Cross-Selling in the U.S. Home Video Industry

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Abstract. We argue that the home video industry is subject to significant cross-selling effects: an increase in the demand for a studio's title leads to an increase in that studio's sales of other titles. We argue that, differently from previous studies of cross-selling effects, these spillovers are due to a supply-side, rather than demand-side, mechanism: by means of bundled sales, studios with strong titles are better able to "push" other titles through retailers; and the latter, finding themselves with an abundance of copies, "push" these additional supplies to consumers by means of lower prices and/or heavier advertising.

Empirically, we estimate that a one standard deviation increase in the demand for a studio's old titles leads to a 0.65 standard deviation increase in new title sales. Our strategy for identifying causality is based on "star power" effects: increases in old movie demand caused by recent success of movies with a similar cast and/or director.

Keywords: cross-selling, bundling, backward spillovers, home video industry.

1. Introduction

Many firms and brands sell different, inter-related products. One particularly important link between these products is given by demand spillovers. For example, Sullivan (1990) shows that the 1986 sudden-acceleration incident with the Audi 5000 reduced the demand for the Audi 5000 *and* the demand for the Audi Quattro, as well. Erdem (1998) estimates positive (if small in magnitude) cross-category effects between two oral hygiene products, toothpaste and toothbrushes. More recently, Hendricks and Sorensen (2009) examine data from the music industry and show that "releasing a new album causes a substantial and permanent increase in sales of the artist's old albums — especially if the new release is a hit" (p. 324).

A second source of product inter-relatedness is given by supply effects. Many firms practice bundling, tying, and other forms of cross-selling. Regardless of whether the purpose of such strategies is to extract additional consumer surplus (e.g., Adams and Yellen, 1976), leverage market power from one product to another (e.g., Whinston, 1990) or other, cross-selling, just like demand spillovers, leads to positive correlation across the sales of different products.

In this paper, we document the correlation among multi-product firms' product sales, and inquire into the nature and source of such correlation. Specifically, we distinguish empirically between a demand-side causal effect (e.g., reputation-induced demand spillovers), a supply-side causal effect (e.g., bundling), and simple correlation possibly due to common factors (e.g., the quality of the firm's sales force). Moreover, we explore the relation between demand-driven and supply-driven cross-selling effects.

Our empirical investigation is based on the home video sales industry, where a product is given by a video title of a particular movie. Although the industry's value chain can be complex, in essence there are three levels to consider: retailers such as KMart purchase DVDs from distributors such as Warner Bros. and sell them to individual consumers.

The question we are interested in is whether sales spillovers take place across different products of a given distributor. Specifically: Does a positive shock to the demand for a distributor's "library" video (i.e., a title released more than a year ago) lead to an increase in that distributor's sales of a "new" video (i.e., a title released within the last twelve months)? We answer in the affirmative; we show that the sales spillover effect is both statistically and economically significant. Moreover, we argue that the source of this cross-selling effect is to be found on the supply side, thus complementing the demand-side examples of cross-selling presented above and in the extant literature.[1] As an additional piece of evidence consistent with the supply-effect story, we show that the increase in sales of "new" videos is associated with a decrease in price.

Our empirical design to identify the supply side of cross-selling is quasi-experimental. To be sure, a simple way to estimate the retail cross-sales effect would be to regress a given distributor's sales of new DVD's on the sales of its library DVDs. However, such analysis would be subject to the usual criticism that causality may go either way or may simply be absent, the correlation resulting from an omitted variable bias (for example, the distributor's sales force ability). We therefore proceed by taking an instrumental variable

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1. The cross-product sales effects considered in the above examples may result from consumer information processing or from shifts in consumer utility, as discussed for example in Hendricks and Sorensen (2009); but either way they correspond to *demand* spillovers.

approach. Our identification strategy is based on an important assumption regarding movie DVD demand, namely that it depends on the movie's credits — specifically, the movie's director and its top cast — but not on corporate identity (that is, the movie's distributor). We believe this is a reasonable assumption: people want to watch James Cameron or Tom Cruise movies, not movies distributed by Warner Bros.[2]

Given this assumption, we use the "star power" channel to introduce an instrument for the effect of within-distributor popularity shocks working through the existing library of each studio. Suppose that *The Vow* (2011), distributed by Sony and starring Rachel McAdams, performs particularly well at the box office (it did). For reasons similar to those in the music example studied by Hendricks and Sorensen (2009), this leads to a "backward spillover" effect whereby the demand for Rachel McAdams movies increases. Warner Brothers, the distributor of *Wedding Crashers* (2005) — also starring McAdams — receives a positive shock to the demand for its movie library. We argue this shock makes a good instrument for our regression of new video sales on library sales because: (a) it is exogenous to Warner Bros.; and (b) it is uncorrelated with current Warner Bros. releases *not* featuring McAdams (or any of the top talent in *The Vow*). We refine our instrumental variable design to bolster the exclusion restriction that demand shocks are not directly affecting the studio's new release sales.

Our IV estimates suggest that a one standard deviation increase in library sales leads to a 0.65 standard deviation increase in new sales, an effect that is economically significant (in addition to statistically significant). We thus find evidence of important cross-selling effects in video sales. Unlike Hendricks and Sorensen (2009) and other related studies, these cross-selling effects are not demand related. In fact, in the eyes of the consumer there is no relation between the titles that are cross-sold. Rather, we argue that cross-selling results from supply-side effects such as upstream bundling: studios with strong libraries are better able to "push" current titles through retailers; and the latter, finding themselves with an abundance of copies, "push" these additional supplies to consumers by means of lower prices and/or heavier advertising. In fact, consistent with this interpretation, we find that the retail prices of the titles associated with the positive cross-selling effects are lower (that is, at the retail level, it is lower prices, not demand shocks, that explain increased sales).

As an additional check to our interpretation of the causes of cross-selling effects, we run a series of placebo matched regressions where we estimate the effect of studio i demand shocks on studio j sales, with j being different from but very similar to i. To continue with the earlier example, we observe that a shock to the demand for *Wedding Crashers*, a Warner Bros. movie, is associated to higher sales by *Contagion*, a demand-unrelated movie by the same studio. However, it is *not* associated to higher sales by demand-unrelated movies not owned by the same studio (e.g., Sony's *Moneyball*, which was released on DVD at about the same time as Warner's *Contagion*).

In sum, our instrumental variable two-stage least squares (2SLS) approach effectively characterizes downstream cross-selling effects that result from upstream supply actions. The instrument we use for demand shocks reflects the type of demand-side cross-selling effects characterized by Hendricks and Sorensen (2009) for the music industry: to the extent that two DVDs share the same talent, their similarity in the eyes of the consumer leads to demand

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2. In this sense, the movie industry is different from industries where corporate-level brands play an important role in determining demand; see, for example, Anand and Shachar (2004).

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spillovers. By contrast, the second stage of our estimation characterizes supply-side cross-selling effects: by constructing sets of DVDs that do not share any of their talent, we are able to identify the correlation in sales as the result of a supply-side, within-firm causal effect. Finally, the structure of our empirical model establishes an important mechanism that relates demand-side and supply-side cross-selling effects.

Our paper makes a contribution to several literatures in industrial economics, strategy and marketing. First, as mentioned above, a number of authors have estimated demand spillovers across products sold by the same firm or under the same brand.[3] In this sense, the paper that is closest to ours is Hendricks and Sorensen (2009). The crucial difference between our papers is that we emphasize sales spillovers caused by *supply* effects, rather than by demand effects. Specifically, the demand spillover effect that Hendricks and Sorensen (2009) estimate for music is used here as an instrument for distributor demand in movies, thus allowing us to estimate the extent of supply-driven sales spillovers.[4]

Second, our paper is related to the literature on bundling. In a monopoly context, this literature has shown how bundling can be used to extract additional consumer surplus (Stigler, 1963; Adams and Yellen, 1976; Schmalensee, 1984; McAfee et al., 1989; Hanson and Martin, 1990; Salinger, 1995; Armstrong, 1996; Bakos and Brynjolfsson, 1999). In an oligopoly context, a question of interest is the effect of bundling on competition (Matutes and Regibeau, 1988, 1992; Anderson and Leruth, 1993) or competitor foreclosure (Whinston, 1990; Choi and Stefanadis, 2001; Nalebuff, 2004). We do not observe sale contracts between studios and retailers. Anecdotal evidence suggests that many aspects of the contractual relationship between studios and retailers are not formal or written. However, our estimates provide indirect evidence of the extent of bundling-type arrangements in the home video sales industry that may be more broadly useful in examining vertical relations in business-to-business markets.

Finally, from a methodological point of view, we show how movie and home video sales data enable a simple strategy for econometric identification. The crucial characteristics of this economic sector that allow us to do so are that (a) consumer demand is a function of the product's inputs (movie credits) and (b) there is considerable variation of inputs across products (movie credits overlap partially across movies). Our design thus complements recent work using the U.S. entertainment sector as an empirical laboratory to study vertical arrangements (e.g., Chu, Leslie, and Sorensen 2011; Ho, Ho, and Mortimer 2012; Crawford and Yurukoglu 2012).

The rest the paper is organized as follows. In the next section, we develop the theoretical framework underlying our empirical predictions of retail cross-selling effects consistent with upstream bundling. In Section 3, we provide an overview of the home video industry, with a particular emphasis on the video sales segment. Section 4 introduces our video sales dataset as well as the empirical results. Finally, Section 5 concludes the paper.

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3. The theoretical background for these papers includes the literature on umbrella branding. See, for example, Wernerfelt (1988), Choi (1998), and Cabral (2000).

4. Also, there is an important different between music and movies. Whereas in the former there is a clear one-to-one correspondence between product and producer (the singer or band), each movie is an organization of its own. This implies that we take a stance on the channel through which demand spillovers take place. We consider several possibilities, all variations of the movie's top credits.

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2. Theoretical Predictions

In this section we present a simple model of an industry vertical chain where the wholesaler sells to retailers by means of mixed bundling. Our goal is to understand the implications of upstream bundling for prices and sales at the downstream (retail) level. Our analysis will result in a two-part theoretical result which corresponds to the main testable implications in the paper.

Consider a generic retailer selling two products, 1 and 2, and a mass m (a continuum) of consumers shopping with the generic retailer. The retailer in turn buys from a wholesaler. Each final consumer's valuation for one unit of product i is given by $u_i v_i$, where u_i is consumer specific and v_i is product specific but common across all consumers. With this notation we can model demand shocks to product i as shifts in the value of v_i, that is, proportional changes in valuations across all consumers. We assume that u_i is distributed according to the c.d.f. $F(u_i)$, with corresponding density $f(u_i)$. An individual consumer buys product i if and only if $p_i \leq u_i v_i$, which is equivalent to $u_i \geq p_i/v_i$, which happens with probability $1 - F(p_i/v_i)$. It follows that the demand for the retailer's product i is given by $q_i = m\left(1 - F(p_i/v_i)\right)$. Finally, regarding the distribution of consumer valuations, we make the following assumption:

Assumption 1. *(a) $F(u_i)$ is continuously differentiable; (b) $\left(1 - F(u_i)\right)/f(u_i)$ is decreasing in u_i.*

Part (a) of Assumption 1 is made primarily for technical ease. Part (b) has the interpretation that the marginal revenue curve corresponding to demand $q_i = m\left(1 - F(p_i/v_i)\right)$ is decreasing (and thus produces a unique profit maximizing price, assuming non-decreasing marginal costs). Most common distributions satisfy Assumption 1, including the uniform, normal, and log-normal distributions.

We consider a wholesaler who offers its two products under mixed bundling: prices w_i for each of the goods in isolation and a price b for a bundle of one unit of each good, where $b \leq w_1 + w_2$. We follow a partial equilibrium analysis. Specifically, we consider the problem of a generic retailer who is faced with given wholesale prices. Our goal is not to derive conditions for optimal bundling by the wholesaler but rather how, given mixed bundling, a shock to the retailer's demand for product i has an effect on the retailer's price and sales of a demand-unrelated product. Our central theoretical result is as follows:

Proposition 1. *A small increase in demand for good j, v_j, leads to:*

  (a) an increase in the retail sales of good i, q_i

  (b) a decrease in the retail price of good i, p_i

The proof is available in the Appendix. Proposition 1 states that upstream bundling implies downstream cross-selling, in the sense that a positive demand shock to product j leads to an increase in sales of product j *and* of product i as well. Intuitively, the retailer's derived demand for product j increases and, to the extent that there is upstream bundling, an increase in retailer's derived demand for j implies an increase in the retailer's purchases of product i as well. Since the retailer's shadow marginal cost of product i is effectively zero,

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this increase in purchases is accompanied by a decrease in price so as to boost demand for product i.[5]

The two parts of Proposition 1 correspond to two specific empirical predictions, which we test in Section 4. Before that, we briefly describe the industry we focus on, the U.S. home video sales industry, and re-state Proposition 1 in terms of specific industry measurables (that is, we define the precise meaning of Proposition 1's i and j in terms of the home video industry).

3. The U.S. Home Video Sales Industry

The setting for our empirical study is the U.S. home video sales industry during the period 2000–2009.[6] In essence, the video sales industry comprises two stages in the value chain: content distribution companies, such as Warner Bros, selling video titles to retail channels such as Kmart.

A distributor's cost structure is typical of an information good: a long development time, corresponding to a large sunk cost; and a product with a long — in fact indefinite — life that can be sold at nearly zero marginal cost. In this context, the distributor's problem, conditional on a set of available titles, is essentially one of revenue maximization.

Downstream, the distributors face a series of retail channels, which range from fairly small specialty stores to larger retail outlets such as Amazon.com. Upstream, distributors obtain content from a series of industries such as feature film, TV and cable producers. In this paper, we focus exclusively on feature film home video titles, which account for the lion's share of the video sales industry revenue.

Video sales correspond to one of the movie industry's multiple revenue sources. The latter also include box-office revenues, video rentals, premium TV, merchandizing, and other smaller items. Typically, one specific piece of content — a movie, that is, a title — is sold through various channels according to the "windows" system, a sequential release system that facilitates price discrimination and revenue maximization. For the purpose of our analysis, we are particularly interested in three channels: box-office revenues, sales of newly released video titles, and sales of library video titles. These are certainly not the only revenue sources captured by a given title. Moreover, the box office is not a direct revenue source of the video sales industry. However, the demand spillover effects across the various windows, starting with box-office revenues, are important enough for us to include them in our analysis.

The main features of the video sales industry, as far as our analysis is concerned, are shown in Figure 2. Upstream there exist a number of distributors, such as Warner Bros. and Sony. Distributors sell videos to retailers. (In the figure we consider one generic retailer.) Among the vast portfolio of home video titles, we make one important distinction: library titles, that is, titles that were released in the video market more than 52 weeks ago; and new releases, that is, titles that were released in the video market within the past 52 weeks.

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5. We should note that Proposition 1 is a "tight" result. One can find counter-examples where Assumption 1 does not hold and Proposition 1 fails as a result.

6. A brief description of this industry is provided by Elberse and Oberholzer-Gee (2007). In many ways, the industry we study resembles the video rental industry, which has been studied extensively by Mortimer (2008). However, there are also important differences, both in the nature of demand and in the structure of the value chain.

In addition to home video sales, distributors also benefit from box-office revenues, which are denoted by a blue (darker) box in Figure 2. However, these are not of direct relevance for retailers, who purchase video titles from distributors. Finally, each retailer sells videos individually to consumers, both newly released and old videos, from Warner Bros., Sony and other distributors.

Very little is known about the contractual details between studios and retailers. Anecdotal evidence suggests that, unlike video rentals, there is very little revenue sharing in video sales. Non-linear pricing is believed to play an important role, as well as mixed bundling, especially in recent years. Industry experts claim that, in this regard, there is considerable variation across studios. There is also considerable variation across time: "Studios do indeed use bundle deals with retail, but they are much more ad hoc than a standardized output deal you would have with Netflix or Rentrak," said one industry expert.

To illustrate with an example from the rental market, when designing retailer contracts, studios typically determine the number of copies for each title, and this is usually a function of (a) the movie's box-office revenue, and (b) the store's average monthly revenue size. It is believed that something similar takes place in the sales market.

One common practice in studio sales to retailers is that of *drafting*. Strictly speaking, it does not correspond to contractual bundling, but the effects are similar. The idea is that, when there is a strong title coming out, studios may coordinate the release with a lesser title so as to push both titles simultaneously. For example, Paramount launched *JackAss 3D* (strong box office) and *Morning Glory* (weak box office) in the home video market. The movies were fairly independent in terms of target audiences. However, Paramount decided to showplace both in the same corrugated (an advertising board placed at the stores entrance). While there is no obligation for the retailer to buy the second movie, the fact that it is advertised in the corrugated means that there may be an incentive to also push that movie.

In sum, while we do not observe the detailed contractual terms governing studio sales to retailers, anecdotal evidence suggests that, by means of bundling, drafting, quantity forcing and so forth, the sales of title x are linked in some way to the sales of title y. This brings us to our testable empirical predictions. According to Proposition 1, a positive demand shock to video title x leads to an increase in the retailer's (derived) demand for video title x. To the extent that x is bundled by the distributor with y, this will result in an increase in the retail supply of y. Even if there is no change in the demand for y, such increase in supply leads to an increase in sales of y as well as a decrease in y's price (the latter considering that price is one of the marketing tools retailers have to "push" the additional inventory of y). Thus, a shock to the demand for x leads to an increase in the sales of y even though there are no demand spillovers between x and y.

Put differently, whereas the demand for video titles by the retailer is a *derived demand* (derived from the final consumer's demand), the supply of video titles by the retailer is a *derived supply*, in the sense that it reflects the nature of upstream supply. This is true in general regarding price levels: a higher wholesale price induces a higher retail price. What is novel in our argument is that upstream bundling induces downstream cross-selling.

Specifically, let x denote a studio's "library" video titles, that is, videos released more than one year ago; and let y denote the same studio's "new releases," that is, videos released less than one year ago. An empirical prediction from our analysis is that a demand shock to x leads to an increase in the sales of y as well as a decrease in y's retail price.

4. Empirical Analysis

In this section, we seek to empirically analyze whether sales spillovers take place across each distributor's title portfolio. We will not be able to unequivocally link bundling with sales spillovers, but we will argue that (a) sales spillovers do take place, and (b) they are due to supply effects, not to demand effects.

Before getting into the details of our estimation, we provide a brief description of our empirical strategy. This can be explained again with reference to Figure 2. Our goal is to assess the statistical relation between sales of different movies by a given distributor. In terms of our notation above, let x be a library video title by Warner Bros, e.g., *Wedding Crashers*; and let y be a recent video title release by Warner Bros, e.g., *Contagion*. Suppose there is a positive shock to the demand for x. Does this lead to an increase in the sales of y? Simply regressing the sales of y on the sales of x will not provide a convincing answer, as there are many potential omitted variables that can explain co-movements in x and y. Our identification strategy employs current box-office success of library stars as an instrument for demand shocks to x.

Consider a simple example given by the three movies listed in Table 1 (as well as in Figure 2). *The Vow*, distributed by Sony, hit the theaters on February 12, 2012. It grossed $41 million during the first weekend, a fairly good performance.[7] Following the reasoning in Hendricks and Sorensen (2009), we expect that the *The Vow*'s success will have increased the demand for older titles available on video that feature some of the same top stars. Specifically, *Wedding Crashers*, released in 2006 by Warner Bros, shares with *The Vow* one of the top 3 stars: Rachel McAdams.

We believe the success of movies such as *The Vow* provides a good instrument to estimate the impact of demand shocks to movies such as *Wedding Crashers* on the sales of movies such as *Contagion*. The idea is that, by sharing some of the top talent, the demands for *The Vow* and *Wedding Crashers* are clearly correlated. However, it is reasonable to assume that the demand for *The Vow* at the box office is uncorrelated with the demand for *Contagion* on video. In fact, none of the top talent in *The Vow* is present in *Contagion*.

While the idea is simple, its implementation raises a number of challenges. We next present that data we use to estimate the presence of cross-selling effects, as well as the precise steps we take in order to implement the above identification strategy.

■ **Data.** We use proprietary data from Nielsen VideoScan, a leading provider of information on video sales. VideoScan covers a large sample of retail outlets (but not Wal-Mart). Although the list of retailers is available, we have no information regarding the specific contractual terms between distributors and retailers.

VideoScan details weekly U.S. units sold of each video title on 24,451 feature films with active sales between 2000 and 2009. In a given week, we can divide the list of video titles into two groups: "library" and "new releases." We define library titles as those that have been released in the video market more than a year before, whereas new releases are those that hit the video market within the past 52 weeks.[8] Thus, in our data new titles

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7. Source: imdb.com. The movie's budget is estimated at $30 million. As of April 29, 2012, it grossed over $124 million.

8. Our data include video sales under all formats. Sometimes companies re-release a video title under a different format, e.g., Blu-Ray; we define "new" releases based on the original release date as recorded video, rather than on title-format combinations.

become library titles right after 52 weeks since release.[9] VideoScan also provides weekly data on retail prices of video units (which are different from the manufacturer suggested retail price). However, the price series is sparse. For these reasons, our analysis focuses primarily on explaining quantity variations.

We combine this information with data on the U.S. theatrical distribution industry drawing from well-known sources. *Variety*, the leading industry periodical, and AC Nielsen EDI, a market research provider, report weekly box-office revenue for all films since 1985. Studio System and *Variety* provide company information. IMDB, an online database owned by Amazon.com, contains film- and person-level data.

Table 2 provides summary statistics of the main variables we use. Our unit of observation is a distributor-week. The sample consists of all distributor-weeks in which a distributor is active in the market. Sales variables are defined as the number of units sold.[10] Specifically, each distributor sells on average 17,391 units of library videos per week. However, the median is considerably lower. This reveals a very skewed distribution of sales, a feature that is common to many other industry segments.

The variable box-office spillovers was constructed from raw information in a way we describe below. Basically, it reflects current week box-office revenues (in dollars) per person (that is, per top talent involved in the movie). Similarly to video sales, it has a very skewed distribution.

The number of titles, number of genres, and number of countries are calculated over the actively sold library titles of each distributor over the last month. Finally, new release prices, in dollars per unit, have a median that is approximately equal to the mean. The distribution is reasonably symmetric but bimodal, with one mode close to $10 and one close to $20.

In addition to distributor-week data, Table 2 also indicates the number of observations of three key derived variables that we explain in detail below.

■ **Specification.** Consider the weekly evolution of distributors' portfolio of feature film sales in the video industry. We seek to understand whether, for a given distributor, a positive shock to consumers' preference for its library titles leads to more sales of its new release titles through a supply-side channel. We propose to do so by using demand-side shocks to the success of film actors reflected in weekly box-office revenues as an exogenous instrument. We believe this is a good instrument for two reasons. First, its origin in a different market with largely unpredictable sales in weekly frequency assuages the usual concerns of omitted variables and reverse causality that would arise if the impact of the endogenous library sales variable were estimated in a reduced form OLS design. Second, it satisfies the exclusion assumption, to the extent that the film actors we consider are not present in the new releases we want to measure, a condition we will ensure through examining the video titles included in the dependent variable. We next develop our instrumental variable strategy in greater detail.

■ **Instrumental variable strategy.** We consider backward spillovers from ongoing box-office performance onto a distributor's existing video library of feature films. The idea of

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9. When redoing the analysis using 26 weeks instead of 52 weeks in defining new releases, the results remain essentially unchanged.

10. The empirical analysis uses quantity variables expressed in logarithms.

backward spillovers was introduced by Hendricks and Sorensen (2009) in the context of the music industry.[11] They show that "releasing a new album causes a substantial and permanent increase in sales of the artist's old albums — especially if the new release is a hit." Our approach differs from theirs in two ways. First, whereas they are interested in backward spillovers in and of themselves, we are primarily interested in these demand-side effects as an instrumental variable. In other words, we take demand-side spillovers as a given and use them to instrument for demand shocks and thus estimate possible supply-side spillovers.

A second important difference between our backward spillovers and Hendricks and Sorensen (2009) is that the movie industry differs from the music industry in one critical way. In music, artists are either individuals or teams that work in a stable manner over time. By contrast, in the movie industry, star performers always work in groups, and these groups are formed on a project-by-project basis and later dissolved. In short, to capture the spillovers from box-office performance to video libraries, it is necessary to have granular data on the teams behind each film, groupings that are short-lived.

Fortunately, our data sources provide the identity of all team members contributing to each film. We assume that spillovers from the box office to the video market take place exclusively through the identity of the director and the top actors (according to each feature film's billing record). There may be dozens or hundreds of actors in a given movie, but it is unlikely that all of them create backward spillovers to their prior material. Accordingly, we limit our analysis to the top three billed actors (although, for robustness purposes, we consider the top five as well, finding the results unchanged).[12]

Specifically, we use data on weekly box-office revenues matched with the identity of the director and each movie's top actors to create a person-week index equal to the weekly box-office revenue of the films featuring that person. From the person-week popularity index we create a distributor DVD library-week popularity index, which we denote by BOS_{it}. We do so by adding the popularity indices of all of the top talent featured in the distributor's library titles. For example, consider Sony Pictures' *The Vow* (2012), starring Rachel McAdams and released in theaters on February 10, 2012. If studio i owns a DVD starring Rachel McAdams as one of the top 3 actors, then BOS_{it} includes all of the period t revenues of firms starring Rachel McAdams as a top 3 actor. If studio i owns n titles starring McAdams as a top actor then the above value is added n times. In other words, BOS_{it} captures the spillovers of McAdams' current success on distributors who have ever had a stake on McAdams. In particular, we note that studio i need not be Sony, the distributor of *The Vow*. Warner Bros owns *Wedding Crashers*, released as a DVD in 2006, and so BOS_{it} includes the current revenues of *The Vow* if i is equal to Warner Bros. Intuitively, the backward demand spillovers work across studios: film viewers care about stars, not the studios that hire them. The success of Sony's *The Vow* is good news for Sony and for Warner Bros. as well.

Our approach to modeling the shock is simple and, we believe, quite natural. It implies that there are two ways in which a library can have a high popularity index: either it has more films featuring talent with current box-office success, or it has more successful actors per library film. In other words, the library-week popularity index results from an actor

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11. Backward spillovers are akin to the backward reputation effect identified in Cabral (2000).

12. It is important to keep the number of spillover-generating team members small because of the exclusion restriction idea introduced below.

composition effect and a title composition effect. In the regressions, we control for library size to deal with the possibility that the index picks up quantity rather than quality effects.

The first stage regression takes the form

$$LS_{it} = \gamma_0 + \beta \cdot BOS_{it-1} + \lambda_i + \theta_t + \epsilon_{it} \tag{1}$$

where LS_{it} denotes logged sales of library videos (in units); and BOS_{it} denotes the logged sum of period t box-office revenues of all top talent that are present in i's feature film video library, as described above. Specifically, by top talent we mean directors and top three actors; and by top talent revenue we mean the revenue generated by the films they work on.

Are these spillovers from box office to video libraries exogenous? We propose they are. First, box-office performance is risky, difficult to predict. Second, the composition effect of flexible, dissolvable teams in the movie industry guarantees that distributors cannot control the *simultaneous connection* between success at the box office and success of their video libraries. For example, from Warner Bros.' perspective Sony's success with *The Vow* is an exogenous shock, not the least because the release of Sony's hit took place 7 years after the release of *Wedding Crashers*. Third, we model these shocks on a weekly basis, thus impeding endogenous adjustments to popularity shocks through other policies.

Our design also seeks to satisfy the exclusion restriction. To see this, let us complete our 2SLS specification with the second-stage regression:

$$NS_{it} = \alpha_0 + \beta \cdot \widehat{LS}_{it} + \lambda_i + \theta_t + \epsilon_{it} \tag{2}$$

where NS_{it} denotes logged sales of new DVD releases (in units). The endogenous LS_{it} variable is instrumented with equation (1). Econometrically, the instrument is valid if it affects NS_{it} only through LS_{it} but not through other channels. The concern with using a popularity metric to create an instrument is that it would generate a demand-side effect rather than supply-side relation. Precisely because we are interested in supply-side arrangements, satisfying the exclusion restriction is crucial.

To bolster the exclusion restriction for our instrument, we "clean" the dependent variable to leave only as non-zero those observations that are plausibly disconnected from demand-side shocks like popularity. Specifically, our definition NS_{it} corresponds to newly released titles with no top talent with a positive popularity index that is present in studio i's library. To go back to the example in Table 1: if any of the top talent in *Contagion* — Steven Soderbergh, Matt Damon, Kate Winslet, Jude Law — have a positive popularity index during period t *and* they contribute to films in Warner's DVD library, then *Contagion* is excluded from NS_{it}. Since there is a large number of titles in our sample, we are able to force this exclusion and still maintain a large number of observations. Given our restricted NS_{it} variable, we argue that the influence of the instrument BOS_{it} on NS_{it} cannot take place through a Hendricks-Sorensen type backward spillover mechanism inside the firm: there is simply no overlap between the box-office shocks and the "cleaned-up" observations used in the dependent variable. In other words, if there is any positive influence of library sales on NS_{it}, it must be operating through a firm-level mechanism, as the only connection is the fact that both titles originate in the same distributor i.[13]

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13. Our results are robust to not cleaning the dependent variable, leaving therefore a larger number of new release titles in the analysis and relying on just a verbal argument for the exclusion restriction.

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■ **Results: Quantity.** Table 3 presents the results of the instrumental variable design proposed in specification (1)–(2), for the case of film directors and top-3 billed actor spillovers from the previous week's box-office revenues. The unit of observation is a distributor-week. The sample is all weeks in which a distributor has a title for sale. All sales variables are defined as the logarithm of total number of units sold. As mentioned earlier, the dependent variable excludes any film for which a director or a top-3 actor appeared in a box office generating film in the previous week. Control variables include quintile dummies with respect to the whole industry for the number of titles, genre variety, and country variety of each distributor's active library over the last month.

In both specifications, the β coefficient from equation (2), measuring the effect of library demand shocks on new release sales, is positive and significant. Because both the dependent and independent variables are in logarithms, β can be interpreted as an elasticity. So an increase of 10% in library sales leads to an increase of 4.7% in new release sales, an economically large effect. This effect is still relatively large when introducing controls for the distributor size, genre, and country-of-films diversity, yielding a value of β equal to 0.496. An additional way of evaluating the economic significance of β is to multiply it by the ratio of the standard deviations of independent and dependent variables. This results in

$$\beta \, \frac{\sigma_{LS}}{\sigma_{NS}} = 0.496 \, \frac{3.59}{2.72} = 0.65$$

In words, a one-standard deviation increase in library sales is associated to an increase of about 0.65 standard deviation in new release sales.

We repeat our regressions by type of retailer.[14] We have no clear theoretical expectation regarding the size of cross-selling effects by type of retailer. Consider for example specialty retailers. On the one hand, smaller retailers might be more easily subject to "quantity forcing" by studios, but on the other hand, specialty stores might also be more focused on certain types of titles and thus less prone to opt for bundling contracts.

We consider all three different types of retailer available in our data source: (i) specialty retailers, (ii) discount mass retailers, drugstores, and grocery stores, and (iii) other mass merchants and Internet retailers. As the name suggests, "specialty" refers to specialty retailers, from A&I Music to Zia Records. It includes the largest number of retailers of all groupings: 500. The second type of retailer refers to discount mass merchants; it includes Bi-Mart, KMart (including supercenters), Rose's, Shopko, Pamida, and Target; but it also includes smaller outlets such as drugstores and grocery stores. Finally, "other mass merchants and the Internet" refers to Amazon.com as well as smaller e-commerce, mail order, and venue retailers.

A caveat is that the grouping of retailers is somewhat coarse in our original data source. For example, the Internet category includes giants like Amazon.com together with much smaller Internet retailers. The specialty group, in turn, includes retailers such as Blockbuster and Starbucks, Movie Gallery and Music Factory — hardly a homogeneous sample.

The results of the analysis of new sales by channel are shown in Table 4. We observe that the effect of library sales on new release sales seems largest for Internet stores and lowest for discount retailers; however, the differences across channels are not statistically

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14. Recall that our observations are at the distributor-week level. Therefore, our regressions by type of retailer do *not* correspond to subsamples of the original sample, rather to subcomponents of the existing variables.

significant.

■ **Results: Pricing.** To the extent that there is upstream bundling, we expect that down-stream cross-selling will take place in two ways: first, a positive demand shock to product i leads to an increase in the sales of product j; and second, the same demand shock also leads to a decrease in the price of product j. So far, we have presented evidence on cross-selling effects in terms of retail sales quantity. We next turn to the effect on retail prices.

Table 5 presents the results from a 2SLS design similar to the one we used for the effect on new release sales. In other words, we substitute new release prices for new release sales as the dependent variable in the second stage of 2SLS. The first stage estimates, in turn, remain the same and are displayed in columns 1 and 2 of Table 3.

The coefficients on LS have the expected negative sign. When we control for size, genre and country dummies, we obtain a coefficient of -1.094. This means that a 1% increase in demand for library movies is correlated with a $1.094 decrease in price, which in turn corresponds to about 6.5% of average price. In terms of magnitude, we estimate that a one standard deviation increase in library sales leads to a 1.32 standard deviation price decrease. The fact we obtain such large price effects may be related to the fact that the price distribution is bi-modal. For some of the j movies — that is, movies that were not hit by demand shocks and for which there is excess inventory — the retailer's policy is sometimes to drastically cut price from a "high" to a "low" price.

Our estimates are statistically significant at the 10% and 5% levels, respectively — a little lower than the sales quantity equations. We offer two possible explanations for the lower significance of our price results, one statistical and one economic. First, as can be seen from Tables 3 and 5, our pricing regressions have substantially fewer weekly observations: less than 5,000, compared to nearly 50,000 in the case of weekly sales. Second, our theoretical prediction is based on a rather simple model where price is the sole marketing variable. Anecdotal evidence suggests that video retailers have other means to "push" titles of which they have a surplus: mounting additional sign boards, placing the titles more prominently, etc. In other words, the broader theoretical prediction is that a positive demand shock to product i should lead to increased marketing efforts in selling product j, of which price is one but not the only means.

In sum, although pricing data are sparse and price is one of several marketing variables, we take these results as suggestive that a supply mechanism is driving the relation between library sales and new release sales.

■ **Placebo tests: Regressions with shocks of matched distributors.** The claim we are testing in this section is that demand shocks to product i lead to increased sales of other products by the same wholesaler, in particular of products that are demand-unrelated to product i. In other words, we claim that the cross-selling effects are due to supply-side actions, not to demand-side shocks. In fact, consumers typically have very little idea of the particular studio responsible for each particular title.

Given this, an additional test that helps sharpen our prediction of a pure supply-side effect is to run regressions where, instead of the proposed demand-unrelated popularity shocks benefiting a studio, we use the demand-unrelated shocks benefiting a different, but very similar, studio as the instrument for the endogenous library sales of the studio of interest. To match each studio with its closest neighbor studio, we use total historical sales

(in video units), total number of different video titles, and date of entry into the sample as the variables whose Euclidean distance is minimized for the closest neighbors. The results are displayed in Table 6. As expected from our theoretical model, we find no statistically significant effects of demand shocks to product i owned by firm x on sales of product j owned by firm y. Recall that Table 3 implies that a demand shock to product i owned by firm x is associated with an increase in sales of product j owned by the same firm x, and Table 5 implies lower prices. Together, the results reported in Tables 3, 5 and 6 strongly suggest that the observed retail cross-selling effects are due to supply effects rather than demand effects.

5. Conclusion

Based on weekly sales data in the U.S. home video industry, we estimate that a one standard deviation increase in the demand for a studio's old titles leads to a 0.65 standard deviation increase in current title sales. We further argue that these cross-selling effects are due to supply channels, rather than demand spillovers. In particular, one natural interpretation of our empirical results is that studios sell titles in bundles, so that a positive demand shock to the final demand for a title from studio i's library leads to an increase in the derived demand for that studio's bundle of titles. Retailers thus find themselves with more copies of new releases to sell than they would otherwise, and thus find it optimal to reduce prices, which in turn leads to higher sales. In other words, our theoretical and empirical results suggest a phenomenon of bundling "pass-through": upstream bundling is reflected in downstream cross-selling effects.

Our strategy for identifying causality is based on "star power" effects: increases in old movie demand caused by recent success of movies with a similar cast and/or director. These demand spillovers are similar to the "backward spillover" effects identified Hendricks and Sorensen (2009) for the demand for music. However, whereas their focus was on the size and interpretation of this effect, we take it as a given and use it as an instrument to identify supply, rather than demand, cross-selling effects.

Appendix

Proof of Proposition 1: Suppose first that the retailer chooses not to buy a bundle, instead purchasing good i at wholesale price w_i. Then profit is given by

$$\pi_S = \sum_{i=1}^{2} (p_i - w_i) \, m \left(1 - F(p_i/v_i) \right)$$

where subscript S stands for "separate purchases." The first-order condition for profit maximization is given by

$$m \left(1 - F(p_i/v_i) \right) - (p_i - w_i) \, m \, f(p_i/v_i)/v_i = 0$$

or simply

$$p_i = w_i + \frac{v_i \left(1 - F(p_i/v_i) \right)}{f(p_i/v_i)} \tag{3}$$

Let $q_i^S(w_i; v_i)$ be the retailer's derived demand for product i (conditional on buying the product separately). Clearly, neither q_i nor p_i depend on v_j, so the proposition holds trivially (if weakly).

Suppose now that the retailer buys q units of the bundle at a price b. The retailer's profit can now be written as

$$\pi_B = \sum_{i=1}^{2} p_i \min \left\{ m \left(1 - F(p_i/v_i) \right), \, q \right\} - b \, q \tag{4}$$

where q is the quantity of the bundle purchased by the retailer and subscript B stands for "bundle purchase." Normally we simply set the quantity purchased by the retailer equal to the quantity demanded, $m \left(1 - F(p_i/v_i) \right)$. In the present case, however, it helps to distinguish the decision of purchasing the bundle from the decision of pricing each of its components, thus the use of the min operator in the above expression.

The following result provides an important step towards solving the bundle purchasing case. Its proof is included after the present proof.

Lemma 1. *In equilibrium, a retailer who purchases q units of a bundle sets retail prices such that $q_1 = q_2 = q$.*

It follows from Lemma 1 that we can treat the retailer's problem as one of choosing q, the quantity of the bundle to purchase, instead of p_i (that is, implicitly choosing the values of p_i that lead to $q_i = q$). In other words, the retailer chooses q so as to maximize

$$\pi = \left(v \, \widehat{F}(1-q) - b \right) q$$

where $v \equiv v_1 + v_2$. The first-order condition for optimal q, where for simplicity we omit function arguments, is given by

$$v \, \widehat{F} - b - v \, \widehat{f} \, q = 0 \tag{5}$$

The second-order condition, in turn, is given by

$$\frac{\partial^2 \pi(q)}{\partial q^2} = -2 v \widehat{f}(1-q) + v \widehat{f}'(1-q) q < 0 \tag{6}$$

where $\widehat{f}'(x) \equiv \partial \widehat{f}(x) / \partial x$.

Recall that $q = 1 - F(p)$ and $p = \widehat{F}(1-q)$. We thus have $d q / d p = -f$ and $d p / d q = -\widehat{f}$, where for simplicity we omit the arguments of $f, \widehat{f}$. It follows that

$$\widehat{f} = 1/f \tag{7}$$

Moreover,

$$\widehat{f}' = -\frac{d \widehat{f}}{d q} = -\frac{d \left(\frac{1}{f}\right)}{d p} \left(\frac{d p}{d q}\right) = -\left(\frac{-f'}{f^2}\right) \left(\frac{-1}{f}\right) = -\frac{f'}{f^3} \tag{8}$$

Substituting (7) and (8) for $\widehat{f}$ and $\widehat{f}'$ into the left-hand side of (6), and also recalling that $q = 1 - F$, we get

$$\frac{\partial^2 \pi(q)}{\partial q^2} = -2 v \frac{1}{f} - v \frac{f'}{f^3} (1 - F)$$

$$= \frac{v}{f} \left(\frac{-2 f^2 - f' (1 - F)}{f^2}\right)$$

$$< \frac{v}{f} \left(\frac{-f^2 - f' (1 - F)}{f^2}\right)$$

$$= \frac{v}{f} \frac{d \left(\frac{1-F}{f}\right)}{d p}$$

It follows from part (b) of Assumption 1 that the second-order condition holds. Moreover, by the Implicit Function Theorem the sign of $d q / d v_i$ is the sign of $\partial^2 \pi / \partial q \, \partial v_i$. Since $v = v_1 + v_2$, from (5) we get

$$\frac{\partial^2 \pi}{\partial q \, \partial v_i} = \widehat{F} - \widehat{f} q$$

But since (5) also implies that

$$\widehat{F} - \widehat{f} q = b/v > 0$$

it follows that $\partial^2 \pi / \partial q \, \partial v_i > 0$ and so $d q / d v_i > 0$. Since $q_j = q$, it follows that $d q_j / d v_i > 0$. Finally, $p_j = v_j \widehat{F}(1-q)$ implies that $d p_j / d v_i = (\partial p_j / \partial q) (d q / d v_i) < 0$. ∎

Proof of Lemma 1: The retailer's profit function is proportional to the size of its customer base. Therefore, for simplicity and without loss of generality in what follows we assume $m = 1$. From $q_i = 1 - F(p_i/v_i)$, we have $F(p_i/v_i) = 1 - q_i$, and thus the inverse demand function is given by $p_i = v_i F^{-1}(1 - q_i)$, or simply $p_i = v_i \widehat{F}(1 - q_i)$, where $\widehat{F} \equiv F^{-1}$. We can then re-write product i's revenue as $q_i v_i \widehat{F}(1 - q_i)$.

Without loss of generality, suppose that $1 - F(p_1/v_1) < q$ and $1 - F(p_2/v_2) = q$. Then the retailer's marginal cost of product 1 is zero. It follows that the first first-order condition from maximizing product 1's revenue, $q_1 v_1 \widehat{F}(1 - q_1)$, is given by

$$v_1 \widehat{F}(1 - q_1) - q_1 v_1 \widehat{f}(1 - q_1) = 0$$

where $\widehat{f}(x) \equiv \partial \widehat{F}(x) / \partial x$, or simply

$$q_1 = \frac{\widehat{F}(1 - q_1)}{\widehat{f}(1 - q_1)}$$

The second first-order condition results from maximizing revenue from the second product's sales minus paying for the bundle: $q_2 v_2 \widehat{F}(1 - q_2) - b q_2$. This leads to the following second first-order condition:

$$v_2 \widehat{F}(1 - q_2) - q_2 v_2 \widehat{f}(1 - q_2) - b = 0$$

or simply

$$q_2 = \frac{\widehat{F}(1 - q_2) - b/v_2}{\widehat{f}(1 - q_2)}$$

Since $F(x)/f(x)$ is increasing, so is $\widehat{F}(x)/\widehat{f}(x)$; and consequently $\widehat{F}(1 - q_i)$ is decreasing in q_i. We thus have

$$q_2 = \frac{\widehat{F}(1 - q_2) - b/v_2}{\widehat{f}(1 - q_2)} < \frac{\widehat{F}(1 - q_2)}{\widehat{f}(1 - q_2)} \leq \frac{\widehat{F}(1 - q_1)}{\widehat{f}(1 - q_1)} = q_1$$

which contradicts the assumption that $q_1 < q_2$. We thus conclude that it must be that $q_1 = q_2$. ∎

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Figure 1

Upstream bundling and downstream cross-selling. Although the demands for products 1 and 2 are independent, downstream cross-selling can take place because of upstream bundling: a demand shock to good 1 implies an increase in q_2 and a decrease in p_2.

Upstream firm

(1,2) bundle sales q at price b

Downstream firm

sales q_1 at price p_1 sales q_2 at price p_2

Consumers
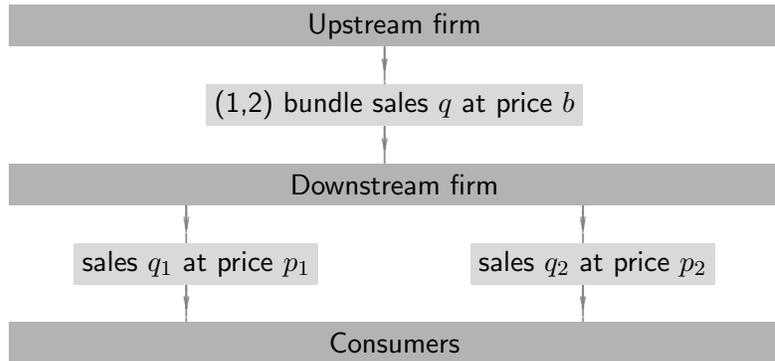
Figure 2

Demand shocks and supply connections in the video sales industry

Studio 1: Warner Bros		Studio 2: Sony	
	Library DVD: *Wedding Crashers* (2005–2006) Rachel McAdams		Library DVD from Sony
	+		+
Box Office movie from Warner Bros	New release DVD: *Contagion* (2011–2012) Matt Damon	Box Office movie: *The Vow* (2012) Rachel McAdams	New release DVD from Sony

Retailer

Library DVD: *Wedding Crashers* (2005–2006) Rachel McAdams	New release DVD: *Contagion* (2011–2012) Matt Damon	Library DVD from Sony	New release DVD from Sony

Consumers

Table 1

Example

Title	Distributor	Theater & DVD release	Director	Top cast
The Vow	Sony	02/12/2012	Michael Sucsy	Rachel McAdams Channing Tatum Jessica Lange
Wedding Crashers	Warner	07/15/2005 01/03/2006	David Dobkin	Owen Wilson Vince Vaughn Rachel McAdams
Sherlock Holmes	Warner	12/25/2009 03/30/2010	Guy Ritchie	Robert Downey, Jr Jude Law Rachel McAdams
Everybody's All-American	Warner	11/04/1988 01/20/2004	Taylor Hackford	Jessica Lange Dennis Quaid Timothy Hutton
Contagion	Warner	09/09/2011 01/03/2012	Steven Soderbergh	Matt Damon Kate Winslet Jude Law

Source: www.moviefone.com/dvd and imdb.com

Table 2
Summary Statistics

Distributor-week data	Mean	Median	Std. Dev.	Min.	Max.	Num. obs.
Library Sales (in units)	17391	3	80026	0	2903919	49724
New Release Sales (in units)	1689	0	18492	0	1478221	49724
Box Office Spillovers (in millions of 2009 dollars)	51	0	214	0	4416	49724
Number of titles	122	14	325	0	2442	49724
Number of genres	6	5	4	0	14	49724
Number of countries	5	2	6	0	30	49724
New Release Prices	16.94	17.27	2.98	2.92	29.97	4867
Library week-person data						
Number of week-person observations						5543519
Number of distinct persons						15847
Number of observations with $BOS > 0$						134517

Table 3

Box Office Spillovers, Library Sales and New Release Sales

| | Dependent Variable: | | | |
	Library Sales Quantity 2SLS First Stage		New Release Sales Quantity 2SLS Second Stage	
Library Sales Quantity (Instrumented)			0.470** (0.19)	0.496** (0.21)
Box Office Spillovers	0.198*** (0.04)	0.166*** (0.04)		
Size quintile dummies$_{it}$	No	Yes	No	Yes
Genre variety quintile dummies$_{it}$	No	Yes	No	Yes
Country variety quintile dummies$_{it}$	No	Yes	No	Yes
Distributor fixed Effects	Yes	Yes	Yes	Yes
Year-week fixed Effects	Yes	Yes	Yes	Yes
R^2	0.13	0.20		
Sample size	49724	49724	49724	49724
Number of clusters (distributors)	130	130	130	130
Weak identification test (F-statistic)			25.7	21.9

***, **,* significant at the 1%, 5% and 10% level. Clustered standard errors in parentheses.

Table 4

Weekly Library Sales and New Release Sales by Retail Channel

	Dependent Variable:		
	New Release Sales Quantity by Channel		
	2SLS		
	Second Stage		
Channel:	Specialty Retail	Discount Mass, Drugstores & Grocery Stores	Other Mass Merchants and Internet Retailers
Library Sales Quantity (Instrumented)	0.392**	0.377**	0.517***
	(0.16)	(0.18)	(0.20)
Size quintile dummies$_{it}$	Yes	Yes	Yes
Genre variety quintile dummies$_{it}$	Yes	Yes	Yes
Country variety quintile dummies$_{it}$	Yes	Yes	Yes
Distributor fixed effects	Yes	Yes	Yes
Year-week fixed effects	Yes	Yes	Yes
Sample size	49724	49724	49724
Number of clusters (distributors)	130	130	130

***, **,* significant at the 1%, 5% and 10% level. Clustered standard errors in parentheses.

Table 5

Library Demand Shocks and New Release Prices

	Dependent Variable:	
	New Release Prices	
	2SLS	
	Second Stage	
Library Sales Quantity (Instrumented)	-0.681^*	-1.094^{**}
	(0.36)	(0.54)
Size quintile dummies$_{it}$	No	Yes
Genre variety quintile dummies$_{it}$	No	Yes
Country variety quintile dummies$_{it}$	No	Yes
Distributor fixed effects	Yes	Yes
Year-week fixed effects	Yes	Yes
Sample size	4865	4865
Number of clusters (distributors)	36	36
Weak identification test (F-statistic)	9.8	11.4

***, **,* significant at the 1%, 5% and 10% level. Clustered standard errors in parentheses.

Table 6

Box Office Spillovers, Library Sales and New Release Sales using Matched Firm's Shocks

	Library Sales Quantity 2SLS First Stage		New Release Quantity 2SLS Second Stage		New Release Prices 2SLS Second Stage	
			Dependent Variable:			
Library Sales Quantity (Inst.)			0.337	0.444	−1.403	−1.502
			(0.72)	(0.94)	(1.02)	(1.08)
Box Office Spillovers	0.048	0.032				
	(0.03)	(0.03)				
Size quintile dummies$_{it}$	No	Yes	No	Yes	No	Yes
Genre variety quintile dummies$_{it}$	No	Yes	No	Yes	No	Yes
Country variety quintile dummies$_{it}$	No	Yes	No	Yes	No	Yes
Distributor fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year-week fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.11	0.19				
Sample size	49724	49724	49724	49724	4865	4865
Number of clusters (distributors)	130	130	130	130	36	36

***, **,* significant at the 1%, 5% and 10% level. Clustered standard errors in parentheses.