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ABSTRACT

Retailer capacity decisions can impact sales for a product by affecting, for example, availability and visibility. Using data from the U.S. video rental industry, we report empirical estimates of the effect of capacity on sales. New monitoring technologies facilitated new supply contracts in this industry, which lowered the upfront cost of capacity and required minimum capacity purchases, thus strongly impacting stocking decisions. Under the traditional supply contract, capacity costs $44 per tape (avg) and the marginal tape produces 10.4 to 18.0 additional rentals. Under the new contract, capacity costs $7 per tape (avg) and the marginal tape produces 0 to 4.9 additional rentals.

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1 Introduction

Capacity choice is a critical decision for firms that face storage costs (e.g., retailers, event venues, airlines). Capacity constraints affect many types of firms, and may be complicated by vertical ownership structures, the nature of supply contracts, and product characteristics. Although higher capacity can lead to fewer stock-outs and greater sales, additional capacity may also increase costs, cannibalize sales of available substitutes, and affect local competition in the short- and long-run. In the retail sector, advances in monitoring technology are improving firms' abilities to manage capacity strategically in order to impact sales. Retailers' continued adoption of these technologies may substantially change the relationship between capacity and sales.

In this paper we study the video rental industry, which is a prime example of an industry where technological advances have contributed to dramatic changes in capacity decisions and related vertical contracts in recent years. We find that larger capacity, measured in terms of more tapes for a given title, can substantially increase rentals of that title. We also find that alternative vertical contractual forms for distributing tapes from studios to rental stores (retailers) can have a large impact on the relationship between capacity and rentals. In particular, we investigate the effect of capacity on rentals under traditional contractual forms for distributing tapes from studios to retailers, and compare this to the capacity effect under a new contractual form, widely adopted in the late 1990s, that distributes tapes at a substantially lower upfront cost. We analyze a panel dataset on video retailers in the U.S. that contains detailed information on stores' capacity decisions and subsequent rentals on a title-by-title basis.

Products in this industry are distributed on three different types of vertical contracts, which have different implications for the cost to the retailer of acquiring capacity. One of these contracts is characterized by a high upfront per-tape cost (roughly $44 per tape) for the first few months following a title's video release, followed by a large price reduction after 5 months in order to encourage sales directly to consumers.[1] We refer to this contractual form as a "linear pricing" contract. A second contractual form also has a linear-pricing structure, but with a much lower upfront per-tape cost (roughly $15 per tape). We refer to this contractual form as a "sell-through pricing" contract, and it is typically meant to

[1]The $44 per-tape cost is the cost for retailers following substantial but common rebates. The price for direct consumer purchases is typically even higher in the first 5 months.

encourage simultaneous sales to both consumers and retailers. New monitoring technologies implemented in the late 1990s allowed for a third contractual form, "revenue sharing" contracts. Under revenue-sharing contracts, tapes are distributed at a very low upfront per-tape cost (roughly $7 per tape), but subsequent rental revenues are shared between the studio and the retailer, in contrast to tapes distributed on linear and sell-through pricing contracts where the retailer keeps all of the rental revenue. Totaling the upfront per-tape cost and the revenue-sharing payments, retailers typically pay a little less than $30 per tape to the studios for titles taken on revenue-sharing contracts. Titles taken on revenue-sharing contracts are also subject to minimum and maximum quantity requirements imposed by the studios. As a result, capacity decisions under revenue-sharing contracts do not necessarily represent the optimal level of capacity for the retailer when those quantity restrictions are binding.

Due to the fact that a significant minority of retailers do not have the requisite monitoring technology to access revenue-sharing contracts, all titles available under revenue-sharing contractual terms are also available under linear-pricing terms. In contrast, not all titles available under linear-pricing contracts are offered under revenue-sharing contracts. Titles available under sell-through pricing contracts are not available under any other contractual terms.[2]

The wide array of contract types offered for different movies and chosen by different stores creates substantial variation in capacity across stores and titles. We observe details on the variation in contracts and capacity for 1,019 titles taken by 7,478 retailers, along with the costs of the capacity, and weekly quantities of rentals and revenues for each store-title pair. Although the data provide rich detail on retailers' capacity choices and subsequent sales, we do not have information on the rental decisions of individual end-consumers, or exact stock-out times. Thus, we do not explicitly model consumer behavior with respect to available capacity, and our analyses allow for several potential effects of capacity on sales without attempting to disentangle the impact of a specific effect such as reduced stockouts, signals on product quality, or shelf-space coverage.

The studio's choice of which contractual form(s) to offer for a title, and the contractual form chosen by a retailer (for titles offered on both revenue-sharing and linear-pricing contracts), are two potential sources of endogeneity. As we discuss in section 2, we believe that

[2]For more discussion of this point, see Mortimer (2008).

the studios' choice of contract for a title is largely predetermined and does not impact our estimates of the effect of capacity on rentals. Retailers have a choice between linear-pricing and revenue-sharing contracts for 57% of the titles in our data, and our treatment of their choice of contract for these titles is discussed in section 3. Given the contractual form, the remaining central challenge for identifying the effect of capacity on sales is the fact that retailers endogenously choose capacity in order to maximize profits. To address this endogeneity concern, we take advantage of the panel nature of the dataset by incorporating both store and title fixed effects. We also implement an instrumental variables approach. We instrument for a store's capacity decision for a title by using the average level of capacity of that same title at all other similar-sized stores, as in Ho, Ho, and Mortimer (2008).

After accounting for store and title effects and instrumenting for capacity, we calculate the impact that capacity choices have on rentals. We show that alternative contractual forms, some facilitated by the adoption of new monitoring technologies, can greatly impact the retailers' choice of capacity relative to sales. Specifically, retailers appear to choose capacity such that expected revenue approximately equals expected cost, which implies that capacity is much lower relative to sales under the contractual form with the highest upfront cost. We find a significant effect of capacity on sales for linear-pricing contracts. We estimate that for titles on these contracts, which have an upfront cost of around $44 per tape, an additional unit of capacity produces between 10.4 and 18.0 more rentals over the life of a movie at the average video retail store, depending on the size of the theatrical box office receipts for the title. For this contractual form, retailers' capacity choice has a profound effect on the level of rentals. The sell-through pricing contracts, which have an upfront cost of around $15, have a smaller estimated impact of capacity on rentals. Titles taken on these contracts generate between 3.3 and 9.2 more rentals from an additional unit of capacity. For the revenue-sharing contracts, which have the lowest average upfront cost per tape, around $7, we find that an additional unit of capacity has very little impact on rentals, generating 0 to 4.9 additional rentals over the life of the movie. The negligible impact of capacity on rentals for these revenue-sharing contracts may in part reflect high capacity levels induced not only by the low per-tape costs, but also by minimum quantity requirements imposed by the studios who may have incentives to encourage higher levels of capacity than is optimal to the retailer for some store-title combinations.

We refer to the above estimates as the "own" effect of capacity, as it considers the

effects of increasing capacity of title j on the sales for title j. We also examine the effect that capacities of competing titles have on sales of title j, the "cross-title" effect. We find little or no average cross-title effect in most cases, although there is some evidence certain types of titles may have a small positive cross-title effect.

Relationship to Literature

While the importance of capacity choice is well recognized in a wide array of theoretical literatures, empirical studies of the effect of capacity on sales are sparse. Issues involving capacity are prominent in the business and marketing literature, as well as the industrial organization literature. In the business and marketing literature, the attention on capacity choice has generally addressed capacity as a production input for manufacturers, also focusing on supply-side effects.[3] Some have extended the supply-side arguments to incorporate the effect of capacity choice on sales. For example, Urban (1995) develops a theoretical rule for optimally replenishing capacity of a single product over an infinite time horizon; he generalizes several models to incorporate effects of stock-level-dependent demand rates in profit-maximization models.[4] Urban (2005) further reviews two types of models of the impact of capacity on sales, one where demand is affected by the initial capacity level and one where it is affected by the instantaneous capacity level, and develops a unifying periodic review model.

Our work in this paper is more closely related to the literature that directly examines sales effects of capacity, such as the "newsboy model". In this model, retailers purchase capacity at the beginning of a period in which sales are realized. If a retailer stocks out in this period, subsequent sales for the period are lost. Narayanan and Raman (2000) extend this model to allow the retailer to carry goods that are close substitutes, and Dana and Spier (2001) extend the model to examine the implications of revenue-sharing supply contracts (compared to linear-pricing contracts). The implication of Dana and Spier's model is that, in the face of either uncertain demand or demand that declines predictably over time, retailers will hold higher levels of capacity under revenue-sharing supply contracts compared to linear-pricing contracts. Consistent with the assumptions of the newsboy model, an important restriction is that subsequent sales of a product are lost after a stock-out occurs; consumers do not search across other stores or substitute intertemporally. Finally,

[3]See Nahmias (1989) for an extensive review of many of these contributions.

[4]Earlier work on the relationship between sales and capacity (or inventory) in retail markets includes Schary and Becker (1972), Wolfe (1968), and Gupta and Vrat (1986).

Balachander and Farquhar (1994) provide a theoretical analysis of optimal stock-outs as a function of local competitive conditions. They find that when consumer search costs are high, stores choose to stock out in order to maintain price.

The remainder of the paper proceeds with some background information on the video rental industry and a description of the data in the next section. We then discuss estimation and identification strategies and present the results in sections 3 and 4. Section 5 concludes.

2 Industry and Data Description

The home video industry grew quickly throughout the 1980's to become the largest source of domestic revenue for movie studios. In 1999, the $16 billion industry accounted for 55% of studios' domestic revenues, compared to 22% generated by theatrical revenues, and 23% from all other forms of media, such as the sales of pay-per-view, cable, and broadcast television rights. By 2006, the home video industry had increased to $24 billion in domestic revenues and generated three times as much revenue as the theatrical channel through approximately 20,000 home video retailer outlets. These outlets are split evenly between independently-owned small chains of retailer locations and large chains of several hundred stores, such as Blockbuster, Inc. and Hollywood Video.

Three primary types of contracts characterize the distribution of tapes in the industry: linear-pricing contracts charge a high initial wholesale cost per tape (typically around $44 in the first five months of release then dropping to around $15 to $20), and leave all subsequent rental revenue with the retailer. Sell-through pricing contracts are similar to linear-pricing contracts but do not have the high initial per-tape cost, instead being released at a $15 per-tape wholesale price. Retailers keep all subsequent rental revenue. These contracts are used for particular kinds of movies for which the producer wants to stimulate sales directly to consumers (e.g., childrens' movies). Revenue-sharing contracts have a low upfront per-tape price (around $7), but the studio keeps a share of the subsequent rental revenue. While some titles are available only on sell-through pricing or linear-pricing contracts, all titles offered on revenue-sharing contracts are also available under linear-pricing terms. For movies offered on both linear-pricing and revenue-sharing contracts, retailers have a choice of the two contract types, although they can only use one contract for any given title.[5]

[5] 33 out of 61 studios offer at least one title under revenue-sharing terms.

For studios, the decision to offer a title on linear-pricing or sell-through pricing terms is determined by many factors, the most important of which is the responsiveness of the consumer sales market to delaying low pricing. For more detail on the nature of this decision and its welfare impacts, see Mortimer (2007). The decision by a studio to offer retailers the choice of taking a title on either revenue-sharing terms or linear-pricing terms is taken at one point in time, when the studio joins the system for monitoring revenues, and is not taken on a title-by-title basis. The timing of this decision is not correlated with any studio observable. Thus, we take the set of contracts available from studios for a title as predetermined in our analyses of the effects of capacity on rentals.

For retailers, there is only a single contractual form offered for a large number of the titles. We observe 1,019 titles in our data, and of those, 326 are offered on linear-pricing contracts alone and 114 are offered on sell-through pricing contracts alone. For the remaining 579 titles (or 57% of titles), retailers have a choice of revenue-sharing or linear-pricing contracts. For these titles, one might be concerned about endogeneity in the retailers' contract choice. In section 3, we discuss how we address this potential source of endogeneity in our estimation of the effect of capacity on rentals.

Revenue-sharing contracts require extensive monitoring of retailer activities, including capacity choices and rental activity. Rentrak Corporation provides these monitoring services to the industry, and we use detailed data from Rentrak in our analyses. Rentrak observes titles under all three contractual forms. Over 10,000 retailers used Rentrak between 1998 and 2002, accounting for over half of all retailers in the industry. We observe detailed data on 7,478 of these retailers ranging in size from single-store locations to a chain with 1,652 locations. Blockbuster Video and Hollywood Video comprise an additional 4,000 or so retailers in the Rentrak system, and we do not observe their transactions.[6]

For each store in our sample, we observe transaction data for the 210 weeks between January, 1998 and June, 2002. We discard observations for titles released after December 2001, so that rental activity for each title is tracked for at least 6 months. At the store level, we observe location at the county, zip code, and Designated Market Area (DMA) level.[7]

[6]Hollywood Video and Rentrak were involved in a legal dispute over data integrity, for which they eventually reached a settlement. The nature of BlockBuster Video's revenue-sharing contracts differed from that of other retailers, in that they dealt directly with each studio and typically agreed to purchase all of a studio's titles under revenue-sharing terms. As a result, BlockBuster only processes selected titles through Rentrak's system. Interestingly, industry trade journals cited Blockbuster's belief that larger capacities would stimulate demand for video rentals as a reason for adopting the revenue-sharing contracts.

[7]Designated Market Areas organize the United States according to the coverage areas of broadcast tele-

We observe total annual and monthly store revenue, and the size of a store's chain. Total monthly store revenue is broken out among rentals and sales for adult, game, DVD, and regular titles. We also observe the date the store joined the Rentrak database, and the date the store left Rentrak, if applicable. Entry into the database is common over the two-year period, and typically represents the choice of an existing retailer to join Rentrak, rather than entry into the industry. The vast majority of store exits (over 90 percent) represent store closure, or exit from the industry. Finally, Rentrak classifies each store into one of ten store size groups ("store tiers") based roughly on the deciles of average monthly store revenues. Store tiers are used by Rentrak to assign stores' minimum and maximum quantity requirements for titles taken under revenue-sharing terms.

For each title, we observe the number of titles released in the same month, a box-office category, the MPAA rating, genre, and the contractual forms and terms offered by the studio. The box-office categories are denoted as A, B, C, or D. Titles in the A category ("A titles") have theatrical box-office revenues of more than $40 million, and titles in the B and C categories ("B titles" and "C titles") have theatrical box-office revenues of $15 - $40 million and $1 - $15 million, respectively. Titles in the D category do not have a theatrical release, and are "direct-to-video" titles, such as instructional or exercise videos. Many of the D titles are only bought by a single retailer, and we exclude these titles from the analysis. Each title is offered under either linear-pricing or sell-through pricing contracts. In addition, some titles distributed on linear-pricing contracts are also available under revenue-sharing contracts.

At the store-title level, we observe the type of contract chosen by the retailer (when more than one option is available), and the number of tapes purchased for all titles released during the period covered by our data. We also observe transactions, which are recorded weekly for each store-title combination, and total weekly quantities of rental transactions and revenues (and the corresponding average price) for all titles from their release date (between January 1998 and December 2001) through the end of the data, June 2002. For the analyses considered in this paper we aggregate the weekly data and calculate total quantities of rental transactions and revenues at the store-title level.

We also utilize data from the 2000 US Census on the demographic characteristics of each zip code. Demographic data include the number of people, median income, and marginal

vision.

distributions of race, education, age, gender, employment, family status, and the level of urbanization in each zip code. The Rentrak and Census data are merged by zip code.

3 Estimation and Identification

3.1 Estimation Framework

Within a store, larger capacities of a title can increase sales through several different mechanisms including: (1) reducing the occurrence of "stock-outs" especially in the early weeks of the release of a new product; (2) serving as a signal to consumers about the film's quality; or (3) increasing consumer awareness of the film by displaying the title over a large shelf area or in multiple areas within the store. Each of these mechanisms affect the sales through a product's own capacity. We refer to this effect as the "own" effect.

"Cross-title" effects may also exist. While the own effect is likely to be positive (i.e., a larger capacity for a title is likely to increase sales for that title in the store), cross effects could be either positive or negative. Larger capacity of one title may increase the store's customer base and thus demand for other titles, for example, by increasing customer expectations that the store has lower stock-out rates generally. Alternatively, larger capacity of one title may displace sales for other titles because of decreased spillover demand resulting from stock-outs, or other factors related to perceived relative film qualities and customer awareness of the films.

We attempt to measure the own effect of capacity on sales without distinguishing among alternative mechanisms.[8] Allowing for a flexible specification of the effect, we use the detailed information on retailers' capacity choices and subsequent rentals to measure the overall effect of capacity on rentals. In addition, we control for possible cross-title effects, and provide estimates for the size and direction of these effects, again without distinguishing among alternative mechanisms. The empirical model developed is meant to account for important features of the market for a store-title combination that affect rentals, but does not represent a random utility maximization model of consumer demand for video rentals.[9]

If one could observe exogenous variation of capacity within the same store-title pair, one

[8] In order to separately estimate the effects of capacity on sales that are attributable to stock-outs versus alternative mechanisms, for example, one would ideally want to examine detailed records of consumers' rental habits across all stores and products, including consumers' unmet demand for stocked-out titles.

[9] For a detailed description of methods for modeling and estimating consumer choice models in markets with limited/variable product availability see, for example, Conlon and Mortimer (2008).

could calculate the effect that capacity has on sales for that product. Consider the demand for title j at store i, given by:

$$Q_{ij} = f(C_{ij}, P_{ij}, X_{ij}; \theta)e^{\epsilon_{ij}}. \tag{1}$$

where Q_{ij} is the observed number of rentals of title j at store i, C_{ij} denotes the capacity (number of tapes) of title j at store i, P_{ij} is the price, and X_{ij} is a vector of store-, title-, or store-title specific variables that affect demand, such as local demographics, time trends, or the capacities of other titles. The parameter vector θ contains three vectors of coefficients: δ contains coefficients for all terms and interactions that include C_{ij}, α and β contain the coefficients for the effect of price and X_{ij} on the number of rentals respectively, which enter linearly in $f(\cdot)$. The marginal effect of an additional unit of capacity is given by evaluating $\frac{\partial Q_{ij}}{df} \cdot \frac{\partial f}{dC_{ij}}$ at the existing level of capacity. In the empirical analyses that follow, we consider several specifications for $f(\cdot)$. Our baseline model is log-linear; we represent the log of variables with lower case letters (e.g., $ln(Q) = q$). We allow for more flexible specifications of $f(\cdot)$ by including: interaction terms between c and relevant elements of x, and by estimating the equation separately for each type of contract, which we denote with superscript t. The equation for estimation is:

$$\begin{aligned} q_{ij}^t =& \gamma^t + \delta_0^t c_{ij} * I(Box_j) + \delta_1^t c_{ij} * chainsize_i * I(Box_j) + \\ & \delta_2^t c_{ij} * timetrend_j * I(Box_j) + \delta_3^t c_{ij} * storetier_i + \beta^t x - \alpha^t p_{ij} + \epsilon_{ij}^t \end{aligned} \tag{2}$$

Where $I(Box_j)$ is a dummy variable identifying the box office category of the title (i.e., if it is an A title, B title, or C title), *chainsize* is the log of the number of stores comprising the chain the store belongs to, *timetrend* is the log of the number of months since January 1998 elapsed when title j was released, and *storetier* is a dummy variable identifying the size category of the store. Store, title, and store-title characteristics are captured by x, which may include store and title fixed effects, and β is a vector of coefficients for these characteristics (and fixed effects). The inclusion of interaction terms with capacity allows the effect of capacity in equation 2 to vary with observable title and store characteristics, such as the box office revenues of the title, the release date, and store size.[10]

[10]We also ran our preferred specification using a logit model based on shares (where a title's rental share at a store was calculated as the number of rentals divided by the number of households in the store's 5-digit zip code, and a logistic transformation was applied to the share). The results for the marginal effect of capacity

Running the analysis separately by contract type allows us to address a couple of issues in the estimation. Because the cost structures differ substantially across all three contract types, one would expect retailers to chose capacity such that the effects of capacity on rentals is very different under each contract type. One approach to accounting for this in the estimation would be to combine the population of store-title pairs under all contractual forms, and interact capacity with contractual form. When retailers have a choice of linear-pricing and revenue-sharing contracts (which occurs for 579 of the 1,019 titles we observe), it would also be appropriate in such a model to instrument for the choice of revenue-sharing to address potential endogeneity in the retailers' choice of contract. However, the effect on rentals of revenue-sharing versus linear-pricing is likely to be different for each store-title pair, requiring a random coefficient on contract choice, which will not be recovered from a single instrumental variable. Thus, rather than including all types of contracts in a single analysis, we condition on contract choice ex-ante and run all analyses separately by contractual form. This allows all coefficients to vary across the different supply contracts. For the 43% percent of titles for which retailers do not have any choice of contract, running the analyses separately by contract simply allows for flexibility in the predicted effects of capacity. For the 57% percent of titles for which retailers have a choice of contract, however, this separation also partially addresses the endogeneity of contractual form, since it determines selection into a given analysis, but does not affect the coefficients, conditional on that selection. This allows us to recover the effect of capacity for the store-title observations where that contract was chosen. In other words, we recover the effect of the "treatment on the treated." The main limitation to this approach is that one would not want to extrapolate the estimated capacity effects to other subpopulations of store-title combinations. As a sensitivity test for the importance of this selection effect, we broke up the sample of store-title pairs on linear-pricing titles into two subgroups: those for which retailers could have chosen revenue-sharing instead, and those for which retailers could not. We find very similar effects of capacity in both groups. For all of the remaining analyses, we estimate separate equations for each of the three contract types (linear-pricing, sell-through pricing, and revenue-sharing), and so we drop the t superscript for ease of notation.

on rentals were slightly higher, but similar, using the logit compared to the log of rentals for the preferred specification. We rely on the log of rentals specification because it provides a more conservative estimate of the capacity effect, is a more direct measure of the effect we are estimating, and because it allows for a more direct comparison to using the log of revenues as an alternative left-hand side variable, as discussed in the remainder of the paper.

3.2 Identification

Capacity levels observed in the data are not exogenously determined; nor do they vary for a given store-title pair. If retailers choose capacity optimally in order to maximize profits, then positive demand shocks (unobservable to the econometrician) lead to higher capacity levels. Thus, capacity levels are endogenously chosen, resulting in a potential upward bias for OLS estimates of the effect of capacity. In addition to the endogeneity of the capacity choice, one might also worry about the usual endogeneity of price in the demand equation (i.e., stores may charge a higher price for titles with rental demand that is unobservably higher). We discuss these two issues separately.

Capacity Choice

Unobserved components of demand likely affect retailers' choice of capacity such that $E(c_{ij}\epsilon_{ij}) \neq 0$ in equation 2. In this case, estimates of δ may be biased. The inclusion of store fixed effects eliminates bias from correlations between c_{ij} and ϵ_{ij} that may result if unobserved, time- and title-invariant store characteristics lead to consistently larger or smaller demand effects of capacity for all titles. For example, local preferences that affect consumers' patience for video rentals (i.e., willingness to wait until the movie is in stock), or store characteristics like location or reservation policies may impact the effect of additional capacity. The inclusion of title fixed effects eliminates bias resulting from correlations between c_{ij} and ϵ_{ij} that result from unobserved characteristics of a title (i.e., studio advertising or promotions surrounding the title's video release) that may raise or lower the capacity effect for that title, and which are store invariant.

Inclusion of both sets of fixed effects is equivalent to specifying the error term in equation 2 as:

$$\epsilon_{ij} = \xi_i + \xi_j + \nu_{ij} \tag{3}$$

In this framework, one can recover unbiased estimates of δ if capacity choices are uncorrelated with ν_{ij}. This is a much weaker assumption than requiring capacity choices to be uncorrelated with ϵ_{ij}, which necessitates that all unobserved characteristics of the store, the title, and the store-title combination do not impact the demand effect of capacity choice.

However, even after accounting for store and title fixed effects, one might be concerned about correlation between capacity choices and ν_{ij}. For example, retailers may have past experience in choosing capacity for certain types of titles for a particular market. Under

these conditions, optimal retailer behavior will imply a positive covariance between c_{ij} and ν_{ij}, and estimates of δ will overstate the effect of capacity on sales. To investigate this remaining source of endogeneity, we implement an instrumental variables approach. Appropriate instruments in this context are variables that affect a store's capacity choice, but do not directly affect consumer demand for a title. We instrument for capacity using the average capacity of the same title across stores of the same tier, as in Ho, Ho, and Mortimer (2008). In all cases we take advantage of the full variation in the data by taking averages over all stores that take the title regardless of the contract type, if a choice of contract types is offered for the title. The validity of this instrument relies on two assumptions: first, that the costs of taking a particular title are correlated across stores within a store tier, implying that similar-sized stores make similar capacity choices; second that demand shocks, except those that are captured by the store and title fixed effects, are not correlated across markets.

Price

In our data we observe revenues (including late fees) and rentals for each title at each video retailer, and use this information to calculate an average price for each title at each store. Based on our calculated average price, we observe relatively little within- and across-store price variation in our data.

We investigated a number of instruments for price in equation 2, including measures of average prices of other similar titles. None of the instruments were successful. The issue is that, after including store and title fixed effects, the only unobservable we need to instrument for is at the store-title level. Price variation at this level exists primarily due to re-shelving titles across various menu prices at different rates. For example, after a title has been stocked at a store for several weeks, the store may remove the "new release" sticker from the tape and either drop the price or increase the rental period (implying lower collected late fees and a lower observed price). We believe this source of price variation is primarily determined exogenously because of the use of rule-of-thumb policies by video retailers in how they instruct employees to move tapes and update stickers on rental inventory. To the extent that such activities are endogenously determined, however, estimates of the price coefficient will be biased upwards.

As our primary approach, we estimate equation 2 without including price as an independent variable. We also report results in which rental revenue, rather than transactions, is

used as the left-hand-side variable. The implications of these revenue regressions are almost identical to those of the rental transaction regressions.[11]

4 Results

We categorize each store-title observation based on the supply contract under which the title was taken (i.e., linear pricing, sell-through pricing, or revenue sharing). Recall that linear-pricing is associated with the highest upfront cost per tape, and that the retailer keeps all subsequent rental revenue; sell-through pricing contracts are similar to linear-pricing contracts, but with a lower upfront cost per tape; and, revenue-sharing contracts are associated with the lowest upfront cost per tape, but the studio shares in the rental revenues. We estimate equation 2 separately for each contract type, allowing the impact of all right-hand-side variables to vary by contract type. For each specification, we allow the impact of capacity to vary by theatrical box office category.

Before discussing the regression results, we present the distribution of the ratio of rentals to capacity (Q_{ij}/C_{ij}) for A titles under each of the three contract types in figure 1. The results for B and C titles are similar, though differences across contract types are slightly less pronounced (see figures 2 and 3).[12] These figures give some indication of potential differences in how intensely capacity is used to generate rentals across contract types. Titles taken on linear-pricing contracts have the largest average number of rentals per unit of capacity, with each unit producing 27 rentals on average. The average unit of capacity produces only 17 and 18 rentals for A titles taken on sell-through pricing and revenue-sharing contracts, respectively. The fact that tapes taken on linear-pricing contracts are used more intensively is consistent with the higher per-tape costs paid by the retailer for those tapes. In the next section, we describe the explanatory variables included in the regression models and we summarize the regression results. Section 4.2 provides the implications for the marginal impact of capacity on rental transactions and revenues. In order to account for

[11] Note that if strong price effects exist and endogeneity of price introduces large biases, then excluding price from the transaction regression should bias the estimates of all coefficients that are potentially correlated with price. In particular, our estimated capacity effect, which is the measure of interest for this paper, would be impacted by the exclusion of the price variable. In robustness checks (not reported), we find almost no effect on any of the coefficients of interest from the inclusion of prices on the right-hand side.

[12] We do not report a small number of observations with ratios of Q_{ij}/C_{ij} that are greater than 100, and we exclude these observations from the regression analyses. The majority of these observations reflect an obvious error in the coding of either tapes or rentals (i.e., they have unreasonably high average number of rentals per tape) and their exclusion has virtually no effect on the regression results.

the potential differences in capacity effects across rental contracts and box-office categories, we present estimates of the marginal impact of capacity on sales separately for each of the nine contract/box-office category combinations.

4.1 Regression Specifications

Table 1 presents results of estimating equation 2 under various restrictions for titles taken under linear-pricing contracts; results for titles taken on sell-through pricing and revenue-sharing contracts are presented in tables 2 and 3, respectively. The results in these tables are from estimating equation 2 for transaction regressions excluding price from the right-hand side; we report results from the revenue regressions after discussing the transaction based specifications. The implications of both models are very similar.[13] In all regressions the t-stats are calculated using robust standard errors with clustering by both store and title.[14]

The first column in all three tables provides results under the most restrictive specification of $f(c_{ij}, X_{ij}; \delta, \beta)$. This specification contains capacity interacted with box-office category, a time trend, and store characteristics, which are store size, the size of a store's chain, the total number of titles carried by the store, and demographic information from a store's zip code, such as population, median age, and the percentage of the population in various race, education, marital status, gender, employment, and urban status groupings. In the specification of column one, these characteristics affect the level of rentals, but do not interact with the capacity effect. As mentioned above, the effect of capacity is allowed to vary by box office category. We explain approximately 78 percent of the variation in the data with this specification for linear-pricing titles, and find similar R-squares for the other two contracts (0.82 and 0.79).

The second column in tables 1 - 3 allows for interaction terms between capacity and store and title characteristics. Specifically we allow for interactions of capacity and chain size; a time trend; and each of ten store-size dummies (store tier 1 through store tier 10). The effects of capacity interacted with chain size and the time trend are further allowed to vary by box office category. The R-squareds from these regressions are similar to those in

[13] Transaction regressions that include price without an IV yield similar implied capacity effects.

[14] For all specifications of the reported regressions we rely on robust standard errors with two-way clustering at the store level and at the title level. For the instrumental variables specification the instrumented capacity measure is treated as data.

column 1. To simplify reporting, we do not report coefficients for the interaction of capacity with store tiers. The coefficients on capacity interactions with the store tier dummies tend to be smallest for store tiers 1 through 4, and increase slightly for larger store tiers. In other words, additional capacity for a given title is more valuable at larger stores.

In the third column, we add a number of variables that describe the stocking of other titles at the store, based on a count of the other titles and the capacity taken for those titles. For new titles taken in the same month as the focal title, we calculate the total number of other titles taken by the store separately for A, B, and C titles. We then interact each of these three variables with three box category dummies for the focal title.[15] We make the same calculation for the total number of tapes taken by the store separately for other A, B, and C titles, and interact this with the three box category dummies for the focal title. Finally, we make these same calculations for titles released in the month prior to, and the month following, the release month of the focal title. We lose about five to 10 percent of observations due to missing values for prior month and subsequent month other title variables in the first and last month a store is in the Rentrak data. The coefficients on these other title/tape variables are typically very small and often individually statistically insignificant; however, they are jointly significant and improve the fit of the model considerably (i.e., R-squareds increase from 0.79 to 0.81, 0.83 to 0.85, and 0.79 to 0.81 for linear-pricing, sell-through pricing, and revenue-sharing contracts respectively). Below we discuss the estimated marginal impact of other-title tapes on own-title rentals and find it to be close to zero in most cases.[16]

We expect a positive bias on the capacity variable in the models investigated in the first three columns because capacity is chosen endogenously by the retailer; conditioning on the other-title variables and other observable demand shifters should reduce some of this bias. To further reduce this bias, we include a full array of store and title fixed effects in

[15]For example, consider a store that stocked 3 new A titles (A_1, A_2, and A_3) and 1 new B (B_1) title in a given month, and suppose that we are looking at the observation for title A_1 at that store. We calculate an "other A title" variable equal to 2, an "other B title" variable equal to 1, and an "other C title" variable equal to 0. Because the focal title is an A title, we would also have an A title dummy equal to 1, and B and C title dummies equal to zero. We then interact each of the three "other title" variables with the three box dummy variables.

[16]One might also want to check the effects of higher capacity levels for the same title at competing stores. Unfortunately, we do not observe all stores in the U.S. (we observe approximately 30 percent of all stores), and we typically do not observe the capacity levels of competing stores in the local market. However, one expects that cross-effects of titles in the same store are likely to be stronger than effects of capacity across stores for a particular title in the short run.

the model reported in column four. The fixed effects further improve the fit of the model (i.e., R-squareds increase to 0.88, 0.90, and 0.87 for linear-pricing, sell-through pricing, and revenue-sharing contracts respectively). In column five we also implement an instrumental variables approach. We instrument for each store's capacity on a title using the average capacity for that title held by stores in other markets in the same store tier. As expected, the R-squareds decline slightly for this specification.

Changes in the coefficients on the log of capacity, as reported in tables 1 - 3, from one specification to another are discussed below, and may be informative with respect to the mechanisms by which capacity contributes to rentals. However, the individual coefficients do not capture the overall impact of capacity on rentals, nor are the changes in these coefficients necessarily comparable across model specifications due to the inclusion of different sets of interaction terms. For the overall capacity impact it is necessary to consider all of the capacity interaction terms with box office category and store-title characteristic variables, as well as the log transformation of these variables, which we do in the next section.

For linear-pricing contracts (table 1), the coefficient on the log of capacity increases slightly between columns 1 and 2 (from 0.97 to 1.07). In column 3, with the addition of cross-title stocking variables, the coefficient on the log of capacity declines substantially to 0.62, and it further declines to 0.54 with the addition of store and title fixed effects in column 4. The T-stat for this coefficient also declines substantially between columns 1 and 4, though in every case the coefficient on the log of capacity is highly significant. In column 5, with the addition of an IV approach, the coefficient on the log of capacity further declines to 0.52 and while it remains statistically significant, the T-stat drops substantially (from 10.37 in column 4 to 3.27 in column 5). The coefficients on the interaction terms of the log of capacity with chain size and a time trend also change substantially when going from column 4 to column 5.

For both the sell-through pricing (table 2) and the revenue-sharing contracts (table 3), the coefficient on the log of capacity drops monotonically and substantially from column 1 to column 4 (0.82 down to 0.31 for sell-through pricing contracts, and 0.96 to 0.36 for revenue-sharing contracts). In contrast to the linear-pricing contracts, estimates of the coefficient on the log of capacity for both sell-through pricing and revenue-sharing contracts are negative in column 5 (-0.23 and -0.31 respectively). This change in the log of capacity coefficient appears to be somewhat off-set by a substantial increase in the coefficients for

the interactions of the log of capacity with chain size and a time trend.

All of the analyses undertaken in tables 1 through 3 were also implemented using the log of rental revenue as the left-hand-side variable. The results for the revenue regressions are reported in tables 4 through 6. As discussed in the next section, the implied capacity effects based on the rental revenue and the transaction regressions are very similar.

4.2 Implications

In this section, we report the implied marginal effect on rental transactions from a one unit increase in the level of capacity in order to provide a more meaningful interpretation of the regression results. We report the results separately for each regression specification and box office category. Taking the derivative of equation 2 with respect to C_{ij} and solving for $d\widehat{Q_{ij}}/dC_{ij}$ yields:

$$d\widehat{Q_{ij}}/dC_{ij} = \frac{\widehat{Q_{ij}}}{C_{ij}}(\delta_0 * I(Box_j) + \delta_1 chainsize_i * I(Box_j) + \delta_2 timetrend_j * I(Box_j) + \delta_3 storetier_i) \tag{4}$$

Where $\widehat{Q_{ij}}$ is the predicted value of rentals based on the regression specification. Table 7 reports the marginal own-capacity effects when the equation is evaluated at the average level of right-hand side variables for store tier 5, which contains medium-sized stores. The table contains three panels corresponding to linear-pricing, sell-through pricing, and revenue-sharing respectively.

Column 1 of table 7 reports the implied marginal effect of capacity based on the specification in column 1 of tables 1 - 3. This provides an upper bound on the marginal benefit one might expect from increasing capacity levels for a title because it controls only for contract type, box office category, time trend, and store characteristics. Focusing on results in the top panel for titles taken on linear-pricing contracts, the implied marginal effect of a store holding one additional tape for an A title under model specification 1 is an additional 23.90 rentals (for that title, at that store). We find a lower effect of own-title capacity after conditioning on capacity interaction effects (in specification 2) with an effect of 23.06, and the stocking of other titles taken in the same or adjacent release months (specification 3) with an effect of 16.06. After the inclusion of store and title fixed effects (specification 4), the estimate of the own-title capacity effect for A titles taken on linear-pricing contracts falls further to 14.06 rentals. The decline in the estimated own-title capacity effect is consistent

with the notion that the models are doing an increasingly better job of controlling for bias resulting from the endogeneity of store capacity choices. Finally, using the instrumental variables approach combined with the store and title fixed effects to further control for any remaining bias results in a marginal capacity effect of 10.42 (specification 5). The last two columns in table 7 report the percentage increase in rentals and the elasticity of rentals with respect to capacity, using the marginal capacity effect calculated for specification 5. For A titles taken on linear-pricing contracts, the 10.42 additional rentals corresponds to a 2.0 percent increase in rentals and an elasticity of rentals with respect to capacity of 0.44.

Generally, across all contract types and box office categories, our estimate of the marginal impact of an additional unit of capacity on rentals gets progressively smaller when moving from specification 1 to specification 5.[17] Within each contract type, an additional unit of capacity for B and C titles is estimated to have a slightly larger effect on rentals than A titles (again using the instrumental variables specification from column 5). For example, the marginal effects for B and C titles taken on linear-pricing contracts are 18.01 and 17.01 respectively, compared to 10.42 for A titles. In percentage terms, B and C titles are estimated to have 6.9 and 17.8 percent increases in rentals (compared to 2.0 percent for A titles).[18]

We estimate substantial differences in the marginal effect of an additional unit of capacity across contract types. Based on the results for specification 5, we find that the marginal effect of capacity on rentals was highest for titles taken on linear-pricing contracts, considerably lower for titles taken on sell-through pricing contracts, and lower still for titles taken on revenue-sharing contracts. For A titles, we estimate that an additional unit of capacity results in 10.42 additional rentals for linear-pricing contracts, 3.29 additional rentals for sell-through pricing contracts, and -0.08 change in rentals for revenue-sharing contracts. For B titles, the estimated effects of an additional unit of capacity on rentals are 18.01, 9.18, and 2.47 for linear-pricing, sell-through pricing, and revenue-sharing contracts respectively. Finally, for C titles, the effects are 17.01, 5.10, and 4.85 for linear-pricing, sell-through pricing, and revenue-sharing contracts respectively. Marginal capacity effects in terms of

[17] There are two exceptions: B titles under linear-pricing and sell-through pricing contracts show a very small increase moving from specification 4 to 5, when the instrumental variables are used; and the effect for C titles increases slightly from specification 1 to specification 3 for all three contract types.

[18] The coefficients for the interaction of capacity and store characteristics/title characteristics from tables 1 - 3 (specification 5) indicate that the marginal effect of an additional unit is: relatively constant over time, larger for the largest store tiers (tiers 8 through 10), and increasing with respect to chain size.

percentage changes in rentals and the elasticity of rentals with respect to capacity follow the same pattern across contract types, as reported in table 7 (for specification 5).

Our estimates for the marginal effect of capacity on rentals suggest that the relationship between capacity and sales is substantially impacted by the adoption of contracts that lower the cost of capacity. Until the late 1990s, titles were typically made available only on linear-pricing and sell-through pricing contracts. Our findings that the marginal impact of capacity on rentals is far lower on sell-through pricing contracts compared to linear-pricing contracts is consistent with lower upfront per-tape costs, and consequently, higher relative capacity levels for sell-through pricing compared to linear-pricing contracts. The introduction of revenue-sharing contracts in the late 1990s allowed studios to make titles available at an even lower upfront per-tape cost, close to the studios' incremental costs of producing the tapes, while still recovering substantial revenues through the revenue-sharing component.[19] Studios also set minimum capacity requirements for titles taken on revenue-sharing contracts. We find even lower estimates for the marginal impact of capacity on rentals for titles taken on revenue-sharing contracts, suggesting that the low upfront per-tape costs and minimum capacity requirements of this contract type encourages even higher relative levels of capacity.

Our estimated own-title marginal capacity effects are consistent with marginal costs by contract type and title. That is, the dollar benefit to the video retail store of taking the last unit of capacity for a title is roughly equal to the cost of obtaining that last unit of capacity. Using the marginal capacity effects from table 7 (specification 5) and applying average prices, we estimate the marginal benefit to the store of an additional tape.[20] For A titles taken on linear-pricing contracts at tier 5 stores the implied marginal benefit is \$30.43 (average price times marginal effect = \$2.92 x 10.42), plus any salvage value the retailer receives from selling the used tape. The average cost of A-title tapes taken on linear-pricing contracts is approximately \$44 (after volume discounts). While this exceeds our estimated marginal benefit of one additional tape, some of the difference may be reduced based on the salvage value from the sale of used tapes (around \$9 on average), and other benefits associated with higher copy-depth for blockbuster titles not measured in our analysis such

[19] Studios typically recover a little less than \$30 per tape between the upfront fee and the revenue-sharing component combined.

[20] Table 8 presents the corresponding results for the revenue regressions, but in that table the marginal effects are already in terms of dollars.

as the ability of A titles to draw consumers into the store.[21] For B and C titles on linear-pricing contracts, the estimate of marginal benefit is $51.34 ($2.85 x 18.01) and $45.09 ($2.65 x 17.01). The corresponding average costs-per-tape are approximately $43 for B titles and $42 for C titles.

For titles taken on sell-through pricing contracts, the estimated benefit for A titles is $9.72 ($2.95 x 3.29), and the average cost of an A-title tape on sell-through pricing contracts is $15.54. The estimated benefit for B titles is $26.09 ($2.84 x 9.18), and the average cost of a B-title tape is $15.15. Finally, for C titles the estimated benefit is $13.73 ($2.69 x 5.10), and the average cost of a C-title tape is $12.53.

For titles taken on revenue-sharing contracts, the estimated benefit is even lower. The estimated marginal benefit accruing to both the retail store and the studio for A titlesis -$0.22 ($2.90 x -0.08), and this estimate is not significantly different from 0. The average cost of an A-title tape taken on a revenue-sharing contract is $7.21. Tapes under this contract also have a salvage value of roughly $9, which is split between the retailer and the studio. The estimated marginal benefit accruing to both the retail store and studio for B titles is $7.00 ($2.83 x 2.47); of this benefit, the retail store keeps on average $3.31 after implementing the revenue-sharing component. The average cost of a B-title tape is $7.28. Finally, for C titles the estimated total benefit is $13.40 ($2.76 x 4.85), with the retail store keeping $6.71 and the average cost of a C-title tape on a revenue-sharing contract is $6.41.

Table 8 presents the same information for the revenue regressions, allowing for a direct calculation of the monetary benefit of additional tapes. As expected, due to the limited amount of price variability, estimates of the marginal capacity effect are almost identical whether one uses the revenue regressions or the quantity regressions (multiplied by average price).

As discussed earlier in the paper, a positive bias on the capacity coefficients may exist if retailers choose capacity on the basis of unobservable rental demand characteristics. Given that in most cases our estimated marginal benefit to the retailer of taking an additional tape is somewhat lower than the cost of the tape, we believe that this endogeneity is not a major issue for our results using store and title fixed effects and IVs. Figure 4 extends our discussion of results for store tier 5 by plotting the marginal own-title benefit

[21] Using the results for the store and title fixed effects without IV (specification 4) yields a result very similar to cost. The marginal capacity effect in that case is 14.06, corresponding to a marginal benefit of $41.06.

for linear-priced A titles by store tier against the cost of acquiring an additional tape (which does not vary by store tier). Figures 5 and 6 report the exercise for titles taken on sell-through pricing and revenue-sharing contracts respectively. Marginal benefits are estimated using specifications 4 and 5 for both the transaction and revenue regressions. The cost measure does not account for the cost of stocking the tape, the cost of shelf-space, or other considerations. The estimated benefit does not account for disposal value of the tape and other potential benefits of carrying greater levels of capacity, such as increased traffic to the store. The marginal benefit of an additional tape tends to increase slightly with store size. For specification 5, the marginal benefit is somewhat lower than the upfront per-tape cost for all three contract types and all store tiers, while under specification 4 the benefit is similar to, or slightly higher than upfront per-tape costs.

Table 9 summarizes the own- and selected cross-title marginal effects under specification 5 based on the rental transaction regressions. The table contains three panels corresponding to focal titles that are A titles, B titles and C titles, and each panel contains results for all three contract types. A-title own-effects (reported in table 7) are referenced in the top row of the top panel, and are 10.42, 3.29, and -0.08; B- and C-title own effects are also reported in the first row of the second and third panels respectively. For cross-title impacts of the number of other titles, one could report up to 9 different effects for each box-office category and contract type: the cross-effects of other titles released in the same (or preceding, or subsequent) month, and other titles in the same (or 2 different) box categories. These effects are further allowed to vary based on a title's own box-office category, which yields a total of 27 different effects. The same calculation can be done using the capacities of other titles rather than the count of other titles.

In table 9 we report three such cross-title results for each contract type and each box-office category; the cross effect of the capacity of other titles in each of the three box office categories released in the same month as the focal title.[22] For focal titles that are A titles, the estimated cross effects are all positive, though generally small and not significantly different from zero. However, when the focal title is an A title distributed on a revenue-sharing contract, a one unit increase in the capacity of other A titles released in the same month is estimated to result in 1.85 additional rentals for the focal title (a statistically significant increase). This result suggests that higher capacity levels of some A titles may

[22]Unreported capacity results are cross-effects of the capacity of other titles released in the previous or subsequent month from the focal titles.

be associated with additional consumer traffic to the store, and increased sales for other A titles. For focal titles that are A titles, the estimated impact of an additional tape taken for other A titles released in the same month is 0.56, 0.48, and 1.85 for linear-pricing, sell-through pricing, and revenue-sharing titles respectively. The estimated impact of an additional tape taken for B titles released in the same month is 2.76, 0.03, and 0.34 for linear-pricing, sell-through pricing, and revenue-sharing titles respectively; none are statistically significant. Similarly, there is no statistically significant impact of an additional tape taken for C titles, with the estimates being 3.65, 0.48, and 0.75 for linear-pricing, sell-through pricing, and revenue-sharing titles respectively.[23]

While all of the estimated cross-effects are positive for focal titles that are A titles, many of the cross-effects for focal titles that are B titles and C titles are negative. For focal titles that are B titles, most of the cross-effects are negative. In general, an additional unit of capacity for other titles is estimated to have an impact of less than one rental for focal titles that are B titles, and the effect is not statistically different from zero. However, similar to focal titles that are A titles, when the focal title is a B title distributed on a revenue-sharing contract, an additional unit of capacity for A titles released in the same month is estimated to result in 1.32 additional rentals for the focal title (a statistically significant increase). This effect is smaller than that estimated for the case where the focal title is an A title distributed on a revenue-sharing contract (1.85 additional rentals); and, unlike with focal titles that are A titles, the estimated impact of additional capacity for A titles on rentals of B titles distributed through linear-pricing and sell-through pricing contracts are both negative (though not statistically different from zero). As a result, while we find some limited evidence that additional capacity of other titles is associated with slightly higher rentals for A titles, this positive effect (if any) is even weaker for rentals of B titles, and restricted to B titles distributed on revenue-sharing contracts. For focal titles that are C titles there is no evidence of cross effects. All of the cross-effects estimates are very small (some positive, some negative) and not significantly different from zero.

[23]Table 10 presents the same information as Table 9, but for the revenue regressions (i.e., where the log of rentals revenues is on the left-hand-side rather than the log of rentals). In this table the marginal own effect of capacity is on revenue rather than rentals. For A titles on all three contract types the revenue estimates are approximately three times higher than the rental transaction estimates, reflecting an average rental price of a little less than $3.

5 Conclusion

In conclusion, we have identified strong empirical evidence that greater capacity can substantially impact sales. In particular, we find that the effect of additional capacity on sales can be very large in situations where maintaining high levels of capacity is particularly costly (e.g., under linear-pricing contracts in our empirical investigation). The adoption of new monitoring technologies may facilitate new contractual forms and other changes that greatly reduce the costs of maintaining additional capacity. As a result, retailers may maintain higher levels of capacity relative to sales, mitigating any impact of a marginal increase in capacity on sales (e.g., under revenue-sharing contracts in our empirical investigation). The theoretical literature has addressed this possible link between capacity and sales, but empirical evidence has been largely lacking. This paper provides both empirical evidence of a strong link between capacity and sales, and evidence that the nature of this relationship can be greatly impacted by new monitoring technologies and supply contracts.

A central challenge for empirically identifying the effect of capacity on sales is the fact that retailers endogenously choose capacity to maximize profits. In order to address the endogeneity concerns, we take advantage of the panel nature of the dataset to incorporate both store and title fixed effects in addition to using an instrumental variables approach. The inclusion of both fixed effects along with an instrumental variables approach significantly reduces the bias resulting from the endogeneity of capacity.

Our main focus in this paper is to identify evidence of capacity effects on sales and measure the size of that effect in a specific industry, video rentals. As such, we allow for several mechanisms through which capacity may affect sales for video rentals, but do not attempt to identify the impact of any individual mechanism. Larger capacities may reduce stock-outs, serve as a signal to consumers about product quality, or simply increase sales by garnering more shelf space. On the other hand, consumers may substitute intertemporally during stock-outs, mitigating the effect of additional capacity on total sales. For example, although video rentals tend to peak within a few weeks for a newly released title, consumers continue to actively rent the title over a period of about four to five months on average. In industries with more time-sensitive demand, such as newspaper sales or automobile rentals, the effect of capacity on sales could be larger.

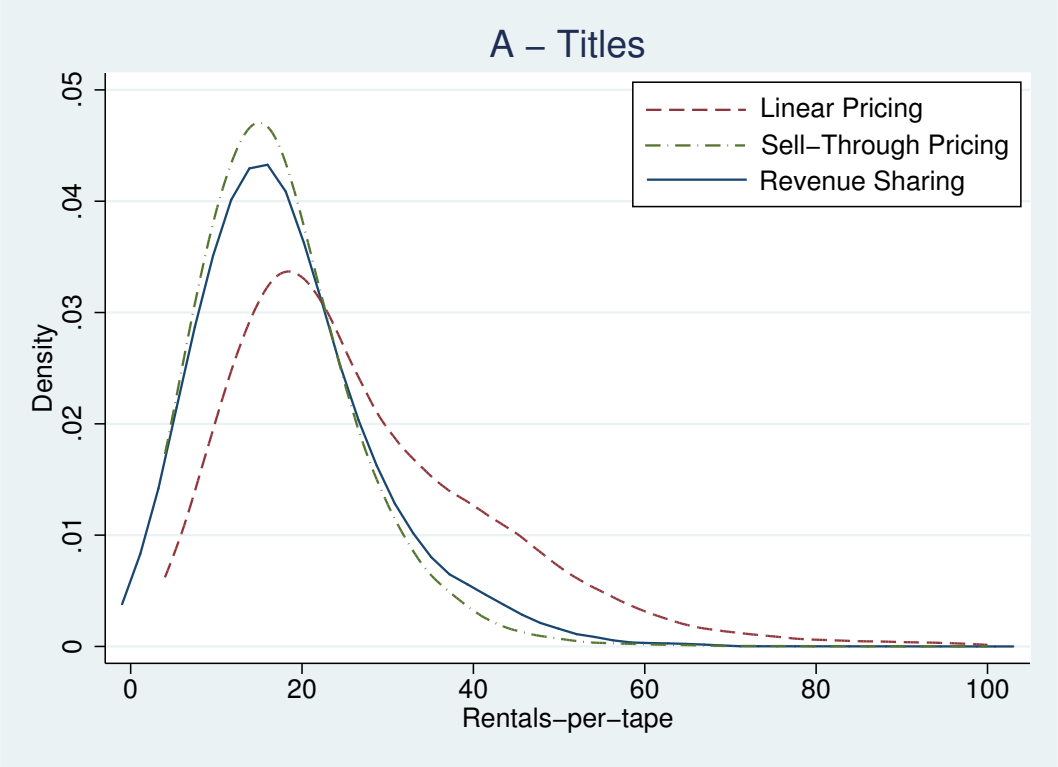

Figure 1: "Rentals-per-tape," A Titles

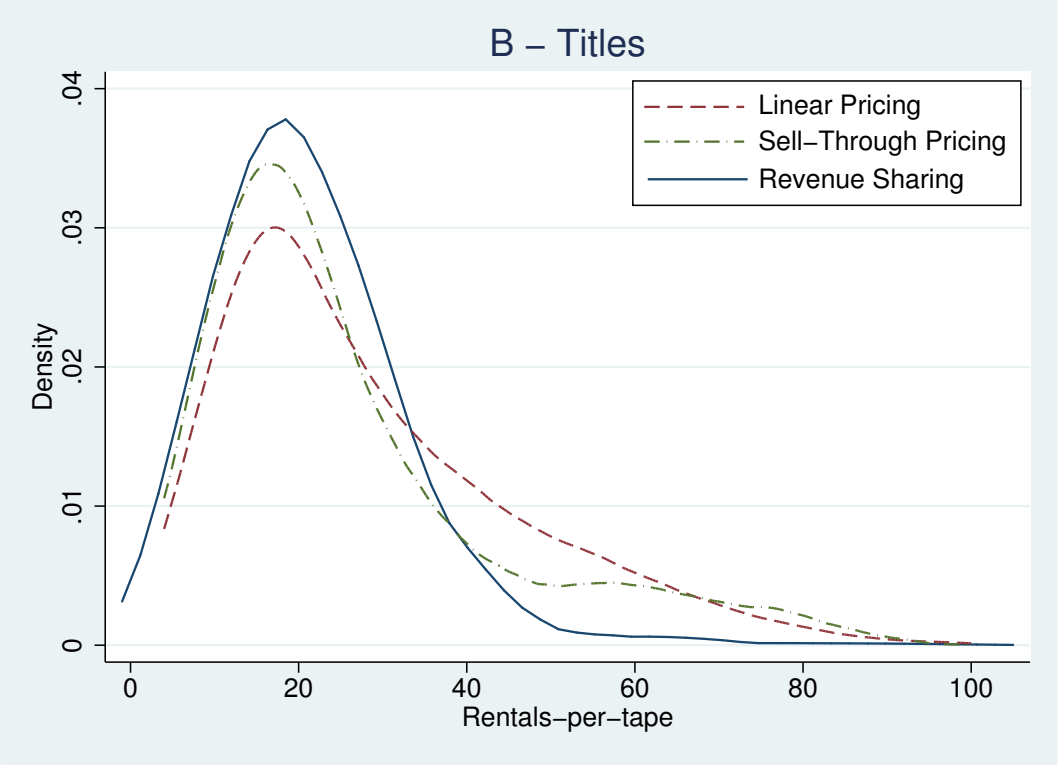

Figure 2: "Rentals-per-tape," B Titles

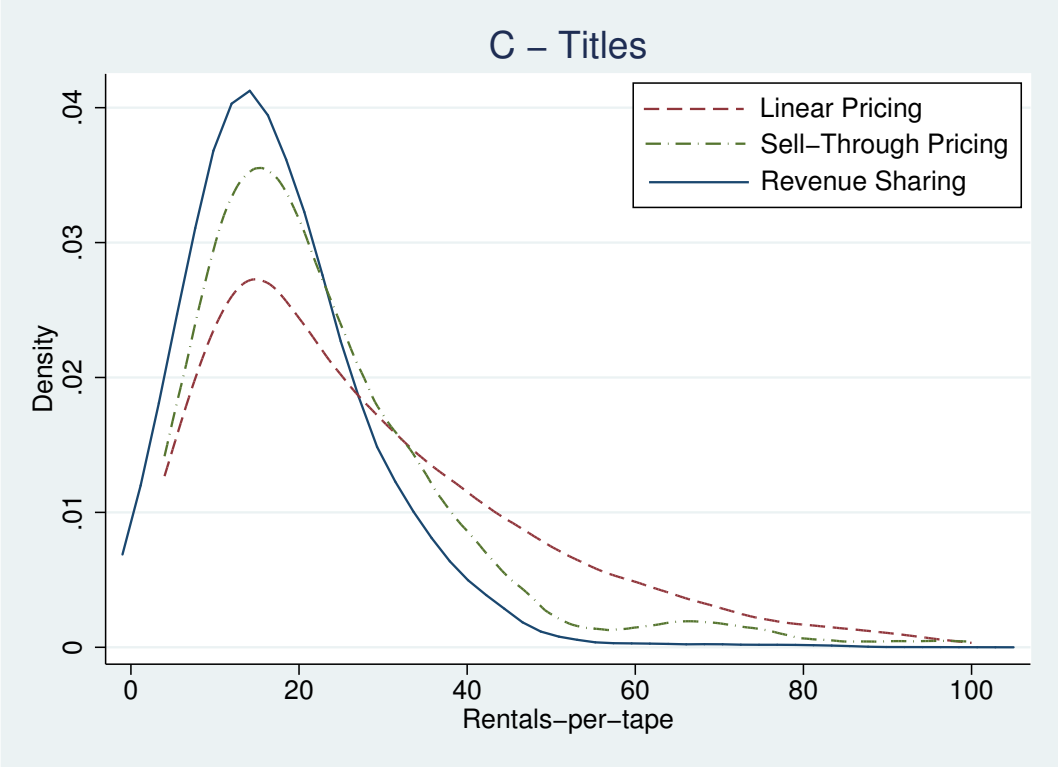

Figure 3: "Rentals-per-tape," C Titles

Table 1: The Capacity Effect for Linear-Pricing Titles
Quantity Regression, Dependent Variable $ln(Q_{ij})$

	1	2	3	4	5
log of Capacity ($ln(C)$)	0.97	1.07	0.62	0.54	0.52
	[96.98]	[23.56]	[10.86]	[10.37]	[3.27]
$ln(C)$*Box B	0.01	0.07	0.12	0.13	0.11
	[0.51]	[1.02]	[1.58]	[2.06]	[0.77]
$ln(C)$*Box C	-0.09	0.04	0.55	0.26	-0.52
	[-7.01]	[0.63]	[7.07]	[4.65]	[-2.69]
$ln(C)$*ln(Chain Size)		-0.01	-0.01	-0.01	0.03
		[-6.89]	[-6.52]	[-5.17]	[12.22]
$ln(C)$*ln(Chain Size)*Box B		0.01	0.00	0.00	0.01
		[3.61]	[0.21]	[0.59]	[3.13]
$ln(C)$*ln(Chain Size)*Box C		0.01	-0.00	0.00	0.05
		[4.98]	[-1.64]	[1.19]	[9.79]
$ln(C)$*ln(Time Trend)		-0.01	0.03	0.02	-0.05
		[-0.88]	[2.87]	[1.24]	[-2.97]
$ln(C)$*ln(Time Trend)*Box B		-0.03	-0.03	-0.03	0.02
		[-1.62]	[-1.80]	[-1.46]	[1.06]
$ln(C)$*ln(Time Trend)*Box C		-0.05	-0.05	-0.03	0.12
		[-3.25]	[-3.48]	[-1.70]	[3.48]
Store/Title/Time Char?	Y	Y	Y	N	N
Capacity*Store Tier Interactions?	N	Y	Y	Y	Y
Cross-Title Stocking?	N	N	Y	Y	Y
Title/Store FE?	N	N	N	Y	Y
Instrument?	N	N	N	N	Y
R-squared	0.78	0.78	0.81	0.88	0.79
Observations	1,606,583	1,606,583	1,535,472	1,535,472	1,535,385

T-stats are in brackets and all T-stats reflect robust standard errors with clustering by both title and store.
In the first-stage regression for column 5, the instrument for capacity is the average level of capacity for the same title held at other stores of the same tier level. The coefficient on the instrument is 0.02 with a T-stat of 14.4. The first-stage regression has an R-squared of 0.71.

Table 2: The Capacity Effect for Sell-Through Pricing Titles
Quantity Regression, Dependent Variable $ln(Q_{ij})$

	1	2	3	4	5
log of Capacity ($ln(C)$)	0.82	0.65	0.55	0.31	-0.23
	[33.23]	[5.96]	[6.34]	[5.88]	[-1.17]
$ln(C)$*Box B	-0.06	-0.08	-0.10	-0.09	0.15
	[-1.89]	[-0.42]	[-0.63]	[-0.94]	[0.60]
$ln(C)$*Box C	-0.13	-0.21	-0.61	-0.11	-0.34
	[-4.57]	[-2.26]	[-3.71]	[-0.99]	[-1.34]
$ln(C)$*ln(Chain Size)		0.01	0.00	0.00	0.02
		[1.89]	[1.94]	[0.03]	[4.55]
$ln(C)$*ln(Chain Size)*Box B		0.01	0.00	0.00	0.01
		[1.41]	[0.65]	[0.54]	[3.04]
$ln(C)$*ln(Chain Size)*Box C		0.01	0.01	0.00	0.03
		[2.40]	[1.19]	[0.42]	[3.29]
$ln(C)$*ln(Time Trend)		0.03	0.06	0.04	0.07
		[1.38]	[3.05]	[3.47]	[4.52]
$ln(C)$*ln(Time Trend)*Box B		-0.00	-0.01	0.03	0.04
		[-0.01]	[-0.23]	[1.48]	[1.24]
$ln(C)$*ln(Time Trend)*Box C		0.00	0.11	0.04	0.06
		[0.21]	[3.40]	[1.49]	[1.46]
Store/Title/Time Char?	Y	Y	Y	N	N
Capacity*Store Tier Interactions?	N	Y	Y	Y	Y
Cross-Title Stocking?	N	N	Y	Y	Y
Title/Store FE?	N	N	N	Y	Y
Instrument?	N	N	N	N	Y
R-squared	0.82	0.83	0.85	0.90	0.85
Observations	343,116	343,116	316,269	316,269	316,260

T-stats are in brackets and all T-stats reflect robust standard errors with clustering by both title and store.
In the first-stage regression for column 5, the instrument for capacity is the average level of capacity for the same title held at other stores of the same tier level. The coefficient on the instrument is 0.01 with a T-stat of 7.7. The first-stage regression has an R-squared of 0.78.

Table 3: The Capacity Effect for Revenue Sharing Titles
Quantity Regression, Dependent Variable $ln(Q_{ij})$

	1	2	3	4	5
log of Capacity ($ln(C)$)	0.96	0.94	0.69	0.36	-0.31
	[47.61]	[13.53]	[8.91]	[6.33]	[-2.52]
$ln(C)$*Box B	0.03	0.09	0.11	0.06	0.13
	[2.01]	[1.14]	[1.19]	[0.89]	[1.66]
$ln(C)$*Box C	-0.05	0.00	0.34	0.19	0.27
	[-2.73]	[0.03]	[3.58]	[2.69]	[2.20]
$ln(C)$*ln(Chain Size)		-0.02	0.00	0.00	0.03
		[-2.65]	[0.47]	[1.39]	[5.67]
$ln(C)$*ln(Chain Size)*Box B		0.01	0.01	0.01	0.01
		[1.97]	[4.87]	[2.74]	[2.24]
$ln(C)$*ln(Chain Size)*Box C		0.00	0.02	0.01	0.03
		[0.57]	[5.25]	[3.25]	[4.43]
$ln(C)$*ln(Time Trend)		0.01	-0.00	0.01	0.04
		[0.86]	[-0.02]	[0.94]	[3.10]
$ln(C)$*ln(Time Trend)*Box B		-0.02	-0.05	0.00	0.01
		[-1.21]	[-2.52]	[0.00]	[0.64]
$ln(C)$*ln(Time Trend)*Box C		-0.02	-0.03	0.01	-0.00
		[-0.84]	[-1.34]	[0.68]	[-0.09]
Store/Title/Time Char?	Y	Y	Y	N	N
Capacity*Store Tier Interactions?	N	Y	Y	Y	Y
Cross-Title Stocking?	N	N	Y	Y	Y
Title/Store FE?	N	N	N	Y	Y
Instrument?	N	N	N	N	Y
R-squared	0.79	0.79	0.81	0.87	0.84
Observations	428,501	428,501	409,113	409,113	408,812

T-stats are in brackets and all T-stats reflect robust standard errors with clustering by both title and store.
In the first-stage regression for column 5, the instrument for capacity is the average level of capacity for the same title held at other stores of the same tier level. The coefficient on the instrument is 0.01 with a T-stat of 9.5. The first-stage regression has an R-squared of 0.85.

Table 4: The Capacity Effect for Linear-Pricing Titles
Revenue Regression, Dependent Variable $ln(Revenue_{ij})$

	1	2	3	4	5
log of Capacity ($ln(C)$)	1.00	1.09	0.61	0.49	0.39
	[95.65]	[24.52]	[10.43]	[9.26]	[2.43]
$ln(C)$*Box B	0.01	0.08	0.13	0.12	0.10
	[1.00]	[1.19]	[1.66]	[1.99]	[0.70]
$ln(C)$*Box C	-0.09	0.05	0.60	0.25	-0.61
	[-7.07]	[0.79]	[7.63]	[4.40]	[-3.13]
$ln(C)$*ln(Chain Size)		-0.01	-0.01	-0.00	0.04
		[-6.02]	[-5.46]	[-1.47]	[14.51]
$ln(C)$*ln(Chain Size)*Box B		0.01	0.00	0.00	0.01
		[3.67]	[0.11]	[1.02]	[3.74]
$ln(C)$*ln(Chain Size)*Box C		0.01	-0.01	0.00	0.05
		[3.99]	[-2.62]	[0.91]	[10.07]
$ln(C)$*ln(Time Trend)		-0.01	0.04	0.03	-0.04
		[-0.68]	[3.47]	[1.67]	[-2.04]
$ln(C)$*ln(Time Trend)*Box B		-0.03	-0.03	-0.03	0.02
		[-1.80]	[-1.85]	[-1.36]	[1.15]
$ln(C)$*ln(Time Trend)*Box C		-0.05	-0.05	-0.02	0.14
		[-3.38]	[-3.76]	[-1.32]	[4.14]
Store/Title/Time Char?	Y	Y	Y	N	N
Capacity*Store Tier Interactions?	N	Y	Y	Y	Y
Cross-Title Stocking?	N	N	Y	Y	Y
Title/Store FE?	N	N	N	Y	Y
Instrument?	N	N	N	N	Y
R-squared	0.77	0.77	0.81	0.88	0.78
Observations	1,606,583	1,606,583	1,535,472	1,535,472	1,535,385

T-stats are in brackets and all T-stats reflect robust standard errors with clustering by both title and store.
In the first-stage regression for column 5, the instrument for capacity is the average level of capacity for the same title held at other stores of the same tier level. The coefficient on the instrument is 0.02 with a T-stat of 14.4. The first-stage regression has an R-squared of 0.71.

Table 5: The Capacity Effect for Sell-Through Pricing Titles
Revenue Regression, Dependent Variable $ln(Revenue_{ij})$

	1	2	3	4	5
log of Capacity ($ln(C)$)	0.86	0.69	0.58	0.31	-0.33
	[32.78]	[6.27]	[6.28]	[5.87]	[-1.60]
$ln(C)$*Box B	-0.06	-0.09	-0.10	-0.05	0.08
	[-2.04]	[-0.51]	[-0.66]	[-0.50]	[0.33]
$ln(C)$*Box C	-0.14	-0.17	-0.61	0.01	-0.36
	[-4.46]	[-1.82]	[-3.32]	[0.09]	[-1.29]
$ln(C)$*ln(Chain Size)		0.01	0.00	-0.00	0.03
		[1.47]	[3.20]	[-0.12]	[5.14]
$ln(C)$*ln(Chain Size)*Box B		0.01	0.00	0.00	0.01
		[1.37]	[0.56]	[0.36]	[3.25]
$ln(C)$*ln(Chain Size)*Box C		0.01	0.01	0.00	0.03
		[2.03]	[0.98]	[0.13]	[3.35]
$ln(C)$*ln(Time Trend)		0.03	0.06	0.04	0.09
		[1.42]	[2.77]	[4.07]	[5.18]
$ln(C)$*ln(Time Trend)*Box B		0.00	-0.01	0.03	0.06
		[0.08]	[-0.19]	[0.98]	[1.86]
$ln(C)$*ln(Time Trend)*Box C		-0.00	0.11	0.02	0.06
		[-0.21]	[3.07]	[0.69]	[1.36]
Store/Title/Time Char?	Y	Y	Y	N	N
Capacity*Store Tier Interactions?	N	Y	Y	Y	Y
Cross-Title Stocking?	N	N	Y	Y	Y
Title/Store FE?	N	N	N	Y	Y
Instrument?	N	N	N	N	Y
R-squared	0.83	0.83	0.85	0.90	0.84
Observations	343,116	343,116	316,269	316,269	316,260

T-stats are in brackets and all T-stats reflect robust standard errors with clustering by both title and store.
In the first-stage regression for column 5, the instrument for capacity is the average level of capacity for the same title held at other stores of the same tier level. The coefficient on the instrument is 0.01 with a T-stat of 7.7. The first-stage regression has an R-squared of 0.78.

Table 6: The Capacity Effect for Revenue Sharing Titles
Revenue Regression, Dependent Variable $ln(Revenue_{ij})$

	1	2	3	4	5
log of Capacity ($ln(C)$)	0.98	0.95	0.69	0.31	-0.39
	[47.69]	[13.34]	[8.52]	[5.83]	[-3.18]
$ln(C)$*Box B	0.03	0.09	0.10	0.05	0.12
	[1.99]	[1.04]	[1.08]	[0.82]	[1.56]
$ln(C)$*Box C	-0.05	0.00	0.35	0.18	0.27
	[-2.48]	[0.00]	[3.50]	[2.66]	[2.14]
$ln(C)$*ln(Chain Size)		-0.01	0.00	0.01	0.04
		[-1.96]	[2.12]	[2.57]	[6.15]
$ln(C)$*ln(Chain Size)*Box B		0.01	0.02	0.01	0.01
		[2.43]	[5.03]	[2.67]	[2.15]
$ln(C)$*ln(Chain Size)*Box C		0.00	0.02	0.01	0.03
		[0.62]	[5.07]	[3.01]	[4.25]
$ln(C)$*ln(Time Trend)		0.02	0.00	0.02	0.05
		[0.99]	[0.15]	[1.90]	[4.16]
$ln(C)$*ln(Time Trend)*Box B		-0.02	-0.05	0.00	0.01
		[-1.16]	[-2.40]	[0.01]	[0.67]
$ln(C)$*ln(Time Trend)*Box C		-0.01	-0.03	0.01	0.00
		[-0.76]	[-1.25]	[0.81]	[0.10]
Store/Title/Time Char?	Y	Y	Y	N	N
Capacity*Store Tier Interactions?	N	Y	Y	Y	Y
Cross-Title Stocking?	N	N	Y	Y	Y
Title/Store FE?	N	N	N	Y	Y
Instrument?	N	N	N	N	Y
R-squared	0.79	0.79	0.81	0.87	0.85
Observations	428,501	428,501	409,113	409,113	408,812

T-stats are in brackets and all T-stats reflect robust standard errors with clustering by both title and store.
In the first-stage regression for column 5, the instrument for capacity is the average level of capacity for the same title held at other stores of the same tier level. The coefficient on the instrument is 0.01 with a T-stat of 9.5. The first-stage regression has an R-squared of 0.85.

Table 7: Marginal Capacity Effects, Quantity Regressions

Titles Taken on Linear-Pricing Contracts

	Table 1, Model Specification					% Increase in Rentals	Elasticity
dQ/dC	1	2	3	4	5	(Spec. 5)	(Spec. 5)
Box A (avg. p=$2.92)	23.90	23.06	16.06	14.06	10.42	2.0%	0.44
	[96.98]	[82.39]	[18.64]	[13.89]	[4.77]		
Box B (avg. p=$2.85)	25.07	25.01	18.13	16.11	18.01	6.9%	0.66
	[73.63]	[63.58]	[39.27]	[44.13]	[7.39]		
Box C (avg. p=$2.65)	20.83	21.14	24.07	18.98	17.01	17.8%	0.63
	[58.97]	[53.10]	[57.84]	[64.67]	[7.41]		

Titles Taken on Sell-Through Pricing Contracts

	Table 2, Model Specification					% Increase in Rentals	Elasticity
dQ/dC	1	2	3	4	5	(Spec. 5)	(Spec. 5)
Box A (avg. p=$2.95)	11.86	12.18	11.78	7.08	3.29	0.8%	0.22
	[33.23]	[28.71]	[18.97]	[26.78]	[1.32]		
Box B (avg. p=$2.84)	11.41	11.70	10.41	8.40	9.18	5.1%	0.55
	[19.64]	[18.18]	[11.17]	[9.81]	[2.69]		
Box C (avg. p=$2.69)	10.48	10.89	12.07	9.24	5.10	6.2%	0.30
	[17.12]	[14.64]	[19.70]	[23.94]	[1.63]		

Titles Taken on Revenue-Sharing Contracts

	Table 3, Model Specification					% Increase in Rentals	Elasticity
dQ/dC	1	2	3	4	5	(Spec. 5)	(Spec. 5)
Box A (avg. p=$2.90)	15.45	14.60	10.50	6.59	-0.08	-0.0%	-0.00
	[47.61]	[32.24]	[19.83]	[28.36]	[-0.05]		
Box B (avg. p=$2.83)	17.04	16.94	10.69	8.87	2.47	0.7%	0.13
	[43.87]	[36.34]	[14.92]	[23.64]	[1.21]		
Box C (avg. p=$2.76)	13.49	13.51	15.48	11.63	4.85	4.2%	0.26
	[29.53]	[25.71]	[32.02]	[36.03]	[2.50]		

Marginal effects are based on coefficient estimates summarized in tables 1 through 3, and are calculated for the average values for tier 5 stores (a medium store size).
T-stats in brackets.

Table 8: Marginal Capacity Effects, Revenue Regressions

Titles Taken on Linear-Pricing Contracts

	Table 4, Model Specification					% Increase in Revenue	Elasticity
dRev/dC	1	2	3	4	5	(Spec. 5)	(Spec. 5)
Box A	71.33	69.05	47.88	41.47	28.75	1.9%	0.42
	[95.65]	[80.11]	[18.14]	[13.50]	[4.42]		
Box B	74.26	74.20	53.40	47.05	50.34	6.7%	0.65
	[74.49]	[63.53]	[38.86]	[42.88]	[7.17]		
Box C	58.25	58.97	67.27	53.02	45.04	17.3%	0.61
	[58.53]	[52.37]	[57.50]	[62.77]	[7.17]		

Titles Taken on Sell-Through Pricing Contracts

	Table 5, Model Specification					% Increase in Revenue	Elasticity
dRev/dC	1	2	3	4	5	(Spec. 5)	(Spec. 5)
Box A	36.98	37.60	36.24	22.05	8.48	0.7%	0.19
	[32.78]	[27.40]	[17.78]	[25.76]	[1.08]		
Box B	33.65	34.31	30.63	25.14	24.83	4.9%	0.53
	[20.15]	[18.10]	[10.70]	[10.82]	[2.49]		
Box C	29.88	30.75	34.41	27.00	12.11	5.4%	0.26
	[16.72]	[13.91]	[19.17]	[25.45]	[1.29]		

Titles Taken on Revenue-Sharing Contracts

	Table 6, Model Specification					% Increase in Revenue	Elasticity
dRev/dC	1	2	3	4	5	(Spec. 5)	(Spec. 5)
Box A	45.82	43.34	31.26	19.85	-0.80	-0.0%	-0.02
	[47.69]	[31.67]	[19.43]	[28.38]	[-0.18]		
Box B	48.98	48.46	30.78	25.14	5.65	0.6%	0.11
	[44.62]	[36.31]	[15.34]	[22.35]	[0.96]		
Box C	38.43	38.31	43.96	33.09	13.30	4.1%	0.26
	[30.20]	[25.89]	[32.83]	[34.94]	[2.43]		

Marginal effects are based on coefficient estimates summarized in tables 4 through 6, and are calculated for the average values for tier 5 stores (the median store size).
T-stats in brackets.

Table 9: Marginal Own- and Cross-Title Capacity Effects on Rentals for A Titles
Quantity Regressions, Specification 5

Effects on Rentals (Q)

	Contract Type		
	Linear Price	Sell-Through Price	Revenue Share
A-Title Marginal Own Effect	10.42	3.29	-0.08
	[4.77]	[1.32]	[-0.05]
A-Title Marginal Cross Effects:			
Other A-Title Capacity	0.56	0.45	1.85
	[0.53]	[1.49]	[4.21]
B-Title Capacity	2.76	0.03	0.34
	[0.99]	[0.05]	[0.45]
C-Title Capacity	3.65	0.48	0.75
	[1.20]	[0.86]	[0.48]
B-Title Marginal Own Effect	18.01	9.18	2.47
	[7.39]	[2.69]	[1.21]
B-Title Marginal Cross Effects:			
A-Title Inventory	-0.13	-0.93	1.32
	[-0.66]	[-1.83]	[2.79]
Other B-Title Inventory	-0.39	-0.65	0.15
	[-0.64]	[-0.55]	[0.16]
C-Title Inventory	-0.15	0.24	-0.67
	[-0.15]	[0.17]	[-0.40]
C-Title Marginal Own Effect	17.01	5.10	4.85
	[7.41]	[1.63]	[2.50]
C-Title Marginal Cross Effects:			
A-Title Inventory	0.02	0.05	0.01
	[1.69]	[1.89]	[0.60]
B-Title Inventory	-0.02	0.12	0.04
	[-0.56]	[1.39]	[0.90]
Other C-Title Inventory	-0.02	0.09	0.13
	[-0.27]	[0.74]	[1.51]

Cross effects based on the count of tapes taken on other titles for titles released in the same release month as the observation title, and are calculated for the average values for tier 5 stores (a medium store size).
T-stats in brackets.

Table 10: Marginal Own- and Cross-Title Capacity Effects on Rentals for A Titles
Revenue Regressions, Specification 5

Effects on Revenues (Rev)

	Contract Type			
			Revenue Share	
	Linear Price	Sell-Through Price	Effect	Store Share
A-Title Marginal Own Effect	28.75	8.48	-0.80	-0.38
	[4.42]	[1.08]	[-0.18]	
A-Title Marginal Cross Effects:				
Other A-Title Inventory	2.30	1.60	5.28	2.54
	[0.74]	[1.76]	[4.03]	
B-Title Inventory	6.67	0.18	0.92	0.44
	[0.80]	[0.11]	[0.40]	
C-Title Inventory	7.38	1.01	1.78	0.85
	[0.82]	[0.60]	[0.40]	
B-Title Marginal Own Effect	50.34	24.83	5.65	2.67
	[7.17]	[2.49]	[0.96]	
B-Title Marginal Cross Effects:				
A-Title Inventory	-0.30	-2.28	4.01	1.90
	[-0.50]	[-1.54]	[2.98]	
Other B-Title Inventory	-1.42	-1.80	0.47	0.22
	[-0.82]	[-0.51]	[0.18]	
C-Title Inventory	-1.01	0.49	-2.63	-1.24
	[-0.36]	[0.12]	[-0.53]	
C-Title Marginal Own Effect	45.04	12.11	13.30	6.66
	[7.17]	[1.29]	[2.43]	
C-Title Marginal Cross Effects:				
A-Title Inventory	0.06	0.13	0.04	0.02
	[1.82]	[1.85]	[0.57]	
B-Title Inventory	-0.04	0.36	0.13	0.07
	[-0.41]	[1.36]	[0.97]	
Other C-Title Inventory	-0.03	0.16	0.37	0.19
	[-0.14]	[0.45]	[1.57]	

Cross effects based on the count of tapes taken on other titles for titles released in the same release month as the observation title, and are calculated for the average values for tier 5 stores (a medium store size).
T-stats in brackets.

Figure 4: Linear-Pricing Marginal Effect, A Titles

Figure 5: Sell-Through Pricing Marginal Effect, A Titles

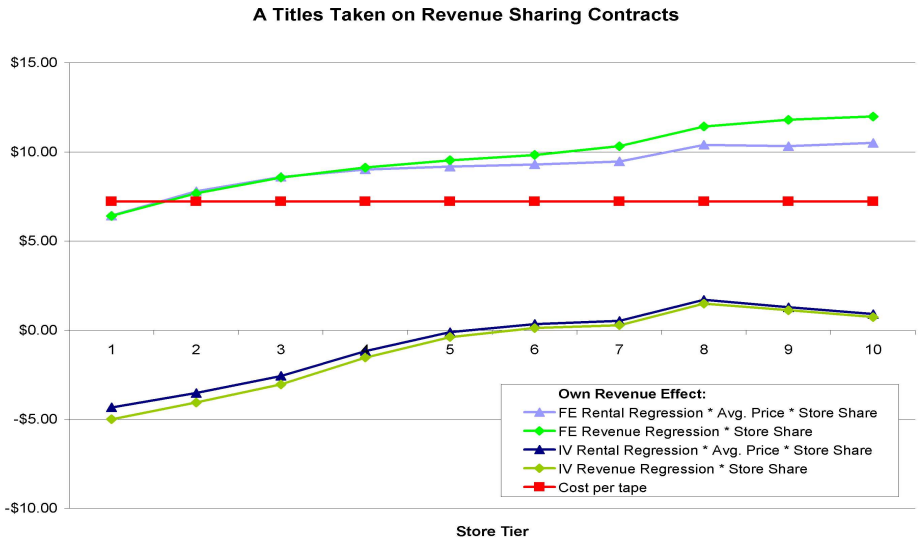

Figure 6: Revenue-Sharing Marginal Effect, A Titles

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