RAND Journal of Economics
Vol. 47, No. 1, Spring 2016
pp. 29–47

Cross-selling in the US home video industry

Luís Cabral*

and

Gabriel Natividad**

We identify significant cross-selling effects in the home video industry: a 10% increase in the demand for a studio's old titles leads to a 4.7% increase in new title sales. We argue this is due to supply-side effects: studios with strong titles are better able to "push" other titles through retailers; and the latter "push" these additional supplies to consumers by means of lower prices and/or heavier advertising. 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.

1. Introduction

■ Many industries are characterized by bundling or related practices. For example, movie studios sell movies to rental stores based on full-line forcing contracts (Ho, Ho, and Mortimer, 2012a); cable providers sell TV channels to viewers based on different packages; and publishers sell academic journals to libraries in large bundles. In some instances, bundling takes place at the retailer-consumer level (e.g., cable TV); in other cases, at the wholesale level (e.g., movie rentals).

When bundling takes place at the wholesale level (as in the case of movie rentals), the precise details of the contractual relationship are not always easy to obtain. Moreover, anecdotal evidence suggests that various aspects of the contractual relationship between wholesalers and retailers are not spelled out explicitly. In this context, one may ask whether and to what extent bundling takes place, and what its downstream effects are.

In this article, we estimate the degree of bundling between wholesalers and retailers in 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.) Unlike Ho, Ho, and Mortimer (2012a), our approach allows us to estimate

* New York University; lcabral@stern.nyu.edu.
** Universidad de Piura; gabriel.natividad@udep.pe.
We thank Editor Aviv Nevo, three referees, Matt Grennan, Julie Holland Mortimer, Scott Shriver, Brian Silverman, Jidong Zhou, and seminar participants at NYU, Boston College, Pontificia Universidad Catolica de Chile, and the Columbia Strategy Conference (2014) for helpful suggestions.

the degree of upstream bundling without knowledge of the precise nature of the contracts between wholesalers and retailers.

Conceptually, our strategy is based on the idea that upstream bundling gets "passed through" to downstream sales in the form of studio-level cross-selling effects. Suppose that there is no bundling at the downstream level. We show that, if wholesalers bundle titles when selling to retailers, then a positive shock to the consumer demand of title x should lead to an increase in consumer sales of title y *even if there is no relation between* x *and* y *in the eyes of the consumer* (i.e., even if the two titles are neither related in terms of consumer utility nor in the way they are sold to the final consumer).

The idea of bundling "pass through" is fairly simple. A positive shock to the consumer demand for x leads to an increase in retailer-derived demand for x. To the extent that the retailer's purchases of title x are contractually linked to purchases of title y, a consumer demand shock to x leads in turn to an increase in the retailer's stock of y. Although there is no positive shock to the consumer demand for y, excess inventory leads the retailer to market y more aggressively, which in turn results in higher sales of y. In sum, an estimate of the degree of upstream bundling between x and y is the degree of correlation in downstream sales between x and y.

Our conceptual framework implies an additional testable prediction: retailers have different instruments to increase the demand for y. In the home video sales market, these include the number and location of copies displayed, the used of "corrugated boards," and other promotion devices. In particular, we would expect retailers to use price as a means to "push" excess inventory. Therefore, an additional testable prediction of our bundling "pass through" story is that a positive shock to the demand for x is correlated with a decrease in the price of y.

Our estimates are consistent with final consumer cross-selling effects that are statistically significant and economically important. If x represents demand for library titles and y sales of new releases, we estimate a one-standard deviation demand shock to x to increase sales of y by two thirds of a standard deviation and to decrease the price of y by four thirds of a standard deviation.

A simple way to estimate the retail cross-sales effect would be to regress y on x. 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 (e.g., the distributor's sales force ability). We therefore proceed by taking an instrumental variable approach. Our identification strategy is based on an important assumption regarding movie demand, namely, that it depends on the movie's credits (the movie's "star power," i.e., its director and top cast) but not on corporate identity (i.e., 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.

Given this assumption, we use the "star power" channel to create an instrument for demand shocks. Suppose that *The Vow* (2012), distributed by Sony and starring Rachel McAdams, performs particularly well at the box office (it did). For reasons similar to those studied by Hendricks and Sorensen (2009) in the context of the music industry, this leads to a "backward spillover" effect whereby the demand for Rachel McAdams movies increases. Warner Bros., 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 (our y variable) on library sales (our x variable) because (1) it is exogenous to Warner Bros.; and (2) 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.

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*).

Overall, we conclude that the degree of upstream bundling is considerable and gets "passed through" in the form of downstream cross-selling effects.

Given that we study upstream bundling of x and y, where x is library sales and y new releases, a natural question to ask is why not estimate the impact of a demand shock to y rather than a demand shock to x. Intuitively, if we think of bundling as a form of "pushing" lower demand goods, it might make more sense to think of successful new releases helping sell older titles. Our results for this alternative formulation are not nearly as good, for two reasons. First, the number of new releases is much smaller than the number of library titles, which in turn considerably reduces the number of "star power" matches we are able to create as a demand instrument. Second, anecdotal evidence suggests that DVD releases are closely coordinated with theatrical releases, which implies that a study of the impact of new sales on library sales would raise a different type of endogeneity concerns that we do not face in our preferred design.

In general, cross-selling effects can result from a variety of supply-side channels (in addition to demand-side channels as those studied by Hendricks and Sorensen, 2009). One possibility is economies of scope: as the demand and sales of product x increase, the marginal cost of y decreases, which leads to a decrease in the price of y and an increase in the sales of y. However, given the nature of the good in question (DVDs) we do not believe this channel has much explanatory power with respect to our data. Alternatively, cross-selling can be explained by unobserved shifts in the seller's selling ability: for example, an increase in bargaining power or an increase in the sales force. Such shifts would lead to an increase in sales of x and y, which could wrongly be perceived as cross-selling. Although these mechanisms are potentially important, we believe our instrumental variable strategy successfully separates causal effects from correlation derived from unobserved variables.

□ **Broader implications.** In recent years, policy makers and economics researchers have increasingly focused on mergers that involve "out-of-market" transactions, particularly in the health space: mergers between hospitals in different markets or mergers between hospitals and groups of physicians. Traditional models of oligopoly competition (e.g., Cournot or Bertrand) have little to say about the effects of such mergers. However, reduced-form empirical evidence (Lewis and Pflum, 2014) suggests that such mergers do have an effect on prices. One natural interpretation, especially in the context of health care markets, is that mergers change the nature of the negotiations process between suppliers, such as hospitals and physicians, and "retailers," such as insurance companies (see, e.g., Capps, Dranove, and Satterthwaite, 2003; Grennan, 2013; Gowrisankaran, Nevo, and Town, 2015; Ho and Lee, 2013; Dafny, Ho, and Lee, 2015; see also Villas-Boas, 2007, in the context of supermarkets).

Our analysis suggests that, in addition to changes in the bargaining equilibrium, simply changing the set of goods offered by the upstream supplier may have an effect on the nature of upstream sales terms. Consider the effect of a two-studio merger on the contracts offered to small retailers. Given the difference in size between upstream and downstream firms, it seems reasonable to assume contracts are offered on a take-it-or-leave-it basis. For this reason, we would expect no significant changes in the bargaining equilibrium following a merger. However, as our results suggest, we should expect important effects on quantities sold, namely due to previously absent cross-selling effects. As we will see in Section 2, the welfare effects of these cross-selling effects are not as easy to sign as in traditional models of mergers. In a related industry (video rentals), Ho, Ho, and Mortimer (2012b), show that the effects are positive for upstream and for downstream firms. We do not have enough data to estimate welfare effects, but we do estimate the effects to be economically and statistically significant.

The above discussion also suggests that, when analyzing mergers between firms in unrelated markets, it makes a difference whether these firms sell to the final consumer or sell through retailers. In the former case, we should expect no direct effects on sales terms.[1] By contrast, when the upstream firms sell through retailers, and to the extent that retailers supply both unrelated markets, then the merger is likely to have an effect on sales terms. The negotiated-prices literature provides a natural channel for such effects; the bundling literature suggests an additional channel through which these effects take place.

Bundling issues are seldom considered in merger analysis. Perhaps the best-known recent case is the blocked merger between GE and Honeywell (Nalebuff, 2009). However, in this case, complementarity between the products offered by GE and Honeywell was very much at the center of the concerns with the bundling that would likely follow the merger (in fact, such bundling was part of the logic for the merger, the idea of creating a one-stop-shopping supplier). Our results suggest that, even when the goods offered by the merging parties are demand-independent, we should expect price discrimination concerns to imply real effects following the merger.

□ **Related literature.** The articles that are closest to ours are Ho, Ho, and Mortimer (2012a) and Ho, Ho, and Mortimer (2012b). Their work is based on an extensive data set that provides detailed information on consumer demand for each title within each bundle. This enables them to estimate a realistic final consumer demand model. Then, from each retailer's derived demand, they estimate the retailer's optimal portfolio and contract choices using a moment inequalities approach. Having estimated such a model, they run a series of counterfactual experiments to infer the impact of full-line forcing contracts (bundling) on the profits of distributors and stores.

In our article, we look at a different industry segment (DVD sales, not DVD rentals). More important, unlike Ho, Ho, and Mortimer (2012a), we do not have data on upstream contracts, only anecdotal evidence that various forms of bundling take place. We are thus forced to take an indirect approach to our estimation of bundling effects. Also, in some ways our goal is complementary to that of Ho, Ho, and Mortimer (2012a): they start by modelling demand interdependencies at the consumer level and from that they estimate optimal upstream contract choices; we take upstream contract choices as given and estimate the impact these have on consumer level cross-sales effects *when demand interdependencies are absent*.

Ho, Ho, and Mortimer (2012a), is perhaps a unique research effort given the richness of the contract information it is based on. Many, if not most, empirical studies of vertical relations must take an indirect approach to the problem. In this sense, another related work is by Crawford and Yurukoglu (2012), who estimate the vertical relation between video content providers and cable distributors as a bargaining game over unit price. Having estimated the model, they run a series of counterfactual experiments, estimating in particular the impact of a switch to à la carte channel pricing. One important difference with respect to our article, as well as Ho, Ho, and Mortimer (2012a), is that, in the cable industry, bundling takes place primarily at the downstream level, not at the upstream level.

Methodologically speaking, our article is related to Hendricks and Sorensen (2009). Based on data from the music industry, 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." In other words, they document important consumer sales spillovers due to demand interactions.[2] One important difference with respect to Hendricks and Sorensen (2009) is that we document consumer sales spillovers that are *not* demand related. However, we use Hendricks-Sorensen-like demand spillovers to create an instrument of demand shocks. An additional difference of our article with respect to Hendricks and Sorensen (2009) is that we deal with movies, not music: whereas in the latter case, there is a clear one-to-one correspondence between product

[1] This is not to say that there are no *indirect* effects. For example, were Comcast and Time Warner Cable to merge, the nature of bargaining between the merging parties and upstream suppliers would change, as would the upstream firms' investment incentives.

[2] The theoretical background for these articles includes the literature on umbrella branding (see, e.g., Wernerfelt, 1988; Choi, 1998; Cabral, 2000).

and producer (the singer or band), each movie is an organization of its own. This implies that we must identify the channel for demand spillovers (for which we consider several variations in the measurement of "star power").

□ **Road map.** The rest of the article is organized as follows. In the next section, we develop the theoretical framework underlying our strategy for indirect measurement of bundling effects (basically, the idea that downstream cross-selling effects follow from upstream bundling through the phenomenon of "bundling pass through"). 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 data set as well as the empirical results, including our estimate of the degree of bundling at the studio level. Finally, Section 5 concludes the article.

2. Theoretical framework

■ We do not know much regarding the details of the contracts between studios and DVD sales retailers. Anecdotal evidence suggests that some form of bundling is common. In a related market—movie rentals—we know that full-line forcing contracts (in which retailers agree to carry the full line of products released by a distributor) are common and binding (i.e., the minimum quantity restrictions are often binding).[3] Inspired by these observations, in this section, we outline a simple model of upstream bundling. Our goal is to estimate the impact this vertical restriction has on downstream sales patterns. In particular, we will show that a positive demand shock to the final demand for product x implies an increase in sales of product y, and a decrease in the price of y, even though y is demand-independent of x (though sold by the same distributor).

Consider a typical retailer selling two products, 1 and 2, and a mass m (a continuum) of consumers shopping with the typical retailer. The retailer in turn buys from a single distributor. Each final consumer k's valuation for one unit of product i is given by $u_{ik}\, v_i$, where u_{ik} is consumer k 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_{ik} is distributed according to the c.d.f. $F(u_{ik})$, with corresponding density $f(u_{ik})$. An individual consumer k buys product i if and only if $p_i \leq u_{ik}\, v_i$, which is equivalent to $u_{ik} \geq p_i/v_i$, which happens with probability $1 - F(p_i/v_i)$. It follows that the demand for the retailer's product i is given by $q_i = m\,(1 - F(p_i/v_i))$. Finally, regarding the distribution of consumer valuations, we make the following assumption:

Assumption 1. (a) $F(u_{ik})$ is continuously differentiable; (b) $(1 - F(u_{ik}))/f(u_{ik})$ is decreasing in u_{ik}.

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

We consider a single distributor 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 typical 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:

[3] "The majority of retailers adopt FLF [full-line forcing] contracts from at least one distributor," write Ho, Ho, and Mortimer (2012a).

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 the retailer's derived demand for j implies an increase in the retailer's purchases of product i as well. As the retailer's shadow marginal cost of product i is effectively zero, this increase in purchases is accompanied by a decrease in price so as to boost demand for product i.[4]

□ **The positive and normative analysis of bundling.** Our goal in this article is to understand the downstream implications of upstream bundling. We do not directly address a variety of important questions regarding bundling: Does a seller benefit from bundling its products? Should a seller choose pure bundling or mixed bundling? What are the welfare implications of bundling?

In a classic article dealing with block-booking of feature films, Stigler (1963) showed that it may be profitable for a monopoly seller to bundle even if the demands for its products are independent (i.e., when the products are sold separately, the demand for one of the products is independent of the price of the other). Since then, an extensive literature has examined conditions under which bundling is profitable. For example, McAfee, McMillan, and Whinston (1989), extended Stigler's (1963) conditions for profitable bundling considerably. Together with more recent research by Armstrong (1999) Chen and Riordan (2013), and Menicucci, Hurkens, and Jeon (2014), among others, the overall picture suggests that the conditions such that mixed bundling or even pure bundling are optimal are quite general. Given these results, our assumption that the upstream seller offers bundling contracts does not seem very restrictive.

An assumption implicit in Proposition 1 is that the upstream contractual terms remain constant with respect to demand shocks. One possible justification for this assumption, based on the particular application we consider, is that demand shocks take place on a weekly basis, whereas contracts are negotiated for longer periods.

If prices adjust frequently, however, then we should consider how bundling prices change as a result of demand shocks. Consider the case of two products and suppose valuations are independent across goods and retailers. Based on McAfee, McMillan, and Whinston (1989), we expect mixed bundling to be optimal for the seller, and a bundle to be chosen by a typical retailer if its valuations fall within an open set of demand parameter values. It follows that, if the demand shock is small with respect to total valuations, then purchasing the bundle remains optimal. Assumption 1 implies that marginal revenue is strictly decreasing. It follows that a shift in demand implies an increase in bundle price *and* an increase in quantity demand. The increase in the quantity of the bundle is not the same as in Proposition 1, where we assume prices to remain constant; however, the signs of the derivatives (and thus the comparative statics implied by Proposition 1) remain valid.

A qualification on the above remarks is that we are assuming that the upstream seller makes a take-it-or-leave-it offer of sale terms to the retailers. If retailers are small, this may be the most reasonable assumption. However, the terms of sale to large retailers such as Amazon and Walmart are likely to result from some negotiation process. Under simple rules such as Nash bargaining, we would expect the comparative statics to be similar to Proposition 1: the increase in bundle value (because of a positive demand shock) is split between parties. The price increase is therefore lower than the demand shock, resulting in increased sales of the bundle and the

[4] We should note that Proposition 1 is a "tight" result. One can find counterexamples where Assumption 1 does not hold and Proposition 1 fails as a result.

comparative statics predicted by Proposition 1. Having said that, we are not aware of any general treatment of the problem of bundling combined with bargaining, and its solution lies beyond the scope of this article.[5]

An alternative justification for the assumption that bundle prices are invariant to individual product demand shocks is that our sellers offer a large number of products (titles). In this context, it would be impractical to offer complete mixed-bundling contracts (the number of prices increases exponentially with the number of products). Pure-bundling contracts, whereby the seller buys a large number or the entire set of products, seem more practical. Moreover, Chu, Leslie, and Sorensen (2011) show that pure-bundling contracts based solely on the number of products yield approximately optimal results. In practice, large bundles are common in DVD rentals (Ho, Ho, and Mortimer, 2012a) as well as in the sale of cable television (Crawford and Yurukoglu, 2012) and academic journals (Bakos and Brynjolfsson, 1999). If our seller effectively offers a bundle with a large number of titles, then the law of large numbers would suggest that the optimal bundle price does not change much as a result of demand shocks to individual titles. All in all, we believe our assumption that bundle prices remain approximately constant as a function of demand shocks to be realistic, and that, even if they change, the comparative statics predicted by Proposition 1 are correct in terms of sign.

Regarding the question of the effects of bundling on welfare, the theoretical evidence is rather mixed. For example, Chen and Riordan (2013) show, by means of example, that, though the seller is generally better off with bundling, consumers may benefit or be harmed by seller bundling. The actual result depends crucially on a variety of parameters, in particular, on the distribution of consumer valuations. For the case of normally distributed preferences, Schmalensee (1984), shows that consumers are generally worse off with pure bundling. However, in a recent application to a related industry (video rentals), Ho, Ho, and Mortimer (2012b) estimate that bundling (full-line forcing) implies a Pareto improvement: it increases producer and consumer surplus.

□ **Testable implications.** Although our data is not rich enough to estimate the distribution of consumer preferences, and so to estimate the welfare effects of bundling, the two parts of Proposition 1 correspond to two specific empirical predictions that we test in Section 4. Our theoretical treatment also suggests that the equilibrium as well as the comparative statics with respect to demand shocks depend on retailer size (large vs. small retailers). Accordingly, we will also estimate how results vary by type of retailer.

Before that, we briefly describe the industry we focus on, the US home video sales industry, and restate 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 US home video sales industry

■ The setting for our empirical study is the US 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.

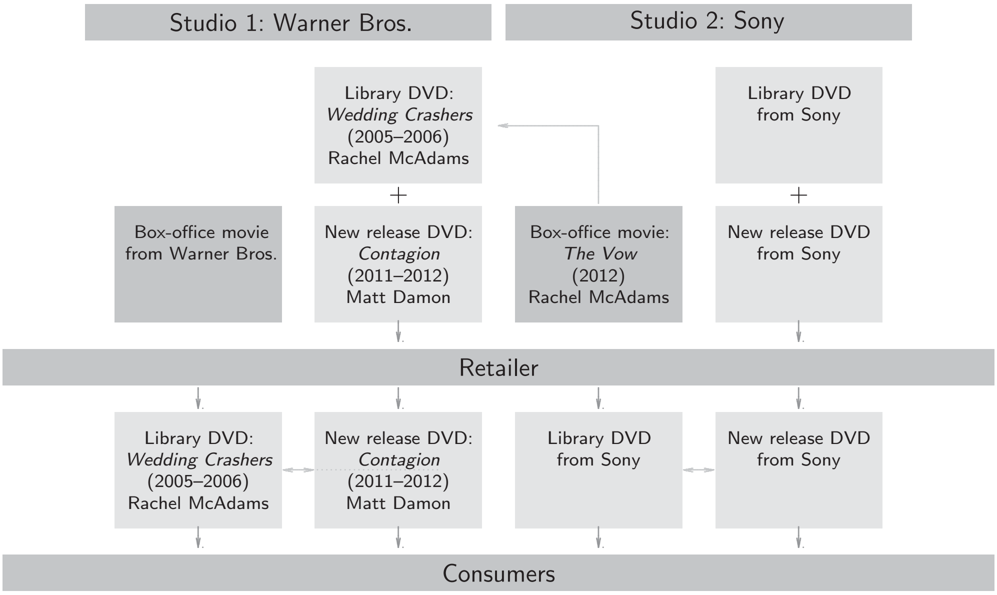
Downstream, the distributors face a series of retail channels, which range from fairly small specialty stores to larger retail outlets such as Amazon.com. Upstream, distributors obtain content

[5] One complication is that, in order for the bundling problem to be nontrivial, one must assume asymmetric information between the parties, and bargaining with asymmetric information is a notoriously difficult problem to solve.

[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, in the nature of demand and in the structure of the value chain.

FIGURE 1

DEMAND SHOCKS AND SUPPLY CONNECTIONS IN THE VIDEO SALES INDUSTRY



from a series of industries such as feature film, TV, and cable producers. In this article, 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, merchandising, 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 1. Upstream, there exist a number of distributors, such as Warner Bros. and Sony. Distributors sell videos to retailers. (In the figure, we consider one typical 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. In addition to home video sales, distributors also benefit from box-office revenues, which are denoted by a blue (darker) box in Figure 1. 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. Nonlinear 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 (1) the movie's box-office revenue, and (2) 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). Although 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, though 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, though 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

■ Our goal is to assess the statistical relation between sales of different movies by a given distributor. In terms of the notation in the previous section, 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? Formally, we would like to estimate the equation

$$NS_{it} = \alpha_0 + \beta \cdot LS_{it} + \lambda_i + \theta_t + \epsilon_{it},$$

where NS_{it} denotes logged sales of new DVD releases in units (our y variable) and LS_{it} denotes logged sales of library DVDs in units (our x variable); and where i stands for distributor and t for time period, a given week. (All our analysis is conducted at the distributor-week level.)

However, simply regressing the sales of y on the sales of x does not provide a convincing answer, as there are many potential omitted variables that can explain comovements in x and y.[7]

[7] To have an idea of the magnitude of the bias of a naive ordinary least squares (OLS) approach, we also implemented the analogous linear regressions of new release quantity sales on library sales, as well as the price regression on library

Our identification strategy employs the current box-office success of library stars as an instrument for demand shocks to x. The idea can be explained again with reference to the example in Figure 1. *The Vow*, distributed by Sony, hit the theaters on February 10, 2012. It grossed $41 million during the first weekend, a fairly good performance.[8] 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 three 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*.

As we will detail later in this section, from a person-week popularity index using box-office revenue, we create a distributor DVD library-week popularity index, which we denote by box-office spillovers, or BOS_{it}. Given this, our first-stage regression takes the form

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

whereas the second-stage regression is given by

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

We believe box-office performance 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 develop our instrumental variable strategy in greater detail after describing the data.

□ **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 Walmart). Although the list of retailers is available, we have no information regarding the specific contractual terms between distributors and retailers.

VideoScan details weekly US units sold of each video title on 24,451 feature films with active sales between 2000 and 2009 distributed by 130 distinct corporate groups. In a given week, we can divide the list of video titles[9] 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.[10] Thus, in our data, new titles become library titles right after 52 weeks since release. VideoScan also provides weekly

sales. We found significant differences with respect to our instrumental variable results. The coefficient of interest in the quantity models in these untabulated tests was 22% smaller than in our two-stage least squares (2SLS) design, and the coefficient on the OLS pricing regression was not statistically significant (t statistic of 0.73). Although these alternative regressions can only be seen as correlations for the reasons stated throughout, the pattern suggests that the OLS approach biases coefficients toward zero.

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

[9] Our data include video sales under all formats. Sometimes companies rerelease a video title under a different format, for example, Blu-Ray; we define "new" releases based on the original release date as recorded video, rather than on title-format combinations.

[10] In untabulated models redoing the analysis using 26 weeks or fewer instead of 52 weeks in defining new releases, the results remain essentially unchanged.

TABLE 1 Example

Title	Distributor	Theater and DVD Release	Director	Top Cast
The Vow	Sony	02/10/2012 01/03/2006	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

	Mean	Median	Standard Deviation	Minimum	Maximum	Num. Obs.
Distributor-week data						
Library sales (in units)	17,391	3	80,026	0	290,3919	49,724
New release sales (in units)	1,689	0	18,492	0	147,8221	49,724
Box-office spillovers (in millions of 2009 dollars)	51	0	214	0	4,416	49,724
Number of titles	122	14	325	0	2,442	49,724
Number of genres	6	5	4	0	14	49,724
Number of countries	5	2	6	0	30	49,724
New release prices	16.94	17.27	2.98	2.92	29.97	4,867
Library week-person data						
Number of week-person observations						5,543,519
Number of distinct persons						15,847
Number of observations with BOS>0						134,517

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 US 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.[11] Specifically, each distributor sells on average 17,391 units of library videos per week. However, the median is considerably

[11] The empirical analysis uses quantity variables expressed in logarithms.

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 (i.e., 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.

□ **Instrumental variable strategy.** As mentioned earlier, we consider backward spillovers from ongoing box-office performance onto a distributor's existing video library of feature films. The idea of backward spillovers was introduced by Hendricks and Sorensen (2009), in the context of the music industry.[12] 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 (though, for robustness purposes, we consider the top five as well, finding the results unchanged).[13]

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.[14] 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-three actors, then BOS_{it} includes all of the period t revenues of films starring Rachel McAdams as a top-three 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

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

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

[14] We view the weekly frequency of the data provided by our sources as an advantageous feature of our design; the results are also robust to alternative lag structures for the weekly popularity shock as long as the box office shock is not too far back from the DVD sales week of interest.

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	49,724	49,724	49,724	49,724
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.

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.

To bolster the exclusion restriction for our instrument, we "clean" the dependent variable to leave only as nonzero 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}. Because there are 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.[15]

□ **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-three billed actors 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-three 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.

[15] 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.

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 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 deviations in new release sales.[16]

We repeat our regressions by type of retailer.[17] 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 retailers available in our data source: (1) specialty retailers, (2) discount mass retailers, drugstores, and grocery stores, and (3) 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 ecommerce, 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 significant.

□ **Results: pricing.** To the extent that there is upstream bundling, we expect that downstream 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

[16] Regarding the first-stage regression, we estimate that a one-standard deviation increase in box-office spillovers is associated to an increase of about .08 standard deviations in library sales, where $0.08 = .166 \, \frac{1.76}{3.59}$. Interpreting both stages of Table 3 in terms of percentages, a doubling of the popularity index of library talent based on box-office sales in a given week implies a 16.6% increase in library sales, which leads to an 8.2% increase in new title sales.

[17] 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.

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, and 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	49,724	49,724	49,724
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	4,865	4,865
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.

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 that we obtain such large price effects may be related to the fact that the price distribution is bimodal. 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.[18] 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

[18] When redoing the analysis of Table 3 for the subsample in which prices are available, that is, matching the sample of Table 5, the results remain essentially unchanged.

TABLE 6 Box-Office Spillovers, Library Sales, and New Release Sales Using Matched Firms' Shocks

	Dependent Variable:					
	Library Sales Quantity 2SLS First Stage		New Release Quantity 2SLS Second Stage		New Release Prices 2SLS Second Stage	
Library sales quantity (instrumented)			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	49,724	49,724	49,724	49,724	4,865	4,865
Number of clusters (distributors)	130	130	130	130	36	36

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

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 tested is that demand shocks to product x lead to increased sales of other products by the same wholesaler, in particular of products that are demand-unrelated to product x. 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 x owned by firm i on sales of product y owned by firm j. Recall that Table 3 implies that a demand shock to product x owned by firm i is associated with an increase in sales of product y owned by the same firm i, 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 US 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, though 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

This Appendix includes all proofs of our theoretical results.

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

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

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

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

or simply

$$p_i = w_i + \frac{v_i\,(1 - F(p_i/v_i))}{f(p_i/v_i)}. \tag{A1}$$

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

$$\pi_B = \sum_{i=1}^{2} p_i \min\left\{m\left(1 - F(p_i/v_i)\right),\, q\right\} - b\,q, \tag{A2}$$

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, $m(1 - F(p_i/v_i))$. 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 toward 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 (i.e., 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

$$v\,\widehat{F} - b - v\,\widehat{f}\,q = 0. \tag{A3}$$

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

$$\frac{\partial^2 \pi(q)}{\partial q^2} = -2\,v\,\widehat{f}(1-q) + v\,\widehat{f}'(1-q)\,q < 0, \tag{A4}$$

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 $dq/dp = -f$ and $dp/dq = -\widehat{f}$, where for simplicity we omit the arguments of $f, \widehat{f}$. It follows that

$$\widehat{f} = 1/f. \tag{A5}$$

Moreover,

$$\widehat{f}\prime = -\frac{d\widehat{f}}{dq} = -\frac{d\left(\frac{1}{f}\right)}{dp}\left(\frac{dp}{dq}\right) = -\left(\frac{-f\prime}{f^2}\right)\left(\frac{-1}{f}\right) = -\frac{f\prime}{f^3}. \tag{A6}$$

Substituting (A5) and (A6) for $\widehat{f}$ and $\widehat{f}'$ into the left-hand side of (A4), and also recalling that $q = 1 - F$, we get

$$\begin{aligned}\frac{\partial^2 \pi(q)}{\partial q^2} &= -2v\frac{1}{f} - v\frac{f'}{f^3}(1-F)\\ &= \frac{v}{f}\left(\frac{-2f^2 - f'(1-F)}{f^2}\right)\\ &< \frac{v}{f}\left(\frac{-f^2 - f'(1-F)}{f^2}\right)\\ &= \frac{v}{f}\,\frac{d\left(\frac{1-F}{f}\right)}{dp}.\end{aligned}$$

It follows from part (b) of Assumption 1 that the second-order condition holds. Moreover, by the Implicit Function Theorem, the sign of dq/dv_i is the sign of $\partial^2\pi/\partial q\,\partial v_i$. As $v = v_1 + v_2$, from (A3) we get

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

However, because (A3) 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 $dq/dv_i > 0$. As $q_j = q$, it follows that $dq_j/dv_i > 0$. Finally, $p_j = v_j\,\widehat{F}(1-q)$ implies that $dp_j/dv_i = (\partial p_j/\partial q)\,(dq/dv_i) < 0$.

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 rewrite 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

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

As $F(x)/f(x)$ 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

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

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

References

ARMSTRONG, M. "Price Discrimination By a Many-Product Firm." *Review of Economic Studies*, Vol. 66 (1999), pp. 151–168.

BAKOS, Y. AND BRYNJOLFSSON, E. "Bundling Information Goods: Pricing, Profits, and Efficiency." *Management Science*, Vol. 45 (1999), pp. 1613–1630.

CABRAL, L. "Stretching Firm and Brand Reputation." *RAND Journal of Economics*, Vol. 31 (2000), pp. 658–673.

CAPPS, C., DRANOVE, D., AND SATTERTHWAITE, M. "Competition and Market Power in Option Demand Markets." *RAND Journal of Economics*, Vol. 34 (2003), pp. 737–763.

CHEN, Y. AND RIORDAN, M.H. "Profitability of Product Bundling." *International Economic Review*, Vol. 54 (2013), pp. 35–57.

CHOI, J.P. "Brand Extension as Informational Leverage." *Review of Economic Studies*, Vol. 65 (1998), pp. 655–669.

CHU, C.S., LESLIE, P., AND SORENSEN, A. "Bundle-Size Pricing as an Approximation to Mixed Bundling." *American Economic Review*, Vol. 101 (2011), pp. 263–303.

CRAWFORD, G.S. AND YURUKOGLU, A. "The Welfare Effects of Bundling in Multichannel Television Markets." *American Economic Review*, Vol. 102 (2012), pp. 643–685.

DAFNY, L., HO, K., AND LEE, R.S. "The Price Effects of Cross-Market Hospital Mergers." Working Paper, 2015.

ELBERSE, A. AND OBERHOLZER-GEE, F. "Superstars and Underdogs: An Examination of the Long Tail Phenomenon in Video Sales." *Marketing Science Institute*, Vol. 4 (2007), pp. 49–72.

GOWRISANKARAN, G., NEVO, A., AND TOWN, R. "Mergers When Prices Are Negotiated: Evidence from the Hospital Industry." *American Economic Review*, Vol. 105 (2015), pp. 172–203.

GRENNAN, M. "Price Discrimination and Bargaining: Empirical Evidence from Medical Devices." *American Economic Review*, Vol. 103 (2013), pp. 145–177.

HENDRICKS, K. AND SORENSEN, A. "Information and the Skewness of Music Sales." *Journal of Political Economy*, Vol. 117 (2009), pp. 324–369.

HO, J., HO, K., AND MORTIMER, J.H. "Analyzing the Welfare Impacts of Full-Line Forcing Contracts." *Journal of Industrial Economics*, Vol. 60 (2012a), pp. 468–498.

HO, K., HO, J., AND MORTIMER, J.H. "The Use of Full-Line Forcing Contracts in the Video Rental Industry." *American Economic Review*, Vol. 102 (2012b), pp. 686–719.

HO, K. AND LEE, R.S. "Insurer Competition and Negotiated Hospital Prices." NBER Working Paper no. 19401, 2013.

LEWIS, M. AND PFLUM, K. "Hospital Systems and Bargaining Power: Evidence from Out-of-Market Acquisitions." Working Paper, 2014.

MCAFEE, R.P., MCMILLAN, J., AND WHINSTON, M.D. "Multiproduct Monopoly, Commodity Bundling, and Correlation of Values." *Quarterly Journal of Economics*, Vol. 104 (1989), pp. 371–383.

MENICUCCI, D., HURKENS, S., AND JEON, D.S. "On the Optimality of Pure Bundling for a Monopolist." Working Paper, 2014.

NALEBUFF, B. "Bundling: GE-Honeywell (2001)." In J.E. Kwoka and L.J. White, eds., *The Antitrust Revolution*, 5th ed. Chicago, Ill.: University of Chicago Press, 2009.

SCHMALENSEE, R. "Gaussian Demand and Commodity Bundling." *Journal of Business*, Vol. 57 (1984), pp. S211–S230.

STIGLER, G.J. "United States v. Loew's, Inc.: A Note on Block-Booking." *Supreme Court Review* (1963), pp. 152–157.

VILLAS-BOAS, S.B. "Vertical Relationships between Manufacturers and Retailers: Inference with Limited Data." *Review of Economic Studies*, Vol. 74 (2007), pp. 625–652.

WERNERFELT, B. "Umbrella Branding as a Signal of New Product Quality: An Example of Signalling by Posting a Bond." *RAND Journal of Economics*, Vol. 19 (1988), pp. 458–466.