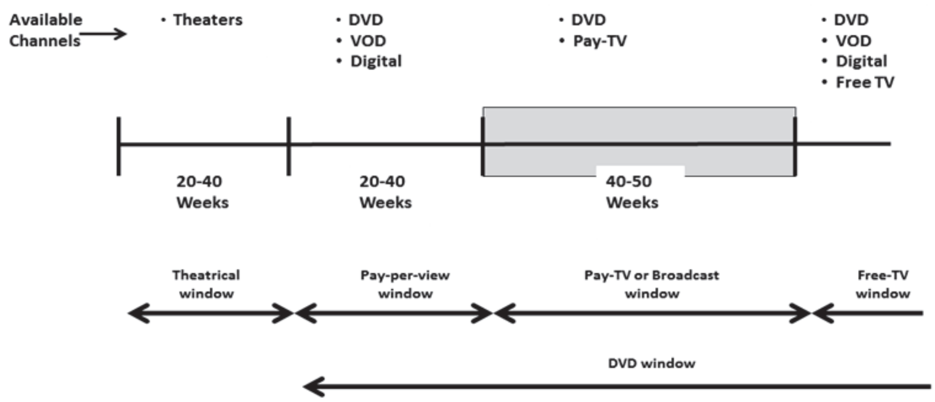


Figure 1. Exclusive Windows in Movie Life Cycle

after release, the DVD sales distribution for our sample of movies is almost identical to its box office sales distribution, and that both are highly skewed. In our data, the top 10 percent of movies make up 48 percent of theatrical sales and DVD sales prior to the pay-cable broadcast, a number which is identical to that reported by Elberse (2008). Moreover, the high skewness of movie sales persists up to the start of the broadcast window.

However, immediately after the pay-cable broadcast, we find an overall increase in the DVD sales and a disproportionately large increase in DVD sales for less popular movies relative to more popular ones. This leads to a large and statistically significant reduction in the skewness of the DVD sales distribution immediately after movies enter the broadcast window, such that in the month after broadcast, the top 10 percent of movies make up only 35 percent of DVD sales. Our empirical analysis indicates the following: (1) DVD sales for movies in our sample increase during their broadcast window and this increase is proportional to the viewership during the broadcast window, (2) the increase in DVD sales persists over the entire period of the broadcast window, and (3) DVD sales for less popular and less well-known studio's movies increase more than popular and major studio movies do.

We further develop a movie discovery model that estimates the impact of the two mechanisms of movie discovery on its DVD sales: (1) the word-of-mouth effect (consumers discover the quality of a movie by hearing about it from others), and (2) the information spillover effect (consumers discover the quality of a movie by watching it during its broadcast window). We find a positive and significant estimate for discovery from both of these mechanisms. However, we find a significantly higher discovery for less popular and niche movies due to information spillover effect during their broadcast window.

Our model allows us to estimate that, at the beginning of the broadcast window, 89 percent of potential consumers have discovered movies in the upper quartile of theatrical sales, but only 57 percent of potential customers have discovered movies in the lower quartile. This suggests that at the time of the broadcast window there is very little additional scope for discovery of movies which were successful in the theatrical window, whereas less successful movies have a larger scope of discovery during the pay-cable broadcast window, leading to a proportionately higher increase in DVD sales.

We believe our paper makes several contributions to the academic literature and to industry practice. First, our paper provides strong evidence informing an important academic and managerial question: why are sales of movies so concentrated in a small number of hits relative to other creative products. Our results suggest that this concentration derives from the small number of distribution channels available to movies early in their life cycle. Second, our paper extends this analysis by providing a nonobvious result for how different channels of movie distribution interact; namely, how movie distribution in one channel (TV broadcast) increases consumption of the same movie in another contemporary channel (DVD sales). This contrasts with the existing literature that primarily studies how demand for a particular product impacts demand for a separate complementary product. Third, our setting allows for clean identification of the two mechanisms of information discovery and thus the role incomplete information plays in the sales distribution of movies, contributing to the growing literature on the impact of information provision on market outcomes. Finally, our research has implications for positioning of broadcast of a movie within its overall life cycle and for exploiting the long tail of movie demand by making long tail content available through subscription channels earlier in the movie's life cycle using the large number of new digital distribution channels available to movie studios.

Literature Review

Our paper draws on three main bodies of literature: the marketing literature on predicting sales patterns in the movie industry, the literature on the long tail phenomenon, and the marketing and economics literature on consumer search and the impact of information provision on market outcomes.

Our paper is most closely related to the growing academic literature on the long tail phenomenon, a term coined by Anderson (2004) to describe how the increased stocking capacity of Internet retailers may allow niche products to make up a larger share of total sales than they would in a brick-and-mortar environment. This literature looks at a variety of issues, including how increased product variety impacts consumer surplus in books (Brynjolfsson, Hu, and Smith 2003), the demand-side and supply-side drivers of the long tail phenomenon (Brynjolfsson, Hu, and Smith 2006), the impact of niche sellers on online markets (Bailey et al. 2008), and the impact of recommender systems on the demand for niche products (Fleder and Hosanagar 2009).[2]

In this literature, our work is most closely related to Elberse and Oberholzer-Gee (2007) who examine the sales concentration in the home video market from 2000 to 2005. They find that (1) a smaller proportion of titles account for the bulk of sales over time, and (2) the number of non-selling titles has increased over time. They find some evidence of a long tail effect in that the numbers of titles that sell only few copies increases two-fold during their study period, but their main finding is that the long tail concept is poorly suited to the characteristics of the motion picture industry. In this regard, our research identifies one potential explanation for this phenomenon—consumers having incomplete information about movies—and discusses ways in which new technology channels may reduce the impact of incomplete information.

Internet markets also provide consumers with search tools, browsing tools, and recommendation system, and these tools may lower consumer search costs and further increase sales in the long tail of the sales distribution. Several papers in the literature have developed predictions regarding how search cost can affect price, price dispersion, product entry, and product variety (e.g., Anderson and Renault 1999; Brown and Goolsbee 2002; Brynjolfsson and Smith 2000; Cachon et al. 2008; Hann et al. 2003). Other studies in the literature analyze how a reduction in search cost affects the concentration of product sales (see, for example, Brynjolfsson, Hu, and Simester 2011; Brynjolfsson, Hu, ans Smith 2010; Tucker and Zhang 2011).

Within this literature, our research is closely related to the literature on search and experience goods. Nelson (1970) defines "search goods" as goods whose quality can be determined by consumers prior to consumption, and "experience goods" as goods whose quality can be completely evaluated only after consumption. Nelson (1974) further finds that advertisements provide direct information for search goods but provide indirect information or simply brand advertising for experience goods. He shows that this difference in the character of information leads to higher advertising for experience goods.

This characteristic is important for our study because movies are a classic example of an experience good: consumers can fully evaluate their true quality only after consumption. Movie studios' advertising, therefore, focuses on information about brand, director power, and star power as signals of quality. These characteristics may cause consumers to rely more heavily on recommendations from friends and peers, and trailers to gather information about movie quality. As a result, movies from major studios, movies with early commercial success, and movies with more prominent directors and actors/actresses will be advertised more, and in turn will get more word-of-mouth recommendations. These factors may drive the high concentration in movie sales that are seen in both the box office and DVD release periods. However, this paper argues that the pay-cable broadcast window provides a new channel for "advertising" the quality of a movie by allowing pay-cable channels' subscribers to evaluate movies more accurately (by watching it) and at a lower search cost than may have been possible in their other release windows.

Our paper is also related to the rich academic literature on the marketing of movies. Most of this work has analyzed issues around the theatrical release of the movie (e.g., Ainslie et al. 2005; Elberse and Eliashberg 2003; Krider and Weinberg 1998; Sawhney and Eliashberg 1994, 1996). In the past decade, the focus of this literature has shifted to include the DVD sales channel, as revenue from DVD sales has grown to about 46 percent of total movie revenue (Epstein 2005, p. 20). This shift toward DVD revenue has led to a series of papers analyzing whether the DVD channel cannibalizes theatrical sales, and the optimal release timing for a movie in the DVD channel (e.g., Lehman and Weinberg 2000; Luan and Sudhir 2006; Prasad et al 2004).[3] However, we are only aware of one other paper that has analyzed the impact of the television

[2]See Brynjolfsson, Hu, and Smith (2010) for a review of this literature.

[3]The impact of new distribution channels on sales in traditional channels is also studied in cross channel literature (e.g., Brynjolfsson, Hu, and Raman 2009).

broadcast of movies on DVD sales: Smith and Telang (2010). However, unlike the current paper, Smith and Telang did not separately identify the information spillover and word-of-mouth mechanisms driving increased sales and did not differentiate between the impacts of these information spillover sources on head and tail movies.

Our paper also contributes to a growing literature analyzing the impact of information provision on market outcomes. In markets with a large number of products whose quality is difficult to determine *ex ante*, consumers face incomplete information about their choice set. Goeree (2008) shows that consumers may be less than fully informed about the set of available personal computers because of the rapid pace of technological change. In cases where consumers are uncertain about quality, a strong reputation of existing products can increase demand for new products sold under the same brand name (forward spillover). Likewise, a high-quality new product can improve the brand's image and thus boost the sales of the existing products (backward spillover) (Cabral 2000; Choi 1998). Similarly, Hendrick and Sorensen (2009) find a substantial and persistent increase in sales of an artist's catalog albums (backward spillover) due to discovery during the release of an artist's follow-on albums.

Unlike these papers, which highlight the spillover effect of one product on sales of other complementary products, we examine the spillover effect of information acquired from one channel of movie distribution (pay-cable networks) on sales of the same product in other distribution channels (DVD sales and rentals).

Data

We collected data on all movies shown on the four major U.S. pay-cable networks (HBO, Cinemax, Starz, and Showtime) between January 2008 and June 2010. These channels account for the majority of pay-cable movie broadcasts during our study period. We then selected 314 movies that entered the pay-cable broadcast window between January 2008 and March 2010 for our present analysis so that we have at least 14 weeks of weekly sales data inside the broadcast window for our selected sample of movies. Among these movies, 250 are from the seven "major" Hollywood studios (Warner, Lionsgate, Sony, Paramount, Disney, Universal, and Fox) and the remaining 64 are from smaller studios. For each movie, we collected data on weekly U.S. DVD sales[4] and rentals,[5] the broadcast window start date, broadcast dates within that window, and the studio, genre, and box office sales of the movie. We also acquired detailed data from ACNielsen on the time and date when movies in our sample were shown on the pay-cable networks, and the number of households that watched these movies during each broadcast. We report summary statistics for these data in Table 1.

These summary statistics show that the DVD release dates and broadcast window dates for movies in our sample are spread out fairly evenly over the calendar year. There is also a large variation between the time of the DVD release and the start of the broadcast window in our sample of movies: the 10th and 90th percentile figures for the start of the broadcast window in our data are 20 and 55 weeks after the DVD release, respectively. This is an important factor that we will utilize in our identification strategy later.

Table 1 also shows that DVD sales are highly skewed across titles and over time. Across titles, the mean sales in the broadcast window are 175,583 and the median is 58,506. Across time, we see that on average 55 percent of DVD sales occur in the first four weeks after release. Still, 17 percent of total DVD sales occur in the broadcast window, highlighting the fact that an economically significant number of DVD sales occur during the broadcast window.

One may worry that pay-cable channels pick-and-choose which movies to show on their networks (presumably choosing only more popular movies). However, based on reporting in the trade press, this seems unlikely. In the United States, the major pay-cable channels do not negotiate deals for specific movies; rather, they negotiate multiyear deals with studios, called output deals, wherein the pay-cable channel pays the movie studio a fixed sum to get the exclusive broadcast rights for all movies that the studio releases during the negotiated period. Consider the following quotes from the industry magazines *Broadcast & Cable* and *Variety*:

> Universal Pictures and HBO renewed their domestic output deal, extending it midway into the next decade. The pact gives HBO the right to program all movies from Universal and its specialty labels Focus Features and Rogue Pictures both on TV and online. (Becker 2007)

> You're buying stuff that, in many cases, hasn't even been thought of yet.…When you do an output deal, you're betting on the studio. You're saying, "I want all the films that this studio releases over the next however many years." (Frankel 2009)

In summary, (1) output deals are negotiated for all movies released by a particular studio (as opposed to on a movie-by-

[4] DVD sales to rental stores are not included in this data.

[5] Rental data were only available for 194 movies out of the total sample of 314 movies.

Table 1. Summary Statistics

	N	Mean	Std. Dev.	Percentile		
				0.10	0.50	0.90
Time between DVD release and broadcast (weeks)	314	31.06	13.09	20 (min 10)	27	55 (max 96)
Theatrical revenue (million U.S. $)	314	37.32	55.36	0.06	15.54	102.36
Total DVD sales (numbers)	314	933,639	1,465,847	9,424	390,905	2,501,037
DVD sales in broadcast window	314	175,583	287,598	986	58,506	529,838
Percent of total DVD sales in first 4 weeks	314	54.52	15.00	33.20	57.03	71.57
Percent of total DVD sales in broadcast window	314	17.38	13.39	3.16	13.91	35.08
Weekly viewership of movie in broadcast window (number of households in millions)	7829	0.078	0.153	0.00	0.00	0.199

movie basis), and (2) these deals are negotiated 5 to 10 years in advance, and thus the box office performance of the included movies is not known at the time the deal is made. We confirmed these contract characteristics through interviews with two industry representatives who have detailed knowledge of output deal negotiations. These interviews reveal that only documentaries and movies of some small studios aren't covered in these output deals. Thus, essentially all mainstream movies are available for broadcast on pay-cable channels, whether successful in the box office or not.

The next challenge is whether all licensed movies are ultimately shown on the cable channel, and whether the cable channels are strategic in scheduling the movie broadcast (for example, by broadcasting successful movies earlier than less successful movies). Based on our discussions with the same two industry representatives, we find (1) that the output deal gives the cable channel the right to broadcast movies starting from a set time (typically 9 months to a year) after the month of the theatrical release, (2) that this lag is the same for all movies covered by the contract, (3) that the cable channels typically show every movie covered by the contract, and finally (4) that pay-cable channels begin showing the movie immediately after it becomes available under the contact to maximize its exposure during the license window period.

As a result, we expect the lag between the theatrical release and the start of the pay-cable broadcast window to be similar for successful and less successful movies within a contract. Thus, for our sample of broadcast movies from different contracts, we expect that movies will enter the broadcast window in a way that is not systematically related to their box office success. This is an important identification requirement in our econometric specification, and we will explicitly test this identification requirement below.

DVD Sales Distribution and its Evolution in the Broadcast Window

Next, we compare the skewness of box office sales to the skewness of DVD sales, and analyze how skewness changes between the initial DVD release and the pay-cable broadcast window. To do this, we take the Lorenz curve for box office sales of the movies in our sample, and *keeping the same rank order of increasing box office sales for movies*, we construct the Lorenz curve for DVD sales in the first month after DVD release. We note that by keeping the rank ordering of movies in our sample the same for both Lorenz curves, we are specifically testing for the similarity between these two curves at the movie level as opposed to at an aggregate level. As is evident from Figure 2, the sales distribution for DVD sales in the first month after release is almost exactly the same as the distribution for box office sales: both curves have a Gini coefficient of 0.67. This shows that the relative sales of popular and less popular movies do not change significantly between the box office and DVD release windows.

We next examine how the distribution of DVD sales changes from immediately before the broadcast window to immediately after the broadcast window (recall that movies enter the broadcast window 20 to 50 weeks after their DVD release). Using the same rank order of increasing box office sales for our sample of movies, in Figure 3 we compare the Lorenz curve for DVD sales of movies one month before and one month immediately after the broadcast window.

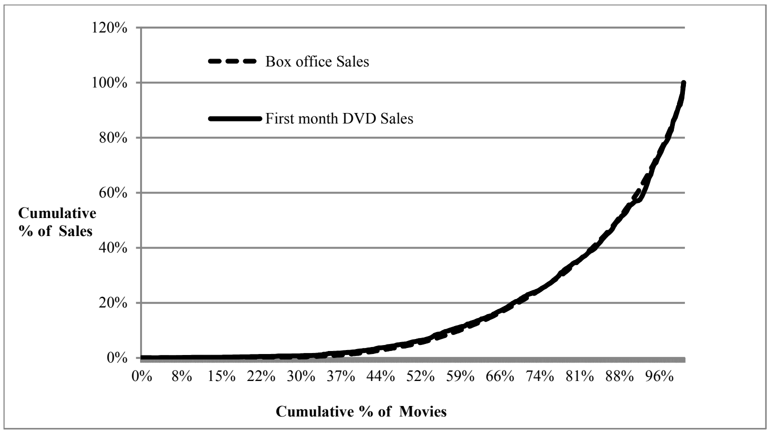


Figure 2. Distribution of Box Office Sales and First Month DVD Sales for Broadcast Movies

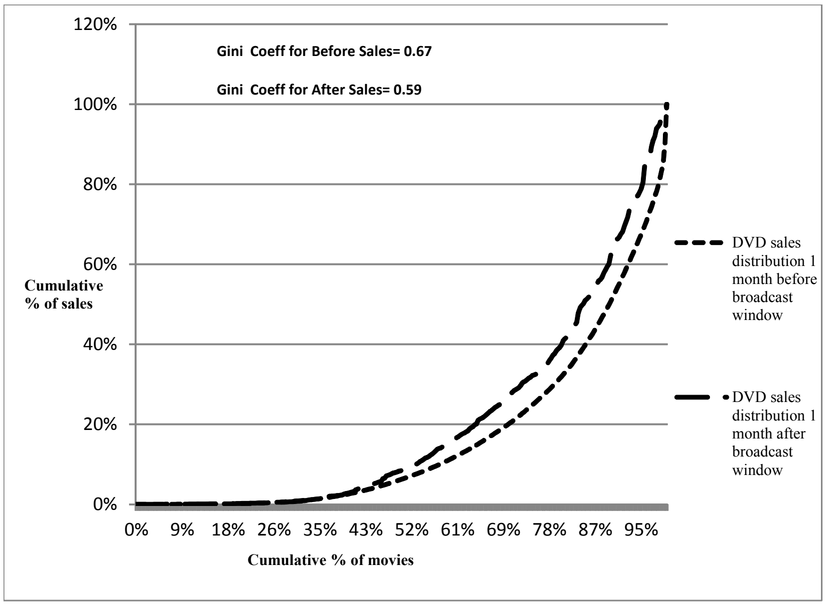


Figure 3. Distribution of DVD Sales Immediately Before and After the Broadcast Window

Figure 3 shows that the proportion of DVD sales for low- and moderate-selling movies increases immediately after the broadcast window. This is reflected in a reduction in the DVD sales concentration for our sample of movies after the broadcast window starts. The Gini coefficient for the DVD sales distribution reduces from 0.67 before the broadcast window to 0.59 in the broadcast window. The reduction of Gini coefficient is also reflected in a shift away from sales in the top movies. Prior to the pay-cable broadcast, the top 10 percent of movies accounted for 48 percent of DVD sales (which is exactly the same as the skewness reported in Elberse for Quickflix movie rentals), whereas after the pay-cable broadcast the top 10 percent of movies account for only 35 percent of DVD sales.

Thus the raw data suggests that the distribution of movie sales does not change from the theatrical window through the DVD release window and up to the pay-cable broadcast, but that in the broadcast window moderate and less popular movies get a higher increase in DVD sales than more popular movies do. We test this finding more rigorously in the following sections.

Empirical Model and Results

Blackout and Broadcast Effects

We now analyze the change in DVD sales of a movie due to its broadcast on a pay-cable channel. To do this, we must first isolate changes in DVD sales that occur due to factors other than the movie broadcast during the broadcast window. Specifically, we note that when a movie is shown on pay-cable networks, licensing contracts require that the studio provide the cable channel with an "exclusive broadcast window." Historically, this exclusive window meant that the studio could not license the movie to show on another competing broadcast channel. With the advent of new distribution channels such as cable video-on-demand (VOD) and electronic channels such as iTunes, this exclusive license has been interpreted to cover these two channels (Vascellaro et al. 2012).

Because of this, when the broadcast license begins, the studio is required to remove the licensed movie from sale on both cable VOD and electronic channels. However, importantly for our study, the movie studio is not required to remove the movie from the DVD channel, in part because once the physical goods have entered the distribution channel it would be nearly impossible to do so. In view of this setup, there are potentially two distinct effects of the movie broadcast window on DVD sales:

(1) *Blackout effect*: A consumer who wants to purchase a movie through a cable VOD or electronic channel cannot do so during the pay-cable broadcast window (due to the blackout of the movie on these channels) but may purchase or rent the movie's DVD instead.

(2) *Broadcast effect*: Broadcasting a movie can have two opposite effects on DVD sales:

   (a) *Information spillover effect*: Broadcasting a movie on a pay-cable channel enables subscribers to sample the movie at a low cost (given the fixed monthly cable subscription fee) and thus evaluate the quality of the movie. These subscribers may decide to purchase the movie themselves (to add to their library of content for later viewing) or may generate word-of-mouth promotional effects for the movie to inform others in their social circle. In either case, the newly informed consumers may either purchase or rent the respective movie on DVD.

   (b) *Cannibalization effect*: Broadcasting the movie on pay-cable channels may also cause consumers who would have otherwise purchased or rented the DVD to watch it on the pay-cable channel instead. This cannibalization effect could be more severe given the prevalence of digital video recorders and other technologies that allow customers to digitally record the movie for later playback.

To separately identify the blackout effect from the (net) broadcast effect we need exogenous variation between the time the blackout effect starts and the time the movie is shown on the cable channel. To do this, we exploit the fact that the output deal contracts specify that the blackout period starts on the first day of the month in which the movie becomes available to the cable channel, and that cable channels typically broadcast newly available movies on the first, second, third, or fourth weekend of the month. For example, in March 2011, the movies "Robin Hood," "MacGruber," "Cop Out," and "Just Wright" premiered on HBO. These movies were all removed from iTunes and VOD channels on March 1 and were first broadcast on HBO on March 5, 12, 19, and 26. respectively.[6] Our estimations use the natural variation between the start of the blackout period and the first broadcast to isolate these two effects.

Given this environment, we separately estimate the broadcast period and blackout period treatment effects on DVD sales of movies with the following specification:[7]

$$Log(S_{it}) = \alpha_i + \beta_{black} \times D_{it}^{black} + \beta_{broad} \times D_{it}^{broad} + \delta_{oscar} \times D_{it}^{oscar} + \sum_t \delta_t \times D_{it}^{t} + \sum_{calwk} \delta_{calwk} \times D_{it}^{calwk} + \varepsilon_{it} \quad (1)$$

where $i \in \{1, 2, \ldots, 314\}$ denotes movies; $t \in \{1, 2, \ldots, t_i\}$ denotes weeks since DVD release; $\text{Log}(S_{it})$ denotes the log of DVD sales; D_{it}^{t} are t indicator variables that are equal to one when the number of weeks since the DVD release equals t; D_{it}^{calwk} are 52 calendar week indicator variables equal to one if t = calendar week; D_{it}^{oscar} is an indicator variable equal to one if movie i was awarded an Oscar where week t for that movie

[6]Note that HBO has an "on-demand" option for a subset of the movies they broadcast in a particular month, but that the blackout and on-demand availability follow the blackout and broadcast schedules outlined above: For the subset of movies available on HBO on-demand, they enter the blackout period on the first of the month and are available on HBO on-demand one day after their initial broadcast date. Therefore, our blackout and broadcast periods remain unaffected by HBO on-demand.

[7]Our approach follows Hendricks and Sorensen (2009), who apply an empirical approach from the literature on treatment effects (e.g., Wooldridge 2002).

falls in the Oscar award month;[8] D_{it}^{black} is an indicator variable equal to one in all weeks when movie i is blacked out from VOD and electronic channels; D_{it}^{broad} is an indicator variables equal to one in all weeks after it starts broadcasting inside the broadcast window; and α_i denotes movie fixed-effects.

Our coefficients of interest are β_{black}, which represents the impact of the blackout effect on DVD sales over the entire broadcast window, and β_{broad}, which represents the average effect of the movie broadcast on its DVD sales. The coefficients of the calendar week indicator variables (δ_{calwk}) capture weekly shocks to DVD sales such as competitive effects from the entry of other movies or seasonal effects from holiday buying. The coefficients of the indicator variables for weeks since DVD release (δ_t) capture a flexible (nonparametric) form of the average decay path of DVD sales that accounts for the decline in DVD sales of movies with time.[9] Any possible increase in DVD sales when movies win an Oscar is captured by δ_{oscar}.[10]

After controlling for movie fixed-effects, weekly calendar effects, and sales decay over time in equation (1), β_{black} and β_{broad} represent the average treatment effect (ATE) on the treated movie for both the blackout period and broadcast period, respectively. Put another way, movies that enter the broadcast window at time t are the treated movies, and other movies that have not entered the window by time t act as controls. Therefore, $ATE_{it} = \log(S_{it}^{T}) - \log(S_{it}^{0})$, where $\log(S_{it}^{T})$ is the log of DVD sales for movie i in week t in the treatment window, and $\log(S_{it}^{0})$ is the log of DVD sales for movie i in week t outside the treatment window. Since movie i cannot simultaneously be in and out of the window, we use the movies that have not yet entered the window as the control movies against which we compare the sales of movies that have entered the window. Therefore, for a movie that enters the broadcast window at week t, counterfactual sales can be inferred from the sales of all the movies that have not entered the broadcast window at week t.

There are two requirements for clean identification of the treatment effect in specification (1). First, there should be variation in the time between the DVD release and the broadcast window in our sample of movies to ensure that we have sufficient untreated movies at any given t to estimate the treatment effect. Second, the movie entry time into the broadcast window should not be systematically related to its characteristics, notably commercial success or sales decay rate.[11]

With respect to the first requirement, the summary statistics in Table 1 show that the average movie enters the broadcast window 27 weeks after its DVD release, with the earliest 10 percent of movies entering before 20 weeks and the latest 10 percent of movies entering after 55 weeks. There are two main reasons for this variation. First, movies in our sample are from several different output deals, and thus cover several different minimum time periods between theatrical or DVD release and the start of the broadcast window. Second, since the broadcast window for movies begins on first day of a month, but the movies could be released in theaters (DVD) in any week of the month, we see up to four weeks additional variation in the time between the theatrical (DVD) release and the broadcast window even for movies from the same output deal.

In the previous section, we showed that output deals between studios and cable networks cover all of the studio's movies to be released in next 5 to 10 years (well before many movies are even conceived, much less commercially released). Thus, contractually there is no reason to expect a relationship between the commercial success of a movie and its entry into the broadcast window.

However, we can also explicitly test whether the timing of entry of a movie into the broadcast window is correlated with its characteristics. To do this, in column 1 of Table 2, we first estimate a Cox proportional hazard model with the number of weeks between the DVD release and the beginning of the broadcast window as the dependent variable, and box office sales as an independent variable, along with control variables for genre and the type of studio that promotes the movie ("small studio" takes on a value of one if the movie is from a smaller studio, and 0 if it is from one of the seven major studios: Sony, Warner Brothers, Lionsgate, Fox, Paramount, Disney, and Universal). We then estimate the same model in column 2, changing only the dependent variable from box office sales to total DVD sales up to the broadcast window. In column 3, in addition to box office sales, we add the estimated movie production budget as a covariate to account for any possibility of high budget but unsuccessful movies enter-

[8]The six-week period from the third week of February until the end of March is taken as "Oscar month." We tried other combinations of Oscar month weeks around this time and got qualitatively similar results.

[9]Note that the average DVD sales decay rate estimated in specification (1) also accounts for the average impact of any DVD price reduction over time on DVD sales across all movies.

[10]We did not include other movie awards, such as the Golden Globe awards, as the effect of Oscar awards on our blackout and broadcast coefficients was negligible.

[11]If successful movies systematically enter the broadcast window early, their counterfactual sales will be inferred from the sales of less successful movies (that enter the window later), leading to biased treatment effect. Similar arguments can be made for the sales decay rate of movies.

Table 2. Estimates of Cox Proportional Hazard Model for Box Office and DVD Sales			
Dependent Variable: Weeks Between DVD Release and Broadcast	**Coefficient Estimates (Standard Errors in Parenthesis)**		
Box office sales in Millions	-0.001 (0.001)		-0.001 (0.001)
DVD sales in Millions		0.017 (0.042)	
Movie estimated budget (millions of U.S.$)			0.0002 (0.002)
Small studio	-0.289 (0.191)	-0.237 (0.158)	-0.381 (0.231)
"Action & Adventure" Genre	-0.175 (0.194)	-0.195 (0.194)	-0.178 (0.192)
"Drama" Genre	-0.032 (0.157)	-0.014 (0.156)	-0.089 (0.192)
"Comedy" Genre	0.033 (0.151)	0.049 (0.151)	-0.023 (0.182)
N	314	314	227

ing the broadcast window early.[12] In Table 2 we find that all of the coefficients of interest (box office sales in column 1, DVD sales in column 2, and box office sales and movie budget in column 3) are insignificant. This suggests that, after controlling for time invariant movie characteristics, the entry of movies into the broadcast window is not systematically related to its commercial success or its production budget. In other words, consistent with the available industry information outlined above, the timing of a movie's entry into the broadcast window is not systematically related to either its box office or DVD sales.

We also test for natural variation in the lag between the blackout and broadcast periods of a movie in the broadcast window across our sample of movies. The concern here is that if pay-cable channels systematically broadcast successful movies in earlier weekends of the month, our blackout and broadcast coefficients would be biased. To test this, we estimate Cox proportional hazard model[13] with the number of weeks of lag between the start of the blackout period and the first broadcast as the dependent variable and box office sales as the independent variable along with the other control variables used in the previous analysis. We also run a linear model with the same set of variables and report the coefficient estimates in Table 3. In these results, the coefficient of box office sales is statistically insignificant, suggesting that the lag between the start of the broadcast window and the actual broadcast of movies is not systematically related to their box office success.

To estimate the treatment effect, we use the total broadcast window of 30 weeks. We do this because weekly DVD sales are almost negligible after this period. The stochastic error term in specification (1) is assumed to be heteroskedastic across movies (the sales of some movies are more volatile than others) and autocorrelated within movies (random shocks to sales are persistent over time). Movie fixed-effects account for differences in the scale of DVD sales across movies in specification (1) while differences in the DVD sales decay paths across movies are subsumed in the error term and may cause endogeneity. In other words, our estimate of the treatment effect will be biased if deviations of a movie's DVD sales decay rates from this average rate are systematically related to their time of entry into the broadcast window.[14] We additionally account for the heterogeneity in DVD sales decay rates across movies by using the first-difference form of specification (1) as below

$$\Delta Log(S_{it}) = \breve{\alpha}_i + \tilde{\beta}_{black} \times D_{it}^{black} + \tilde{\beta}_{broad} \\ \tilde{\delta}_{oscar} \times D_{it}^{oscar} + \sum_t \tilde{\delta}_t \times D_t + \\ \sum_{wk} \tilde{\delta}_{wk} \times D_{wk} + \tilde{\varepsilon}_{it} \qquad (2)$$

[12]We could only get production budget for 227 movies out of our full sample of 314 movies.

[13]We get similar insignificant coefficient estimates for box office sales with Weibull proportional hazard model. These results are available from the authors upon request.

[14]If slow decaying movies enter the broadcast window earlier than fast decaying movies do, our treatment effect will be biased upward due to inferring lower counterfactual sales of the treated (slow decaying) movies from the untreated (fast decaying) movies.

Table 3. Exogenous Variation Between Blackout and Broadcast Periods

Dependent Variable: Lag Between Start of Window and Actual Broadcast	Coefficient Estimates (Standard Errors in Parenthesis)	
	Cox Hazard Model	Linear Model
Box office sales in Millions	0.000 (0.001)	0.003 (0.002)
Small studio	0.176 (0.167)	-0.629 (0.415)
"Action & Adventure" Genre	-0.025 (0.200)	0.199 (0.268)
"Drama" Genre	0.112 (0.167)	0.061 (0.210)
"Comedy" Genre	0.026 (0.161)	0.093 (0.222)
Constant		2.140*** (0.196)
N	314	314

***Statistically significant at the 1% level (two-sided test).

Table 4. Estimates for DVD Sales

Dependent Variable: Log(DVD Sales) / Log DVD Sales	Specification (1)	First-Difference Specification (2)	Specification (1)
Blackout period dummy	0.096*** (0.032)	0.007** (0.004)	0.159*** (0.044)
Broadcast period dummy	0.101** (0.043)	0.013*** (0.005)	
Weekly viewership in millions			0.150*** (0.05)
N	17194 (314 movies)	17189 (314 movies)	17194 (314 movies)
R sq	0.946	0.747	0.946

***Statistically significant at the 1% level (two-sided test). **Statistically significant at the 5% level (two-sided test).

where $\Delta Log\ (S_{it}) = Log\ (S_{it}) - Log\ (S_{it-1})$, and where the other variables have the same definition as in specification (1). This model estimates the impact of the broadcast window on the proportional rate of change in a movie's DVD sales from week to week. The advantage of this specification is that heterogeneity in sales levels is accounted for by first differencing, and the fixed-effects, $\breve{a}_i$, control for unobserved heterogeneity in DVD sales decay rates. Taking this heterogeneity in sales decay paths across movies out of the error term mitigates concerns about potential endogeneity due to any systematic correlation between the DVD sales decay rates and time of entry in broadcast windo for movies. Also note that this specification is equivalent to treating the previous week's DVD sales as the right-hand side variable and thus additionally accounts for the effect of the previous week's DVD sales on the current week's DVD sales.

Table 4 reports the coefficient estimates from specifications (1) and (2). We find positive and significant coefficient estimates for the blackout period indicator variable and the broadcast period indicator variable. These estimates suggest that DVD sales increase by 10 percent due to the blackout effect and by an additional 10 percent due to the broadcast effect of the movie.[15] Note that in this specification, we are able to estimate the broadcast effect (i.e., the net effect of both the information spillover and cannibalization effects), but not the two effects separately. We further find positive and significant estimates for the blackout and broadcast period coefficients in the first-differences form (specification 2),

[15]To save space we have not included the coefficient estimates for time indicators in Table 2, but these coefficients are consistent with expectations: DVD sales decline with time.

which indicates a decline in the proportional decay in DVD sales from week-to-week during the broadcast window. The estimated coefficients from specification (2) translate into a 7 percent and 9 percent increase in DVD sales during blackout and broadcast periods respectively.

Therefore, we find a similar effect in DVD sales during broadcast window even after accounting for any systematic heterogeneity in decay rates across movies. These estimates translate into, on average, an additional 464 DVD sales per week for each movie due to the broadcast window. For the 30 weeks broadcast window for our sample of 314 movies, this translates into additional sales of approximately 4.4 million DVDs and additional revenue of approximately $66 million (assuming an average DVD sales price of $15). Thus the impact of the broadcast window is economically significant for the movie industry.[16]

To check whether the estimated increase in DVD sales are due to the information spillover from the broadcast, we explore how the increase in DVD sales for movies is correlated with their viewership inside the broadcast window. For this analysis, we use the weekly viewership (number of households in millions) for a movie instead of indicator variable as the broadcast variable in specification (1). We report the estimated coefficient in the third column of Table 4. We find a qualitatively similar estimate for the blackout period coefficient. We further find a positive and significant estimate for the weekly viewership of movies, which indicates that the net effect of information spillover and cannibalization effects increases with higher viewership of movies.[17] As higher viewership of a movie during its broadcast is expected to result in both higher information spillover and higher cannibalization effects, this suggests, on average, a higher information spillover effect due to higher viewership.

We recognize that DVD rentals are another channel for watching a movie during its broadcast window. We therefore analyze what happens to DVD rentals of a movie during its broadcast window. As demand shocks unobserved to us may affect DVD sales as well as rentals (i.e., the errors terms for the DVD sales and rentals regressions may be correlated), we used the seemingly unrelated regression (SUR) model to jointly estimate specification (1) for DVD sales and DVD rentals for a sample of 194 common movies, and we report these estimates in Table 5. We also separately estimate specification (1) for DVD sales and rentals for the sample of 194 movies and report them in Table 5.

First, we find that the coefficient estimates from the joint estimation are qualitatively similar to that from the separate estimation on DVD sales and rentals. This reassures us that our results on DVD sales for a full sample of 314 movies are robust to not jointly estimating it with DVD rentals. Next, we find a positive and significant coefficient estimate for the blackout period, indicating that DVD rentals increase by 6 percent due to substitution from the cable VOD and electronic sell through (EST) channels to DVD rentals. However, we find an insignificant coefficient estimate for the broadcast period, indicating that there is (statistically) no additional increase in the DVD rentals during the broadcast period. The significant blackout effect on DVD rentals suggests that consumers substitute their VOD and other electronic rentals with DVD rentals. Like cable VOD and other electronic rental channels, consumers rent movies on DVD to watch over the limited rental period. Moreover, the price of cable VOD and electronic rentals (such as iTunes rentals) are approximately $3 to $4, which is close to the price of DVD rentals ($1 to $2). However, an insignificant impact of the movie's broadcast on its DVD rentals reflects the net impact of the information spillover effect and cannibalization effect. Although some consumers may rent a DVD after becoming aware of the movie through the broadcast, others may avoid the DVD rental because they can watch it on the pay-cable network (if they have access to it).

It is also important to differentiate between the reasons consumers may purchase versus rent DVDs. Consumers mainly purchase a movie's DVD to keep it in their collection for repeated viewing, but they rent its DVD to view it over the limited rental period. If a consumer discovers a movie during its broadcast window and likes it enough to add it to her collection for repeated viewing, she is more likely to purchase its DVD. However, if the consumer does not wish to keep the movie in her collection, she is more likely to either watch it on the pay-cable network or rent its DVD. This suggests that watching a movie on pay-cable network is a substitute to DVD rentals but a complement to DVD purchase. Therefore, we expect a significant cannibalization effect of the movie broadcast on its DVD rentals but an insignificant cannibalization effect on its DVD sales, which is consistent with our empirical results.

Variation in Broadcast Effect across Movies

In the previous section we found a positive and significant broadcast effect over and above the blackout effect. As noted earlier, the broadcast effect is the net of the information spill-

[16]To preserve parsimony in our exposition, we do not report estimates on weekly indicator variables or movie release time indicator variables.

[17]We recognize, of course, that weekly viewership of movies is endogenous in specification (1), as consumers choose to watch the movie broadcast based on a variety of unobserved factor that may be correlated with its demand.

Table 5. Estimates for DVD Sales and Rentals

Dependent Variables: Log(DVD Sales) & Log (DVD Rentals)	Coefficient Estimates (Robust Cluster Corrected Standard Errors)			
	SUR Model		Specf. (1)	Specf. (1)
	DVD Sales	DVD Rentals	DVD Sales	DVD Rentals
Blackout period	0.01 (0.02)	0.06*** (0.012)	0.01 (0.04)	0.08*** (0.03)
Broadcast period	0.08*** (0.03)	0.03 (0.04)	0.07** (0.03)	0.03 (0.03)
N (Number of movies)	9353 (194 movies)		9353 (194 movies)	9353 (194 movies)
R^2	0.91	0.96	0.91	0.96

***Statistically significant at the 1% level (two-sided test).
**Statistically significant at the 5% level (two-sided test).

over effect and the cannibalization effect. Hence, a net positive broadcast effect indicates a higher information spillover effect during the broadcast period. Moreover, we observe a change in the distribution of DVD sales from before the broadcast window to just after the broadcast window (Figure 3). Specifically, we observe that DVD sales increase more for low and moderately popular movies than for hit movies, and this change is not explained by the blackout effect.

We now test how the increase in DVD sales varies as a function of movies with high and low box office sales. Specifically, in Table 6 we divide our sample of movies into quartiles based on box office sales, and use specification (1) to separately estimate the blackout and broadcast period coefficients for each quartile of movies.[18] The mean box office sales revenue (and range) for each quartile of movies in our sample are as follows: $110 million (more than $50 million), $32.7 million (between $16 million and $50 million), $7.3 million (between $1 million and $16 million), and $0.2 million (less than $1 million), respectively. Table 6 shows large and statistically significant coefficient estimates for the broadcast period for the bottom two quartiles, but small and insignificant coefficient estimates for the top two quartiles.[19] These results indicate that less popular movies experience a higher information spillover effect as compared to the cannibalization effect but the comparison of the two effects in popular movies is unclear. We find similar results with the weekly viewership of movies during the broadcast period.

We further compare the broadcast effects for movies from major studios (Paramount, Warner Brothers, Disney, Lionsgate, and Universal) and from smaller "independent" studios. In Table 7, we estimate specification (1) separately for movies promoted by major and smaller studios. We find a positive and significant broadcast effect for movies of minor studios and for the less popular movies promoted by major studios but a small and insignificant broadcast effect for all movies released by major studios. These results also suggest that less popular and less promoted movies experience a higher information spillover effect as compared to the cannibalization effect.

A higher broadcast effect for less popular movies or movies from the smaller studios may be due to the higher information spillover effects for such movies. Since these movies get limited promotions during their theatrical release and pay-per-view window prior to broadcast window, consumers are likely to discover them during their pay-cable broadcast, leading to higher increase in their DVD sales. In contrast, popular movies receive disproportionately high promotions during their theatrical release and pay-per-view window; when such movies are shown on cable television, consumers are already likely to be well informed about their quality and are thus less likely to change their purchase behavior following the broadcast. In the following section, we rigorously test this possibility.

Movie Discovery Model

We argue that the lower DVD sales of less popular movies are partly due to incomplete information about these movies to

[18]As time lag between the DVD release and broadcast window for movies is uncorrelated to their commercial success, the key identification requirement is satisfied while applying specification (1) for each quartile separately.

[19]We also estimated specification (1) for the whole sample of movies with indicator variables for each quartile of movies and find qualitatively similar results: an increase in DVD sales for movies in the bottom two quartiles of popularity.

Table 6. Differential Increase in DVD Sales Based on Movie Popularity

Dependent Variable: Log(DVD Sales)	Coefficient Estimates (Robust Cluster Corrected Standard Errors)							
	(1) Top Quartile	(2) Second Quartile	(3) Third Quartile	(4) Bottom Quartile	(5) Top Quartile	(6) Second Quartile	(7) Third Quartile	(8) Bottom Quartile
Blackout period	-0.057 (0.053)	0.072 (0.057)	0.052 (0.060)	0.057 (0.088)	-0.102 (0.065)	0.086 (0.063)	0.044 (0.077)	-0.137 (0.347)
Broadcast period	-0.092 (0.078)	-0.008 (0,063)	0.134* (0.067)	0.198*** (0.089)				
Weekly Viewership in millions					-0.005 (0.016)	-0.016 (0.036)	0.142*** (0.052)	0.279*** (0.122)
N (Number of movies)	4105 (78)	4061 (78)	4221 (77)	4807 (81)	4105 (78)	4061 (78)	4221 (77)	4807 (81)
R^2	0.875	0.836	0.887	0.864	0.875	0.836	0.887	0.864

***Statistically significant at the 1% level (two-sided test).
**Statistically significant at the 5% level (two-sided test).

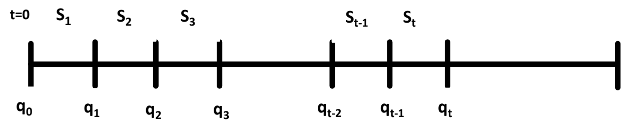
Table 7. Broadcast Effect for Movies from Major Studios Versus Other Studios

Dependent Variable: Log(DVD Sales)	Coefficient Estimates (Robust Cluster Corrected Standard Errors)					
	(1) Minor Studios	(2) All Movies of Major Studios	(3) Less Popular Movies of Major Studios	(1) Minor Studios	(2) All Movies of Major Studios	(3) Less Popular Movies of Major Studios
Blackout period	0.129 (0.102)	0.034 (0.033)	0.027 (0.050)	0.206 (0.192)	0.015 (0.033)	0.057 (0.050)
Broadcast period	0.152*** (0.057)	0.028 (0.043)	0.08** (0.036)			
Weekly viewership in millions				0.121*** (0.057)	0.023 (0.051)	0.089** (0.033)
N (No. of movies)	3768 (64)	13426 (250)	6765 (125)	3768 (64)	13426 (250)	6765 (125)
R^2	0.898	0.941	0.923	0.898	0.941	0.923

***Statistically significant at the 1% level (two-sided test).
**Statistically significant at the 5% level (two-sided test).

the consumers. In the previous section, we showed that DVD sales of less-known movies increase proportionately more during their broadcast than DVDs of well-known movies do. We attributed this higher increase in DVD sales of less-known movies to a higher proportion of consumers discovering such movies during their broadcast. In this section. we explicitly identify this effect by specifying a parametric function for the probability of movie discovery to precisely model the proportion of consumers discovering movies in a time period. We then estimate the parameters of this model on our data to compute the lost DVD sales for movies due to incomplete information to consumers. This model is similar to the model proposed by Hendricks and Sorensen (2009).

Specifically, let $t = 0, 1, 2, 3,\ldots, n$ represent the weeks since the release of a movie on DVD, such that $S_1, S_2, S_3, S_4, \ldots, S_n$ are its DVD sales in these weeks, and $q_0, q_1, q_2, q_3,\ldots, q_n$ are the proportion of potential consumers who have discovered the movie at the end of these weeks.



During the DVD release period, a consumer learns about the movie from advertisements or from word-of-mouth (WOM) created by consumers who have already watched the movie. Moreover, consumers who discover the movie up to week t spread word-of-mouth to other consumers in week t+1. Therefore, we model the probability that a consumer discovers a movie in week 1 with the following logistic learning function:[20]

$$P_1 = \frac{ae^{bT_1}}{(1-a)+ae^{bT_1}} \tag{3}$$

where, T_1 denotes the total DVD sales and DVD rentals of a movie in the first week.[21]

Note that if T_1 is very small, the probability of discovery approaches a. Therefore, the parameter a indicates the awareness of the movie from all factors other than the current week's sales. Similarly, as T_1 gets large, the probability of discovery converges to 1. Therefore, the magnitude of b determines the WOM effect or the rate at which sales in a prior week lead to movie discovery. The probability of purchase is the product of two probabilities: the probability that a consumer likes the movie conditional of having discovered it, and the probability that the consumer discovers the movie. Therefore, DVD sales in week 1 can be given as

$$S_1 \propto P_{1\,(pur\,|\,dis)} \times q_0 \times N$$

where $P_{1\,(pur\,|\,dis)}$ is the probability that a consumer purchases the movie conditional on having discovered it in week 1 (i.e., the consumer preference for the movie in week 1), q_0 is the proportion of consumers who have discovered the movie at the time of its DVD release, and N is the total number of potential consumers who will purchase the movie.

The proportion of aware customers at the end of week 1 is then given by

$$q_1 = q_0 + (1 - q_0) \times P_1 \text{ or } (1 - q_1) = (1 - q_0)\,(1 - P_1)$$

The proportion of new customers, who discover the movie in week 1, is $(q_1 - q_0)$. Let the total proportion of aware customers, who have not purchased the movie until week 1, be a multiple of these newly aware customers say $k_1*(q_1 - q_0)$, where k can vary for different weeks, then the DVD sales in week 2 is given by

$$\begin{aligned} S_2 &\propto P_{2\,(pur\,|\,dis)} \times k_1 \times (q_1 - q_0) \times N \\ &= P_{2\,(pur\,|\,dis)} \times k_1 \times N \times (1 - q_0) \times P_1 \end{aligned}$$

The proportion of aware consumers at the end of week 2 can then be computed as

$$\begin{aligned} q_2 = q_1 + (1- q_1) \times P_2 \text{ or } (1 - q_2) &= (1 - q_1)\,(1 - P_2) \\ &= (1 - q_0)\,(1 - P_1)\,(1 - P_2) \end{aligned}$$

Given this, we can write the DVD sales for any week $t > 2$ as

$$\begin{aligned} S_t &\propto P_{t\,(pur\,|\,dis)} \times k_{(t-1)} \times (q_{(t-1)} - q_{(t-2)}) \times N \\ &\propto P_{t\,(pur\,|\,dis)} \times k_{(t-1)} \times N \times (1 - q_0)\,(1 - P_1)\,(1 - P_2) \text{ ---------} \\ &\qquad (1 - P_{t-2}) \times P_{t-1} \end{aligned}$$

Taking the ratio of DVD sales for consecutive weeks, we obtain

$$\frac{s_t}{s_{(t-1)}} = \frac{P_{t(pur|dis)}}{P_{(t-1)(pur|dis)}} \times \frac{k_{(t-1)}}{k_{(t-2)}} \times$$

$$\frac{(q_{t-1} - q_{t-2})}{(q_{t-2} - q_{t-3})} = \frac{P_{t(pur|dis)}}{P_{(t-1)(pur|dis)}} \times \frac{k_{(t-2)}}{k_{(t-2)}} \times \frac{(1 - P_{t-2}) * P_{t-2}}{P_{t-2}}$$

As consumer preferences for a movie attenuate with age of the movie—newly released movies capture consumer's attention more than older movies do—we expect the ratio of the probability of movie purchase given discovery would reduce with time. Likewise, due to decline in preference for the movie with time, the number of aware consumers who did not purchase the movie would increase with time, and accordingly the ratio k would increase with time. We assume that consumer preferences for a movie decays exponentially with time and accordingly account for the net of these two effects by substituting the first two terms in equation (1) with an exponential decay term.[22] We also add a factor for holiday effects to account for higher consumer preferences for shopping during the holiday season. Therefore, the first two terms in above equation can be simplified as

$$\frac{P_{t(pur|dis)}}{P_{(t-1)(pur|dis)}} \times \frac{k_{(t-1)}}{k_{(t-2)}} = e^{\delta t + \delta_h I_h}$$

[20] In this function, we assume that the WOM created for a movie in a week largely comes from the consumers who consumed it in that week. We also tried modeling WOM from cumulative sales of movies up to the week and found qualitatively similar results.

[21] We recognize that WOM effect about movies from DVD rentals and sales may be different. We cannot identify these effects separately because of multicollinearity problem due to high correlation between DVD rentals and sales (Pearson correlation coefficient of 0.79). However, this limitation does not affect our ability to identify the information discovery effect after controlling for WOM effects, which is the main point of our model.

[22] Literature on movie marketing empirically validates the exponential decay of movie sales with time (Ainslie et al. 2005; Hendricks and Sorensen 2009; Lehmann and Weinberg 2000; Sawhney and Eliashberg 1996).

where the coefficient δ captures the net of the decline in probability of purchase given discovery and increase in number of aware non-purchasing customer with time, I_h are indicator variables for holiday weeks, and δ_h capture the holiday effect.[23]

After taking logs and simplifying, we get

$$Log\left(\frac{s_t}{s_{(t-1)}}\right) = t\left(T_{t-1} - T_{t-2}\right) + Log\frac{(1-a)}{\left\{(1-a)+ae^{bT_{t-1}}\right\}} + \delta t + \delta_h I_h$$

Inside the broadcast window ($t \geq t_{brd}$), pay-cable channels start broadcasting the movies and thus consumers have additional opportunities to discover the movie by sampling it during its broadcast. Therefore, the discovery probability in week t inside the broadcast window is enhanced and given by

$$P_t = \frac{ae^{bT_t + cV_t}}{(1-a)+ae^{bT_t+cV_t}}$$

where V_t is the number of households that watched the movie in week t and parameter c captures the rate at which the probability of movie discovery increases with every additional million viewerships of movie broadcast. A positive value of c indicates that a higher viewership of the movie during its broadcast leads to a higher probability of its discovery.

So for any week $t > 2$, we take the following general specification (3) for the ratio of DVD sales in two consecutive weeks to the data

$$Log\left(\frac{s_t}{s_{(t-1)}}\right) = b\left(T_{t-1} - T_{t-2}\right) + c\left(V_{t-1} - V_{t-2}\right) + Log\frac{(1-a)}{\left\{(1-a)+ae^{bT_{t-1}+cV_{t-1}}\right\}} + \delta t + \delta_h I_h + \varepsilon_t \quad (4)$$

where V_t (i.e., pay-cable viewership) in any week t prior to broadcast window will be zero.

For week $t = 2$, the ratio of sales for week 2 to week 1 is given by specification (4)

$$\frac{S_2}{S_1} = e^{\delta t + \delta_h I_h} \times \left(\frac{(1-q_0)}{q_0}\right) \times \frac{ae^{bT_1}}{(1-a)+ae^{bT_1}} \quad (5)$$

We estimate specification (4) on data for our full sample of 314 movies as well as the limited sample of 194 movies where we have DVD rental data.[24] We use DVD sales as total sales (*TS*) in equation (3) for our full sample of movies, and we utilize the sum of DVD sales and rentals as total sales for our limited sample of 194 movies. The estimated parameters are reported in Table 8. We then substitute these parameters in equation (5) to compute the proportion of consumers who are aware of a movie at the time of its DVD release (q_0) for our sample of movies. The average value for q_0 is also reported in Table 8.

Table 8 shows similar parameter estimates for the full sample and the sample of 194 movies, which indicates that the inclusion of DVD rental data in total sales only scales the parameter estimates but does not qualitatively change them. We find a positive and significant estimate for parameter b that indicates a higher previous week's sales for a movie results in higher movie discovery, and thus higher DVD sales in the current week through a positive WOM effect on DVD sales. We further find a positive and significant estimate for parameter c, indicating that the probability of discovery increases proportionally to the number of households who watched the movie on pay-cable networks in its broadcast window. We also find a negative and significant estimate for δ, and positive and significant estimates for the holiday coefficients (δ_h) indicating, as expected, that preferences for movies decline with time and that DVD sales are higher in holiday weeks than in other weeks.[25] Thus, the parameter estimates of the movie discovery model are in line with our results from the reduced form specifications (1) and are consistent with our theory of movie discovery due to broadcast.

We further find that, on average, 14.7 percent of total consumers are aware of the movie at the time of its DVD release.[26] Next, we compute the economic significance of the estimated parameter c. Using equation (3) and the estimated parameter values, we compute the average weekly DVD sales in the broadcast window for our sample of movies with $c = 0.071$ and with $c=0$, where the difference in the two DVD sales values indicates the increase in DVD sales due to movie discovery. We find that discovery leads to an additional 504 DVD sales per week per movie. This value is close to the

[23]We further relax the assumption of uniform exponential change for the preferences for a movie with time by estimating separate weekly indicator coefficients for each week from DVD release (i.e., estimating different δ_t for different weeks) and find qualitatively similar estimates for information discovery effect.

[24]As noted above, we have DVD rentals data for only 194 movies out of our total sample of 314 movies.

[25]Estimates for holiday dummies are not shown in Table 8 to save space. The complete estimates are available on request from the authors.

[26]We get a higher value of q_0 for the sample of 194 movies because many lesser known movies belonging to small studios are not present in this smaller sample.

Table 8. Estimates for Movie Discovery Model		
Nonlinear Least Square Estimates (Std. Errors in Parenthesis)	**(1) For All Movies**	**(2) For 194 Movies**
a	0.038*** (0.006)	0.044*** (0.006)
b	1.675*** (0.111)	0.620*** (0.105)
c	**0.071*** (0.021)**	**0.056*** (0.016)**
Average preference decay (δ)	-0.119*** (0.007)	-0.121*** (0.008)
Holiday dummies (δ_h)	Yes	Yes
N	17,344	11,556
R sq	0.969	0.964
Average proportion of aware customers at DVD release (q_0)	0.147	0.182

***Statistically significant at the 1% level (two-sided test).
**Statistically significant 5% level (two-sided test).

corresponding value of 464 DVDs per week per movie that we estimated from our reduced form specification (1).

We can now use these parameter estimates to compute the estimated proportion of consumers who have discovered the movies in our sample at the time its broadcast window begins (q_{brd}) and further compare that number to actual DVD sales up to the broadcast window for each movie to obtain counter-factual sales (actual DVD sales / q_{brd}) if all potential consumers had discovered the movie at the broadcast window. Table 9 reports these values for movies at different percentiles (based on box office sales) in our sample. Table 9 indicates that movies in the top decile of box office sales are not substantially undersold in the DVD window. Almost all consumers are informed about the quality of top decile "hits" before they reach the cable broadcast window: Full information sales for these titles are less than 1 percent higher than their actual sales. However, we find a much larger increase in "full information" DVD sales in all other deciles, suggesting a higher scope of discovery due to broadcast for these movies. We find that at the time of the broadcast window, roughly 89 percent of the potential consumers are aware of the movies in the top quartile but only 57 percent are aware of the movies in the bottom quartile.

It is also important to note that preferences for movies decline substantially with time. Table 6 reports the average preference decay parameter (δ) of -0.119, indicating that preferences for a movie decline by 11% [1-exp (-0.119)] from week to week. Recall that DVD sales in a period are the product of two probabilities: the probability of purchase given discovery (preference for movie) and the probability of discovery. So if discovery happens in a later period, sales may increase very little despite higher discovery because of the very low consumer preference for the movie in later periods. In other words, the effect of discovery on movie sales also depends on the time of discovery, making the timing of the broadcast window for movies a very important managerial question.

Robustness Checks

We perform several falsification tests in this section to rule out other alternative explanations for our results.

It is possible that pay-cable networks may broadcast certain movies more often or more in the prime time slots versus other movies based on factors such as success of other recently released movies of the same actors/actresses at the box office or on DVD. As most of such factors guiding strategic scheduling of movies are unobservable to us in the data, using broadcast variables such as number of times or timings of broadcast of movies would be endogenous in our specification (1) and may lead to biased estimates. In contrast, using an indicator variable for movie broadcast period (when the start of movie broadcast inside the broadcast window is exogenous) results in an unbiased estimate of the average broadcast effect. Nonetheless, to further provide support to our results, we estimate specification (1) with the total number of times a movie is shown during its broadcast window as the broadcast variable. The resulting coefficient

Table 9. Counterfactual Sales Under Full Information				
Percentile	**Movie**	**Observed Sales up to Broadcast Window**	**Full Information Sales**	**Difference**
Max	Kung Fu Panda	5,572,200	5,605,835	33,635 (0.6%)
0.90	Eagle Eye	1,708,240	2,004,977	296,737 (17.4%)
0.75	Tale of Despereaux	1,074,330	1,257,998	183,668 (17.1%)
0.50	Pride and Glory	406,240	520,154	113,914 (28.0%)
0.25	Fired up!	98,256	135,713	37,457 (38.1%)
0.10	Reservation Road	54,349	66,850	12,501 (23.0%)
Min	How to Rob a Bank	5,245	7,387	2,142 (40.8%)

estimates are reported in Table A1 in Appendix A, which show that the DVD sales of movies increase with their increasing number of broadcasts. These estimates show that our results are robust to controlling for the (albeit endogenous) intensity of broadcast.

Our results showing increased DVD sales in the broadcast window could also be attributed to systematic DVD price reduction and promotional expenses around the broadcast window for movies. For instance, a reduction in DVD prices around the broadcast window would result in higher DVD sales for treated movies (inside the broadcast window) but not for untreated movies (still outside the broadcast window), which would bias our results. To test for this possibility, we collected the weekly DVD prices for 10 movies in our sample and found no systematic variation in their DVD prices around their broadcast window. We also estimated specification (1) for these movies with their weekly DVD prices as an additional right-hand side variable and found a similar broadcast window effect to those reported above.[27]

One may also argue that our results are due to specific decay patterns for movies in our sample rather than the broadcast window effect, such that we would get a similar treatment effects by running specification (1) even in the pre-broadcast window period for our sample of movies. We test for this possibility in Appendix B by randomly inducing a placebo treatment of broadcast in the pre-broadcast window period for our sample of movies. We do not find any statistically significant coefficients for the placebo treatments, suggesting that our results are not driven by differences in decay patterns across movies.

It is plausible that forward-looking consumers who were interested in purchasing a movie would first check to see whether that movie was going to be broadcast on pay cable channels, and then shift their consumption from the DVD to the pay-cable broadcast if it was. Thus, if consumers are forward-looking, and take upcoming pay-cable broadcasts into account when deciding whether to purchase DVDs, we would expect to see a decrease in DVD sales just before the broadcast window. In Appendix C, we check and find no evidence of such forward-looking behavior in our data.

First, we note that it is possible that pay-cable networks select movies for broadcast based on the holiday season. For example, horror movies may disproportionately enter the broadcast window around Halloween, romantic comedies around Valentine's Day, and so forth. If this is true, then the broadcast effect that we observe may be partially attributed to the increase in DVD sales of themed movies in a related holiday season, rather than the actual broadcast. To check for this possibility, we compute the genre-wise percentage allocation of movies that enter the broadcast window in each calendar month in a year (see Table D1 in Appendix D). This table does not show obvious differences in the genre of newly released pay-cable broadcasts over time, suggesting that our results are not driven by holiday-themed movies.

The increase in DVD sales we observe could also be due to an intertemporal demand shift for movies: consumers who would have otherwise purchased the DVD shifted their purchase ahead in time due to awareness created by its TV broadcast. We examine this possibility by including weekly dummies for each week in the broadcast window, using the following regression model:

$$Log(S_{it}) = \alpha_i + \delta_{oscar} \times D_{it}^{oscar} + \beta_{black} \times D_{it}^{black} + \sum_{brwk} \beta_{brwk} \times D_{it}^{brwk} + \sum_t \delta_t \times D_{it}^t + \sum_{calwk} \delta_{calwk} \times D_{it}^{calwk} + \varepsilon_{it} \quad (6)$$

[27]Results are available upon request from the authors.

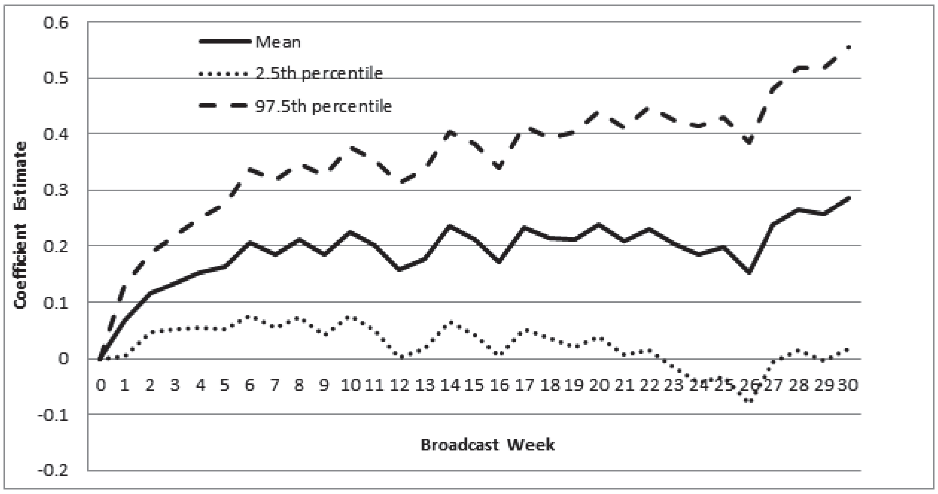


Figure 4. Weekly Broadcast Coefficients in Broadcast Window

where D_{it}^{bwrk} are indicator variables for each week in the 30-week broadcast window and all other variables are the same as in specification (1). To save space, we report the coefficient estimates for specification (6) in a graphical form in Figure 4. This figure shows that all weekly coefficients are positive and, with a few exceptions, statistically significant. If the spillover effect represented a transitory demand shift, we would expect the coefficient estimates for the broadcast week dummies to decline and eventually become negative and significant. Thus, we see no evidence that an intertemporal demand shift impacts our results.

Conclusions

While long tail markets have been observed for some media products such as books, sales of movies remain concentrated in a relatively small number of hits. The literature (Elberse 2008; Elberse and Oberholzer-Gee 2007) provides two main explanations for this concentration: (1) heterogeneity in quality and (2) increasing returns from the social nature of movie demand.

In this paper, we inform this ongoing managerial and academic debate by developing an additional explanation for the observed skewness in movie sales: incomplete information about movie quality. We test this explanation in the context of the pay-cable release window for movies. The pay-cable window is useful for our analysis for several reasons: First, unlike theatrical sales, DVD sales, or video-on-demand sales, the pay-cable broadcast channel is a distribution channel for a movie where there is no "per-item" cost of viewing additional movies, allowing for easier sampling of movies. Second, the timing of the broadcast on the pay-cable channel is such that we can isolate the effect of the broadcast from the effect of other changes in distribution that occur in this window. Finally, the nature of the licensing agreements between pay-cable channels and studios reduces selection bias or timing bias that might otherwise exist between popular and less popular movies.

Our analysis shows that movie broadcasts in the pay-cable window significantly increase DVD sales among less popular movies and thereby reduce the skewness of movies sales. To illustrate this change in our data we see that, prior to broadcast, the top 10 percent of movies in our sample account for 48 percent of total sales (the same proportion reported by Elberse) whereas immediately after broadcast the top 10 percent of movies account for only 35 percent of total sales.

We argue that consumers might be poorly informed about the true quality of movies because movies are a classic "experience good" that must be consumed to be fully evaluated, and because the nature of movie distribution is such that consumers are likely to be exposed to a relatively small set of available movies. Currently, movies are initially released exclusively through "brick-and-mortar" theatrical channels with limited capacity for variety, as opposed to through long tail channels that allow a larger diversity of offerings. This means that, during the theatrical window, consumers are able to view only a relatively small number of movies and, as a result, studios have incentives to only promote a small number of movies. However, as movies enter the pay-cable window, pay-cable subscribers are able to sample a wider-variety of movies (without incurring an additional per- movie cost), and our data suggest that this causes their purchase behavior to shift toward more obscure and previously less commercially successful titles.

Our research illustrates the importance of product discovery in markets with frequent inflow of new products like movies, music, and books. These results are particularly important as studios begin to experiment with new digital distribution channels and alternative distribution windows. For example, MGM, Paramount, and Lionsgate have started to put their movies on a new pay-cable channel called Epix *before they enter the DVD window*. Likewise, Magnolia Pictures released their movie "All Good Things" on cable VOD a month before it was released in theaters and the movie sold very well in both channels. Our results suggest that these experiments with distribution in digital channels that have the capacity to make larger product variety available to a wider consumer base than do traditional movie channels such as theaters, and they may promote movie sales on other contemporary channels. The increased discovery offered by these channels may even make long tail movies more commercially viable than they are in the current distribution structure.

Our research has direct implications for managing different distribution channels. The broadcast of a movie on pay-cable has a positive effect on DVD sales. Studios can utilize this finding in variety of ways. They can promote the movie, manipulate prices, or bundle the movie with other products when the movie is shown on broadcast channels, and they can vary these strategies across more and less popular movies. Pay-cable broadcasts also create rent-seeking opportunities for movie studios in the form of increased DVD sales, and this has the possibility of affecting the contractual language between studios and cable channels.

Our research also has direct implications for the timing of movie broadcast windows. In particular, our results suggest that studios would benefit by changing the pay-cable window so that movies that were less successful in the box office are broadcast on pay-cable channels before more successful movies. In particular, it is not obvious from the current industry practice that pay-cable broadcast should start from 9 to 12 months after DVD release. While more research is needed for a precise answer, our results suggest that some movies will benefit from accelerated entry into the broadcast window.

Our study is, of course, not without limitations. First, because output deals don't cover movies from very small studios or documentary movies, our sample is not perfectly representative of all released movies. Second, although we have shown that the entry time in the broadcast window for our sample of movies is not related to box office sales, the level of DVD sales, or the decay rate of DVD sales, we cannot completely rule out the possibility that pay-cable channels are strategically choosing the broadcast timing of movies. Finally, we also have not been able to separately identify the information spillover and cannibalization effects in our reduced form models.

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RESEARCH ARTICLE

INFORMATION DISCOVERY AND THE LONG TAIL OF MOTION PICTURE CONTENT

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Appendix A

To show how the DVD sales for movies are affected by the intensity of their broadcast, we estimate specification (1) with total number of times a movie is shown during its broadcast window as the treatment variable. The movies in our sample were broadcast, on average, 35.4 times in the 30 week-long broadcast window (standard deviation = 24.8, min = 1, max = 108). Table A1 reports the resulting coefficient estimates, which shows that the DVD sales for a movie increase with the intensity of its broadcast.

Table A1. Estimates for DVD sales

Dependent Variable: Log(DVD sales)	Coefficient Estimates (Robust cluster corrected std. errors)
Blackout period dummy	0.132*** (0.05)
Number of movie broadcast	0.002** (0.001)
N	17194 (314 movies)
R^2	0.947

***Statistically significant at the 1% level (two-sided test).
**Statistically significant at the 5% level (two-sided test).

Appendix B

One might worry that our observed broadcast window effect is mainly due to differences in decay rates of popular versus less popular movies (i.e., flatter decay rates of less popular movies as compared to faster decay rates for popular movies). We test for this possibility by only taking observations for the pre-broadcast window period and randomly assigning a placebo "broadcast" treatment to the movies prior to their actual broadcast. We can then use specification (1) to test whether we see any increase in DVD sales due to this artificial treatment infused in our data. Table B1 reports these coefficient estimates. We find a statistically insignificant coefficient estimate for the placebo treatment effect, suggesting that the treatment effect that we observe in our data is not merely due to systematically different decay patterns for the movies in our sample. We also estimated the effect of the placebo treatment applied between 1 to 5 weeks before the broadcast window and find similar results. By placing the placebo treatment right before the actual treatment, we better compare the effects of the placebo and actual treatment.

Table B1. Estimates for Placebo Treatment Effect on DVD Sales

Dependent Variable: Log(DVD sales)	Coefficient Estimates (Robust cluster corrected std. errors)
Placebo treatment dummy	-0.005 (0.042)
N	7452
R^2	0.967

Appendix C

If consumers are forward-looking, and take upcoming pay-cable broadcasts into account when deciding whether to purchase DVDs, we would expect to see a decrease in DVD sales just before the broadcast window. To test for this possibility, we take the pre-broadcast window data for our sample of movies and put up a pre-window indicator variable (D^{prewnd}) equal to 1 for the last one, two, or three weeks before the broadcast window and zero otherwise. We then run the following specification:

$$Log(S_{it}) = \alpha_i + \beta_{prewnd} \times D_{it}^{prewnd} + \delta_{oscar} \times D_{it}^{oscar} + \sum_t \delta_t \times D_{it}^t + \sum_{calwk} \delta_{calwk} \times D_{it}^{calwk} + \varepsilon_{it}$$

Table C1. Estimates for Forward-Looking Consumer Behavior

Dependent Variable: Log(DVD sales)	Coefficient Estimates (Robust and cluster corrected std. errors)		
	One Week pre-window	Two Week pre-window	Three Week pre-window
Pre-window dummy	0.022 (0.035)	-0.017 (0.02)	-0.032 (0.03)
N	8879 (314 movies)	8879 (314 movies)	8879 (314 movies)
R^2	0.964	0.964	0.964

Table C1 reports the resulting insignificant coefficient estimates for the pre-window dummy variable for one-, two-, and three-week pre-windows, showing no evidence of an unusual decline in DVD sales before the beginning of the broadcast window and thus no evidence that forward-looking behavior is impacting our results.

Appendix D

To check for the possibility that a proportionately higher number of themed movies enter the broadcast window during particular holiday seasons, we compute the genre-wise percentages of movies entering the broadcast window in each calendar month of the year and report these figures in Table D1.

Table D1. Genre-Wise Percentage Breakup of Monthly Movie Broadcast

	Action	Comedy	Drama	Family	Horror	Others
JAN	12%	30%	35%	2%	7%	14%
FEB	18%	29%	21%	11%	11%	11%
MAR	14%	50%	14%	9%	9%	5%
APR	29%	50%	14%	0%	7%	0%
MAY	14%	14%	14%	21%	14%	21%
JUN	20%	40%	20%	10%	0%	10%
JUL	16%	42%	16%	6%	3%	16%
AUG	11%	25%	39%	7%	7%	11%
SEP	3%	24%	34%	10%	7%	21%
OCT	7%	25%	46%	7%	11%	4%
NOV	16%	31%	31%	6%	0%	16%
DEC	8%	36%	40%	4%	4%	8%

From Table D1, we find that a higher proportion of romantic comedies enter the broadcast window in seven months of the year versus its corresponding value in month February. Likewise, we find that a higher proportion of horror movies enter the broadcast window in at least two months of the year as compared to October. In all, we do not find clear evidence of systematic release of themed movies based on the holiday seasons in our data. This is likely because, while these movies are timed to enter *theaters* during a particular holiday month, the lag between the theatrical window and the broadcast window for the entire studio's output deal is not timed to correspond to an even-year increment after the theatrical broadcast.