The Effects of Revenue-Sharing Contracts on Welfare in Vertically-Separated Markets: Evidence from the Video Rental Industry

Julie Holland Mortimer*

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Abstract

In this study I analyze the implications of contractual innovation in vertically-separated industries, using the example of the video rental industry. Prior to 1998, video stores obtained inventory from movie distributors using fixed-fee contracts. In 1998, revenue-sharing contracts, which include inventory restrictions, were widely adopted. I investigate the effect of using revenue-sharing contracts on firms' profits and consumer welfare, relative to fixed-fee contracts. I analyze a new panel dataset of home video retailers that includes information on individual retailers' contract and inventory choices, weekly rentals and sales, and contract terms (prices and quantity restrictions) for 1,114 movie titles and 6,594 retailers in the U.S during each week of 1998 and 1999. A structural econometric model of firms' behavior is developed and estimated, and counterfactual experiments are performed. The results indicate that total upstream and downstream profits increase by seven percent, and consumers benefit substantially when revenue-sharing contracts are adopted. I also examine the effects of the observed quantity restrictions. I find that these restrictions serve to increase profits for upstream firms and decrease profits for downstream firms, relative to revenue-sharing contracts without inventory restrictions.

*Department of Economics, Harvard University, Cambridge, Massachusetts 02138. E-mail: mortimer@fas.harvard.edu.

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1 Introduction

Coordinating inventory decisions between manufacturers and retailers can be a challenge in industries where both firms are separately maximizing profits. In particular, retailers' market power may cause output to be reduced below the level a monopolist manufacturer would prefer. Revenue-sharing contracts, in which the retailer pays the manufacturer a fee per unit of inventory and a percentage of the revenue generated from the inventory, allow firms greater flexibility for solving this problem than simple linear pricing (that is, a fixed fee per unit of inventory only). This study examines the effect of the recent widespread adoption of revenue-sharing contracts in the vertically-separated video rental industry. I present a theoretical model of firm behavior and consumer demand that incorporates the institutional details of the contracting environment, including the presence of inventory restrictions in revenue-sharing contracts. The structural model is estimated using a new dataset on video retailers in the US. Using the estimated demand system, I conduct counter-factual experiments to analyze the implications of both revenue-sharing and inventory restrictions in this industry.

Prior to 1998, video stores obtained inventory from movie distributors using fixed-fee contracts, consisting of a single wholesale price per unit of inventory (typically around $70 per tape). In 1998, revenue-sharing contracts, consisting of an upfront fee per unit of inventory and a revenue-split paid on the basis of rental revenue, were widely adopted by the largest chains in the industry. These contracts typically charge between $0 and $8 per unit of inventory with the retailer keeping between 40 and 60 percent of rental revenues. Movie distributors and the large chains (most notably Blockbuster, Inc.) directly negotiate revenue-sharing agreements covering most titles distributed by the upstream firm.[1] Smaller chains and independent retailers do not have access to directly negotiate such bilateral agreements. However, a third party aggregates the demand of these independent retailers and negotiates and monitors revenue-sharing agreements with movie distributors on their behalf. Retailers participate by paying a relatively small sign-up fee and purchasing the necessary computer and modem technology. Although the bilateral revenue-sharing agreements between the distributors and the largest chains tend to apply to most titles

[1] Parts of Blockbuster's revenue-sharing contracts were filed as part of the firm's September, 1999 initial public offering on the New York Stock Exchange. The first contract is dated November 1997, and four similar contracts follow in the spring of 1998. These contracts may be viewed at http://www.freeedgar.com.

released by the distributor, independent retailers may choose between revenue-sharing and fixed-fee terms on a title-by-title basis. Empirically, retailers choose revenue-sharing terms for approximately half of all movie titles for which both fixed-fee and revenue-sharing terms are offered, excluding direct-to-video releases.

When choosing a contract for a title, all retailers face the same price under fixed-fee terms, and also face the same upfront fee and revenue-split under revenue-sharing terms. No inventory restrictions apply to fixed-fee contracts, but the upstream firm can and does set inventory restrictions as part of the revenue-sharing contracts. Furthermore, while fixed-fee prices, upfront fees and revenue splits tend to vary only across three broad box-office categories, inventory restrictions vary across products within box-office categories, and across store size. Stores must adhere to both minimum and maximum inventory restrictions in order to participate in revenue-sharing agreements. These inventory restrictions are often binding for retailers: 37 percent of titles on revenue-sharing are purchased at the minimum inventory level, and 7 percent of titles are purchased at the maximum level.

The typical analysis of revenue sharing in vertically-separated markets focuses on the usefulness of this contract for alleviating understocking or double-marginalization problems that may exist under fixed-fee contracts.[2] Thus, the existence of both inventory minimums and maximums, and the fact that these restrictions are so often binding, presents a puzzle for the standard analysis. Inventory minimums and maximums are the only terms in the contract that vary across retailers for a given movie, suggesting that these terms play an important role in discriminating between downstream firms. I develop a theoretical model of firm behavior that incorporates the details of the institutional setting and rationalizes the use of inventory restrictions. Multiple, heterogeneous downstream markets exist, which differ in both their demand conditions and their competitive conditions. Inventory restrictions help the upstream firm to fine-tune retailers' inventory choices across downstream markets when the upstream firm is constrained to offer the same upfront fees and revenue-splits to all retailers. The model offers specific predictions linking retailers' contract and inventory choices to the competitive conditions and demand conditions in their market.

[2]See, for example, Dana and Spier (2000) and Cachon and Lariviere (2000), which both examine revenue-sharing contracts in the video rental industry. Other issues addressed in the empirical literature on the determinants of contractual form include issues concerning moral hazard (for example, Shepard (1993), Slade (1996), Lafontaine (1992) and Corts (1999)), and the effects of transactions costs and the role of risk (for example, Allen and Leuck (1993, 1992)). For a summary of the empirical literature on contractual relations between manufacturers and retailers, see Lafontaine and Slade (1997).

The empirical model uses observed variation in firms' competitive conditions and contract and inventory choices across different geographic markets and products to identify the expected demand conditions facing each firm. The data are provided for all retailers that have used a revenue-sharing contract at least once in the past two and one-half years; these firms represent approximately 30 percent of all U.S. video rental retailers. The dataset includes information on individual retailers' contract and inventory choices, weekly rentals and sales, and contract terms (prices and quantity restrictions) for 1,114 movie titles for 6,594 retailers in the U.S during the 104-week period from 1998 through 1999. Using these data, I estimate the structural model to generate predicted demand conditions.

Based on the estimated demand conditions, I conduct several counter-factual experiments. The results of these experiments indicate that total upstream and downstream profits increase by over seven percent and consumers benefit substantially when revenue-sharing contracts are adopted. I also examine the effects of inventory restrictions. I find that these restrictions serve to increase profits for upstream firms and decrease profits for downstream firms, relative to revenue-sharing contracts without quantity restrictions.

This paper complements two previous theoretical studies that have examined the adoption of revenue-sharing in the video rental industry. Dana and Spier (2000) consider the usefulness of revenue-sharing with perfectly competitive retailers in a single downstream market under two sets of demand conditions. In the first case, demand is uncertain and prices are sticky. In the second case, demand is known but declining in a predictable way over time, and prices are flexible. The authors derive optimal revenue-sharing terms, which differ according to the assumed demand conditions. The implication of their study is that both upstream and downstream firms will prefer revenue-sharing terms to fixed-fee terms for all titles. In another paper, Cachon and Lariviere (2000) compare revenue sharing to other methods of coordinating inventory in vertically-separated industries, such as buy-back and quantity-flexibility contracts. They also consider two possibilities in which revenue-sharing may not work as well. First, they conjecture that administrative costs may prove too high to implement revenue-sharing in some settings. Second, they note that the increased potential for reduced sales effort under revenue-sharing terms may make revenue-sharing a poor contractual form in some industries. Neither of these issues seems critical to the video rental industry, and the authors identify the video rental industry as a prime candidate for the successful use of revenue-sharing contracts.

The rest of the paper proceeds as follows. First, I discuss some of the institutional details of the video rental industry. Section 3 describes the data used in the analysis and summarizes the data. The theoretical model of firm behavior is presented in section 4, and I discuss the estimation methodology in section 5. Section 6 provides results from the estimation procedures, and section 7 presents the results of counter-factual experiments. The final section concludes.

2 The Home Video Industry and Contract Forms

The home video industry grew quickly throughout the 1980's to become the largest source of domestic revenue for movie studios.[3] 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. Currently, there are 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.[4]

The traditional method of distributing motion pictures on videocassette occurs via a fixed-fee transfer from the distribution arm of a movie studio to home video retailers.[5] Price typically does not vary by title, with each distributor charging between $65 and $70 per tape, regardless of the identity of the movie.[6] According to industry sources, the marginal cost of producing, packaging and shipping a pre-recorded videocassette tape is around three dollars.

In addition to this traditional fixed-fee pricing, revenue-sharing contracts have existed for about ten years, but were only used on a very small scale until recently. In 1998, revenue-sharing became a widely-used contractual arrangement for both large chains and independent stores. The distributor typically negotiates revenue-sharing contracts separately with large chains, such as Blockbuster, Inc., and with Rentrak, which is a private company that administers revenue-sharing arrangements for a large clientele of smaller

[3] VSDA white paper, 1996, pg. 12.

[4] VSDA 1998 and 1999 annual reports. Revenue splits reported in 1998 annual report, pg. 18.

[5] The distribution arm of a movie studio is the upstream firm in this context. For the remainder of the paper, I refer to the upstream firm as the distributor.

[6] Exceptions to this rule are titles priced for "sell-through." In this case, titles are priced to encourage direct sales to consumers, and price does vary by title. Prices obtained through interviews with studio executives. Other volume discounts or price breaks through "copy-depth" programs may apply. I do not observe these discounts, and assume that retailers pay the full wholesale price before discounts.

chains and independent video rental outlets. Blockbuster, Inc. initially proposed revenue-sharing agreements to the major distributors in late 1997. Other retail firms soon followed Blockbuster's lead, signing up with Rentrak in large numbers throughout 1998. Although Blockbuster reported that revenue sharing accounted for 90 percent of their revenue in 2000, the typical independent retailer reports using revenue-sharing terms through Rentrak for roughly 28 percent of titles, and 25 percent of revenue.[7]

Under the typical revenue-sharing arrangement, the retailer pays an upfront fee of $3 to $8 per unit of inventory. In return, the retailer must share rental receipts with the distributor, and adhere to inventory restrictions. For movies with large theatrical box-office receipts, the retailer retains about 45 percent of rental revenue, and receives some portion of the eventual sale of the pre-viewed cassette. Although the upfront fee and revenue-splits vary across three broad box-office categories, they do not vary by title.[8] Retailers must choose between fixed-fee and revenue-sharing terms for a given title before it is released on video. Once the retailer chooses a contractual form, she must accept the same contractual form for all tapes purchased for that title. Thus, the retailer makes two decisions for each title: first, she chooses a contract form. Second, she chooses the number of tapes to purchase. This inventory choice may be constrained under revenue-sharing terms. I discuss the nature of these restrictions in greater detail later.

Distributors also face some restrictions when setting contractual terms. Anti-trust concerns prevent distributors from offering different prices to different buyers. Section 2 of the Clayton Act, as amended by the 1936 Robinson-Patman Act, makes price discrimination of this type illegal. The Robinson-Patman Act does not, however, speak to quantity requirements in any way. For this reason, I assume that the upstream firm must offer the same contractual terms (wholesale prices, upfront fees, and revenue-splits) to all downstream retailers. This assumption is borne out empirically.

In addition to setting contractual terms, the distributor can in theory choose whether or not to offer both contractual forms. In particular, one might expect that the upstream firm might choose to only offer revenue-sharing terms, since revenue sharing is a more flexible contractual arrangement. However, revenue sharing requires extensive computer monitoring

[7] Blockbuster, Inc. data reported in *Weekly Variety*, October 12-18 1998, p. 18. Rentrak figures compiled by author.

[8] The only observed variation in these fees that exists within a box-office category is variation across distributors.

of millions of transactions. As recent technological advances have made revenue-sharing a feasible contractual option, both upstream and downstream firms have widely adopted these contracts and approximately 10,000 firms had access to revenue-sharing contracts in 2000.[9] However, the remaining 10,000 retailers in the industry are either not technologically equipped to participate in this form of distribution, or may not qualify for credit terms with Rentrak. Thus, if fixed-fee contracts are withdrawn, distributors lose access to half of all retail outlets, and may also face potential foreclosure charges for excluding retailers from acquiring inventory. One might expect that the upstream firm would therefore restrict fixed-fee contracts to downstream firms that do not have the ability to participate in revenue-sharing contracts. This is not possible because the Copyright Act of 1976 states that the owner of a lawful copy can "sell or otherwise dispose of" the copy. This is commonly referred to as the Right of First Sale Doctrine, and allows the owner of a lawful copy to rent, lease, lend or resell a legally owned copy of a work. Thus, retailers with the ability to participate in revenue-sharing agreements cannot be excluded from choosing fixed-fee terms when ordering inventory for particular titles (although they are limited to a single contractual form for any given title). Thus, downstream firms can discipline the upstream firm by opting to take fixed-fee terms when revenue-sharing splits are not satisfactory. Finally, the empirical evidence before and after the introduction of revenue sharing suggests that fixed-fee terms continue to be offered to all firms, and that fixed-fee prices do not change after the introduction of revenue sharing.

3 Motivation and Data Summary

In this section, I describe a new dataset on firms in the video rental industry. This description is followed by some summary statistics on revenue-sharing and fixed-fee contracts, paying attention to differences in firms' choices and outcomes across the two contractual forms.

3.1 Data Description

The data for this study are provided by Rentrak Corporation. The use of revenue-sharing contracts requires extensive computer monitoring of transactions in order to enforce the

[9] Stores using Rentrak account for over 6,000 stores, with an additional 4,000 stores belonging to Blockbuster, Inc. and other large chains also wired for revenue sharing.

revenue-sharing payments. Independent retailers, as well as many large retail chains, rely on Rentrak as a central source for the provision of these monitoring services. Rentrak also negotiates contractual terms with upstream firms on their clients' behalf. Over 10,000 retailers used Rentrak between 1998 and 1999, accounting for over half of all retailers in the industry. Blockbuster Video and Hollywood Video comprise about 4,000 of these retailers, and I do not observe their transactions.[10] I observe 6,594 retailers, ranging in size from single-store locations to a chain with 1,147 locations. Of these 6,594 retail locations, I am able to match 5,895 stores with local demographic and phone book data.

For these 5,895 stores, I observe transaction data for 104 weeks between January, 1998 and December, 1999. These stores represent about 30 percent of all stores in the industry. I discard observations for titles released after July 1999, so that rental activity for each title is tracked for at least 6 months. The data may be organized according to the frequency with which I observe each variable. At the store level, I observe location at the county, zip code, and Designated Market Area (DMA) level.[11] I 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. I 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.

For each title, I observe the number of titles released in the same month, and a box-office category. The box-office categories are denoted as A, B, C, or D. Titles in the A category have theatrical box-office revenues of more than $40 million, and titles in the B and C categories 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 I exclude these titles in the analysis. The analysis is conducted for the 1,114 titles in the data that had a previous theatrical release.

At the store-title level, I observe the type of contract chosen by the retailer (when

[10] Blockbuster Video does not release their data, and only process some titles through Rentrak's system. Hollywood Video recently settled a lawsuit with Rentrak involving a dispute over data integrity.

[11] Designated Market Areas organize the United States according to the coverage areas of broadcast television.

more than one option is available) and the number of tapes purchased.[12] Transactions are recorded weekly for each store-title combination. Thus, transactions data are store-title-week triples. These data provide average weekly prices and total weekly quantities of rental transactions for all titles over the two year period. The same information is provided for the sales of each title.

The Rentrak dataset is an especially rich source of information on firm behavior. However, Rentrak cannot provide information on local competitive conditions facing each store in the database. In order to observe (or at least proxy) for local competitive conditions, I use Yellow Pages listings for all video retail stores in the United States, including Blockbuster stores, for 1998 and 1999. From these data, I identify the number of competing video retail stores (and the number of Blockbuster stores separately) within the same zip code of each observed store in the Rentrak database. This additional information helps to distinguish between the competitive conditions facing different observed retailers. Finally, I utilize US Census data on the demographic characteristics of each zip code. Demographic data include the number of people, median income, and marginal distributions of race, education, age, gender, employment, family status, and the level of urbanization in each zip code. These three data sources are merged by zip code. When estimating the model, I define a local market as a zip code area and use the merged data to characterize local market conditions.

3.2 Summary Statistics

Tables 1 - 3 and 4 - 6 examine differences between titles taken by stores on revenue-sharing versus fixed-fee contracts for A, B, and C titles, respectively. Tables 1 - 3 examine differences between stores that choose different pricing contracts for the same title. Tables 4 - 6 examine differences between titles on fixed-fee versus revenue-sharing terms within a store.

Differences Between Stores for the Same Title

The first panel of Tables 1 - 3 shows differences in store and market characteristics between stores accepting fixed-fee contracts and stores accepting revenue-sharing contracts for the same title. Table 1 provides information for the 23 A titles released during 1998 and 1999 for which stores had a choice of contract. Tables 2 and 3 provide information for the 35 B titles and the 1,055 C titles respectively. Stores accepting fixed-fee contracts

[12] Fixed-fee contracts are offered on all titles, although some distributors do not offer revenue-sharing terms until after 1999. Titles for which only fixed-fee terms are offered are not currently used in the analysis.

tend to be correlated with demographic variables associated with higher levels of rental demand. For example, stores on fixed-fee contracts tend to have more households and more people between the ages of 25 and 39, which is an active rental population. Differences in demographics are not strongly significant across the two groups of stores, although the difference is positive for all variables, and for all three categories of titles.

Competitive conditions do not differ significantly, except in the case of B titles, where stores accepting fixed-fee contracts tend to face fewer competitors. There are no significant differences in the presence of competing Blockbuster retailers between the groups of stores. Store size differs significantly between the two groups. Stores choosing revenue-sharing are significantly smaller than those accepting fixed-fee, and they carry a greater variety of titles.

The second panel of Tables 1 - 3 shows differences in inventories, rental activity, and profits for the two groups of stores. Inventories are significantly different between the two groups. Stores choosing revenue-sharing contracts purchase approximately twice as much inventory as their fixed-fee counterparts for the same title. However, rental activity is not significantly different despite the larger inventory levels. Neither retailer nor distributor profits are significantly different between the two groups of stores, except in the case of C titles, where retailers actually appear to be losing money on average under fixed-fee terms, and distributors appear to be better off under fixed-fee terms.

Differences Between Titles Within a Store

Table 4 provides information on the A titles taken by each store. Tables 5 and 6 provide information for the B and C titles taken by the stores, respectively. The first panel of Tables 4 - 6 shows differences in the revenue-sharing contract terms for titles taken under fixed-fee terms, and titles taken under revenue-sharing terms within each store. If a revenue-sharing contract is taken by the retailer, these are the actual terms of the contract. If a fixed-fee contract is accepted, then the retailer is assumed to pay a fixed-price of \$70 per tape with no inventory restrictions. In this case, the revenue-sharing terms reflect the terms a retailer would have faced if he had accepted revenue-sharing terms. There is little variation in both the upfront fee and the portion of revenue kept by the retailer within each of the three movie categories. The variation that does exist is variation across studios: in particular, one studio charges an upfront fee of \$10.30 rather than \$8.30 for A and B titles. Much larger variation is seen for minimum and maximum inventory requirements. The A and B titles that are taken on revenue-sharing terms display lower minimum inventory requirements

and higher maximum inventory requirements, although the differences are not significant. The inventory restrictions are often binding under revenue-sharing terms: between 34 and 42 percent of titles are taken at the minimum inventory level, and between seven and 14 percent of titles are taken at the maximum inventory level.

The second panel of Tables 4 - 6 shows differences in inventories, rental activity, and profits for the two groups of titles. Inventories are approximately three times higher for titles taken on revenue-sharing terms. Rentals are also higher for revenue-sharing titles, but by a smaller amount than the increase in inventory, roughly 1.5 times. Both retailer and distributor profits are higher for titles under revenue-sharing terms than titles under fixed-fee contracts.

If the contractual form associated with different store-title pairs were randomly assigned, then computing the effect of revenue-sharing contracts would be straightforward, given the level of detail in the dataset. One could estimate the average effect of revenue sharing on retailer and distributor profits simply as the difference between average firm profits under fixed-fee terms and average firm profits under revenue-sharing terms. Of course, contractual form is not randomly assigned; retailers optimally choose contracts on the basis of some unobserved heterogeneity. Thus, a simple difference between the average "accounting" profits for firms that chose fixed fee and firms that chose revenue sharing is a biased estimate of the effect of the contractual change. Furthermore, simply computing the difference in profits for the two groups of store-title pairs does not help us to understand why some retailers are constrained by inventory minimums or maximums, or why upstream firms set these inventory restrictions.

4 A Theoretical Model of Firm Behavior

In this section, I develop a theoretical model of firm behavior that incorporates the details of the contractual environment facing video retailers, and rationalizes the use of inventory restrictions. Using the data described above, I estimate the parameters of this model in the next section. The primary motivation for developing the theoretical model is two-fold. First, simple accounting measures of the effect of revenue-sharing contracts are biased because of the endogeneity problems discussed above. An important role of the theoretical model is to provide a complete description of the data generating process, including a role for unobserved heterogeneity in firms' contract choices. Second, the data on their own do

not shed light on the reasons for implementing inventory restrictions in revenue-sharing contracts. The second role of the theoretical model is to clarify the purpose of inventory restrictions. The variation in these restrictions across store size and products, and the lack of variation in the upfront fee and revenue-split, suggests that upstream firms pay considerable attention to setting these restrictions.

4.1 A Single Downstream Market

To simplify discussion of the model, I first consider a monopolistic upstream firm producing one product that is sold in a single downstream market. I extend the model to many downstream markets in the next section. Each unit of inventory of a particular title is produced at a small constant marginal cost. I specify a linear demand function for rentals in the market as

$$Q = V - \eta p \tag{1}$$

where V is a measure of the title's appeal in this market, p is the market price, and Q is the quantity of rentals in the market.

Profit-Maximization for the Vertically-Integrated Firm

As a baseline comparison, I examine the profit-maximization problem for a vertically-integrated upstream monopolist. A vertically-integrated firm chooses the price and quantity of rentals that maximize total industry profits. Let the marginal cost of producing a unit of inventory be denoted as l. Then the maximum industry profit, and the profit achieved by a vertically-integrated firm, is

$$\max_{\{Q,C\}} \pi_s^{VI} = pQ - lC = \left(\frac{V}{\eta}Q - \frac{1}{\eta}Q^2\right) - lC \tag{2}$$

where the market-clearing price, p, is given by the inverse demand function, Q is the market supply of rentals, and C is inventory. The relationship between inventory and the quantity of rentals is given by

$$Q = min(V - \eta p, \tau C) \tag{3}$$

where the quantity of rentals is limited by a technological constraint on the number of rentals produced per unit of inventory, τ. Thus, for a given τ, the firm's inventory decision

determines the maximum number of rentals produced.[13] In order to minimize cost, the upstream firm will not carry extra inventory, and Q will exactly satisfy the equation $Q = \tau C$. Under this assumption, one can re-write equation 2 as a function of C alone:

$$\max_{\{C\}} \pi_s^{VI} = \left(\frac{V\tau}{\eta} C - \frac{\tau^2}{\eta} C^2 \right) - lC. \tag{4}$$

First-order conditions for equation 4 give the inventory level, C_{VI}^*, that maximizes industry profits.

$$C_{VI}^* = \frac{1}{2\tau} \left(V - \frac{l\eta}{\tau} \right). \tag{5}$$

The use of fixed-fee or revenue-sharing contracts are irrelevant for the vertically-integrated monopolist, as C^* depends only upon market demand conditions (V, η), the marginal cost of producing inventory (l), and technology (τ). In a vertically-separated industry, however, the upstream firm does not directly choose inventory for the industry. Instead, the upstream firm sets contractual forms and terms, and downstream firms choose inventory based on these terms. Under fixed-fee terms, the upstream firm sets a wholesale price, F. Under revenue-sharing terms, the upstream firm sets two contractual terms: a revenue-sharing component, γ, and an upfront fee per tape, u.

4.1.1 Retailers' Profit-Maximization

Downstream firms observe the contractual terms set by the upstream firm, (F, u, γ), select the optimal contract, and choose inventory to maximize retailer profit. I assume that downstream firms are symmetric. Retailers observe market demand and compete with (N-1) identical retailers in a Cournot fashion. The same relationship between inventory and the quantity of rentals holds for all retailers, so τ is constant across retailers and markets. Total revenues for firm i are given by:

$$q_i p = (\tau c_i) p = (\tau c_i) \frac{1}{\eta} \left(V - \tau \sum_{k=1}^{N} c_k \right).$$

[13] Naturally, one might worry that the relationship between inventory and rentals results from a more sophisticated model of rental activity in which retailers choose not only inventory and price, but also stock-out rates and the length of the rental period. The current model is equivalent to viewing one unit of inventory (a video tape) as a "box" of τ rentals. Generalizations of the relationship between inventory and rentals are discussed in the empirical section, and will be incorporated in future versions of the paper.

Retailer i maximizes profits by choosing a contractual form, $I(RS)$, and inventory level, c_i. The indicator variable $I(RS)$ takes the value one if a revenue-sharing contract is chosen, and zero if a fixed-fee contract is chosen. The retailer chooses $I(RS)$ and c_i to solve the problem

$$\max_{\{I(RS),c_i\}} I(RS)\pi_i^{RS}(c_i) + (1 - I(RS))\pi_i^{FF}(c_i) \tag{6}$$

Given the optimal inventory decision of the retailer under each contractual form, one can compute retailer profits under both contracts. The retailer then chooses the contractual form and inventory decision that maximizes profits. Profits under the fixed-fee contract for retailer i are

$$\pi_i^{FF}(c_i) = \frac{V\tau}{\eta}c_i - \frac{\tau^2}{\eta}c_i\sum_{k=1}^{N} c_k - Fc_i$$

where F is the fixed-fee or wholesale price per tape set by the upstream firm. Under revenue-sharing terms, retailer i's profits are

$$\pi_i^{RS}(c_i) = \gamma\left(\frac{V\tau}{\eta}c_i - \frac{\tau^2}{\eta}c_i\sum_{k=1}^{N} c_k - uc_i\right)$$

where γ is the percentage of revenue (less costs) remaining with the retailer, and u is the upfront fee paid by the retailer to the manufacturer per unit of inventory under revenue-sharing terms.[14] I assume the downstream firm incurs no cost to produce a rental from a unit of inventory.

Solving for the symmetric equilibrium choice of c_i gives

$$c_{i,FF}^{*} = \frac{1}{(N+1)\tau}\left(V + N_{RS}u\tau + N_{FF}F\tau - N\frac{F\eta}{\tau}\right). \tag{7}$$

where N_{RS} denotes the number of competing firms choosing a revenue-sharing contract and N_{FF} denotes the number of competing firms choosing a fixed-fee contract. The cost per tape for firm i is given by w_i which equals F when a fixed-fee contract is chosen and equals u when firm i chooses a revenue-sharing contract.

[14]Revenue-sharing contracts are often written as if revenue payments are made on the basis of revenue, not revenue less costs. However, retailers are typically allowed to cover costs by selling inventory at the end of the pre-determined rental period, or by keeping all revenues from rentals generated after the rental period if the tape is not sold. These activities are not explicitly modeled here. Instead, I model the revenue-sharing payments as being applied to revenues after costs have been covered.

One can show that multiple equilibria may exist with respect to firms' contract choices. These may include a pure strategy revenue-sharing contract equilibria, a pure strategy fixed-fee contract equilibria, or an asymmetric pure strategy contract equilibria, depending on the values of the demand parameters and the number of downstream firms.

In the restrictive case in which firms are assumed to be in either a pure strategy revenue-sharing contract equilibria or a pure strategy fixed-fee contract equilibria the choice of contract is determined by the relative level of demand in a market. In these equilibria, equation 7 reduces to $c^*_{i,FF}$ and $c^*_{i,RS}$ under the two contracts with inventory given by

$$c^*_{i,FF} = \frac{1}{(N+1)\tau}\left(V - \frac{F\eta}{\tau}\right) \qquad c^*_{i,RS} = \frac{1}{(N+1)\tau}\left(V - \frac{u\eta}{\tau}\right). \tag{8}$$

with market inventory under the two contractual forms equal to

$$C^*_{FF} = \frac{N}{(N+1)\tau}\left(V - \frac{F\eta}{\tau}\right) \qquad C^*_{RS} = \frac{N}{(N+1)\tau}\left(V - \frac{u\eta}{\tau}\right). \tag{9}$$

Retailers choose the pricing contract that maximizes their profits. Solving the retailer's profit equation, one finds that retailers choose fixed-fee terms whenever V exceeds V^*, defined as

$$V^*(\tau, \eta, F, u, \gamma) = \frac{\eta(F - \gamma u + \sqrt{\gamma}(F-u))}{(1-\gamma)\tau}. \tag{10}$$

The retailer's contractual choice depends critically on the relative contract terms, F, u, γ, and the demand conditions, η and τ. A higher fixed-fee price, F, or a shorter technological "lifespan" of a unit of inventory, τ, increases V^*, implying that retailers in a market with a higher draw of V will accept revenue-sharing contracts. On the other hand, increasing the upfront fee, u, or decreasing the percentage of revenues kept by the retailer, γ, reduces V^*. Importantly, for a given set of contractual terms, firms with higher draws of V accept fixed-fee terms, while firms with low draws of V accept revenue sharing.

4.1.2 The Upstream Firm's Profit-Maximization

The upstream firm takes the retailers' decisions as given and maximizes profit according to the following relationship:

$$\max_{\{F,u,\gamma\}} \sum_{k=1}^{N} \left[\rho(F,u,\gamma)\pi_s^{RS}(u,\gamma) + (1-\rho(F,u,\gamma))\pi_s^{FF}(F)\right] T_i + \pi_s^{FF}(F)(1-T_i) \mid \tau, \eta, N, V, T \tag{11}$$

where the probability that retailer i chooses revenue sharing is ρ, and the probability that retailer i chooses fixed fee is $(1-\rho)$. The term T_i is an indicator for whether or not the retailer is technologically equipped to implement revenue-sharing contracts. If the firm cannot implement revenue sharing, they can only choose fixed-fee terms. The upstream firm's profit when retailer i chooses revenue sharing is given by π_s^{RS} and its profit when retailer i chooses fixed fee is given by π_s^{FF}. For example, when all retailers choose revenue-sharing contracts, studio profits are

$$\pi_s^{RS}(u,\gamma) = (1-\gamma)\sum_{i=1}^{N}\left(\frac{V\tau}{\eta}c_i - \frac{\tau^2}{\eta}c_i\sum_{k=1}^{N}c_k - uc_i\right) + (u-l)\sum_{i=1}^{N}c_i \tag{12}$$

When all retailers choose fixed-fee contracts, studio profits are

$$\pi_s^{FF}(F) = (F-l)\sum_{k=1}^{N}c_k \tag{13}$$

Profit-Maximization in the Absence of Revenue-Sharing

Suppose that revenue-sharing is not a feasible contractual form, perhaps because the transactions costs of monitoring a revenue-sharing contract are too high. In the absence of revenue-sharing, the upstream firm maximizes profits according to equation 13.

If the upstream firm could induce the downstream retailers to stock the same level of inventory as the vertically-integrated firm, it would need to set F such that C_{VI}^* from equation 5 equaled C_{FF}^* from equation 9. The fixed-fee price that equates these inventory choices is

$$F_{VI} = \frac{(N-1)\tau V}{2N\eta} + \frac{(N+1)l}{2N}. \tag{14}$$

However, the profit-maximizing fixed-fee price for the vertically-separated upstream firm is the F^* that solves equation 13, given by

$$F^* = \frac{\tau V}{2\eta} + \frac{l}{2} \tag{15}$$

Comparing equations 14 and 15 illustrates the double-marginalization problem facing the upstream firm. As $N \to \infty, F_{VI} \to F^*$. In this case, F^* achieves the maximum level of industry profits, and satisfies a zero-profit condition for downstream retailers. There is no need to use revenue-sharing terms to induce the correct inventory choices. However, when $N = 1, F_{VI} = l$ and $F^* > F_{VI}$. Charging $F^* > F_{VI}$ reduces the inventory held by a monopolistic downstream retailer, and achieves less than the maximum level of industry profits.

Equations 14 and 15 illustrate the fact that for finite N, fixed-fee pricing contracts face a double-marginalization problem. The upstream firm cannot achieve the maximum level of industry profits because a wedge between the price charged to the retailer (F^*) and the marginal cost of producing the product (l) induces downstream firms to hold too little inventory and charge too high a price for renting the tape. Revenue-sharing terms can circumvent this problem by reducing the cost per tape and taxing subsequent rental revenues.

Profit-Maximization Under Revenue-Sharing Contractual Terms

Revenue sharing solves the double-marginalization problem for downstream markets with N firms. If the upstream firm can induce the downstream retailers to stock the same level of inventory as the vertically-integrated firm, it would need to set (u, γ) such that C^*_{VI} from equation 5 equals C^*_{RS} from equation 9. As in equation 14, the upfront fee that achieves this result is given by:

$$u_{VI} = \frac{(N-1)\tau V}{2N\eta} + \frac{(N+1)l}{2N} \tag{16}$$

which induces downstream retailers to hold the correct level of inventory. The ability of the upstream firm to tax profits through γ implies that the optimal $u^* = u_{VI}$ for any value of γ. Setting retailers' portion of revenue, γ, equal to zero satisfies a zero-profit condition for the downstream firms. However, setting γ equal to zero will also induce them to reject revenue-sharing terms and accept a fixed-fee contract. Thus, one expects the upstream firm to set $\gamma > 0$, such that the downstream retailers are at least as well off as they would have been under fixed-fee terms. Both the upstream and downstream firms benefit from revenue sharing because revenue sharing allows the firms to attain the maximum level of industry profits. Thus, all firms can be made better off by these terms.

4.2 Many Downstream Markets

In the previous section, it is shown that fixed-fee pricing results in a double-marginalization problem when downstream markets are not perfectly competitive. Revenue sharing eliminates the double-marginalization problem by transferring inventory at $u^* = u_{VI}$ (given by equation 16) and taxing subsequent revenues. When downstream markets are perfectly competitive, however, both fixed-fee pricing and revenue sharing induce the efficient level of inventory and prices. Furthermore, the upstream firm captures all rents in such markets, under either contractual form. A situation in which fixed-fee pricing does not induce efficient inventory holdings in perfectly competitive downstream markets occurs when multiple, heterogeneous downstream markets exist, but the upstream firm is not allowed to charge a different wholesale price in each market. Consider the upstream firm's profit-maximization problem in the absence of revenue sharing when M downstream markets exist. The profit function is:

$$\pi_s^{FF}(F) = (F - l) \sum_{m=1}^{M} \frac{N_m}{(N_m + 1)\tau} \left(V_m - \frac{F\eta}{\tau} \right) \tag{17}$$

First order conditions for equation 17 give the optimal wholesale price:

$$F^* = \frac{\tau \sum_{m=1}^{M} \frac{N_m V_m}{(N_m+1)}}{2\eta \sum_{m=1}^{M} \frac{N_m}{(N_m+1)}} + \frac{l}{2} \tag{18}$$

The studio would like to charge a different F_m^* for each of the M markets, but is constrained to charge the same price to all retailers. The optimal F^* in equation 18 is a weighted average of the set of F_m^* that would be charged in each market if perfect price discrimination were possible. The weights assigned to the optimal individual market depend on the competitive conditions in the individual markets.

When multiple markets exist, it is possible that some markets understock and some markets overstock inventory, relative to the efficient, vertically-integrated firm's inventory choice. For example, consider two markets with many firms ($N_1 \to \infty$ and $N_2 \to \infty$). Market 1 has $V_1 = V_l$ and market 2 has $V_1 = V_h$, where $V_h > V_l$, and the marginal cost of producing a unit of inventory is zero. The upstream firm has set F^* according to equation 18, so

$$F^* = \frac{\tau(V_l + V_h)}{4\eta}$$

The vertically-integrated firm chooses to stock

$$c_1^{VI} = \frac{1}{2}V_l \qquad\qquad c_2^{VI} = \frac{1}{2}V_h$$

The vertically-separated firms choose

$$c_1^{VI} = \frac{1}{4}(3V_l - V_h) \qquad\qquad c_2^{VI} = \frac{1}{4}(3V_h - V_l)$$

Firms in the low-value market, market 1, understock because F^* is relatively too high, while firms in the high-value market, market 2, overstock because F^* is relatively too low.

Under revenue-sharing terms, $u^* = u_{VI}$. However, setting u^* optimally still depends on V and N in the downstream market. Recall u^* from equation 16:

$$u^* = u_{VI} = \frac{(N-1)\tau V}{2N\eta} + \frac{(N+1)l}{2N}$$

With multiple downstream markets, u^* is optimally set at

$$u^* = \frac{\tau \sum_{m=1}^{M} \frac{(N_m-1)V_m}{N_m}}{2\eta} + \frac{l \sum_{m=1}^{M} \frac{(N_m+1)}{N_m}}{2} \tag{19}$$

Note that u^* is a weighted average of the set of optimal u_m^* that the upstream firm would like to charge in each individual downstream market. Similarly, γ^* will be set to induce retailers in some "average" market to accept revenue sharing.

Equation 19 illustrates the potential for both under- and over-stocking in individual markets under revenue sharing, relative to the vertically-integrated firm's choice of inventory in each market. Individual markets are differentiated by two features: their size (V_m) and their competitive conditions (N_m). The size of a market could depend upon the number of customers in the market as well as the appeal of the product in that market. The competitive conditions are given by the number of symmetric retailers in a market, and I assume the retailers compete in a Cournot fashion.

I consider the role of revenue-sharing in three cases. In the first case, V varies across markets, but the number of firms in a market is held constant, so $N_m = \overline{N} \ \forall \ m$. This example is similar to the first model of Dana & Spier (2000), in which variation in market conditions is generated by uncertainty in the demand conditions in a perfectly-competitive market, rather than by the existence of multiple, heterogenous markets. In this case, I find that revenue sharing helps, but cannot achieve the maximum level of industry profits

when N is finite and demand conditions are not perfectly elastic. A single pair of quantity requirements (a single minimum and maximum for all markets) can increase the upstream firm's profits. In the second case, V is the same across markets, so $V_m = \overline{V}\ \forall\ m$, but the number of downstream firms varies across markets. Again, it is shown that revenue-sharing is an improvement over fixed-fee contracts, but does not achieve the maximum potential level of industry profits. A single pair of quantity requirements can be difficult to implement in this case. In the third and final case, both V and N vary across markets. In this case, revenue-sharing also increases the upstream firm's profits, but still results in over- and under-stocking. Stipulating minimum and maximum purchase requirements allows the upstream firm to further increase profits. In addition, the upstream firm now benefits by conditioning quantity requirements on store size. I discuss the first case at length here. The remaining two cases are discussed in Appendix A.

4.2.1 The Use of Quantity Requirements when V Varies

The revenue-sharing terms that induce the efficient level of inventory in each market are given by u^* in equation 16. With multiple downstream markets, the best the upstream firm can do is to set a single revenue-sharing contract, with terms given by equation 19. If $N = \overline{N}$ in all markets, then equation 19 reduces to

$$u^* = \frac{(\overline{N}-1)\tau E(V)}{2\overline{N}\eta} + \frac{(\overline{N}+1)l}{2\overline{N}} \tag{20}$$

When $\overline{N} = 1$, transferring inventory at marginal cost induces a downstream monopolist to charge the correct price and carry the efficient level of inventory in the average market. When $\overline{N} > 1$, however, competitive retailers would choose to overstock relative to the vertically-integrated firm's choice of inventory. Setting u^* as in equation 20 eliminates over- and under-stocking for the market with $V = E(V)$ and $N = \overline{N}$.[15]

If V varies across markets, equation 20 shows that one expects over- and under-stocking in all but the average market. In particular, for markets with high draws of V_m, u^* will be relatively too low, and firms in these high-value markets will overstock. For markets with low draws of V_m, u^* will be set relatively too high, and firms in these markets will understock. The under- and over-stocking problem under revenue-sharing terms is analogous to the

[15]For the remainder of the paper, over- and under-stocking refer to inventory choices relative to the vertically-integrated firm's choice of inventory, which maximizes industry profits.

under- and over-stocking problem laid out in the discussion of fixed-fee pricing in multiple, heterogenous downstream markets. As shown in this example, revenue sharing requires a positive upfront fee in excess of marginal cost ($u^* > l > 0$) to avoid excessive price competition, unless $\overline{N} = 1$.

This leads to two questions: first, what can the upstream firm do to reduce inefficiencies in inventory levels, and second, why can the upstream firm not implement the same strategies in fixed-fee contracts? In order to reduce inefficiencies in inventory levels, the upstream firm can set quantity restrictions in the revenue-sharing contract. Consider the highest-value market, V_h. Each market has $N = \overline{N}$ firms, and u^* has been set to induce the correct inventory levels in the average market. Thus, u^* is given by equation 20. This u^* induces firms in the average market to stock the efficient level of inventory, which is

$$C^*_{\overline{V}}(u^*) = \frac{\overline{V}}{2\tau} - \frac{l\eta}{2\tau^2}.$$

However, firms in the market with $V = V_h$ stock

$$C_{V_h}(u^*) = \frac{\overline{V}}{2\tau} - \frac{l\eta}{2\tau^2} + \frac{\overline{N}(V_h - \overline{V})}{(\overline{N}+1)\tau}$$

which is greater than the efficient level of inventory for the high-value market,

$$C^*_{V_h} = \frac{V_h}{2\tau} - \frac{l\eta}{2\tau^2}. \tag{21}$$

The difference between $C_{V_h}(u^*)$ and $C^*_{V_h}$, and the extent of overstocking in the high-value market, is given by

$$(C_{V_h}(u^*) - C^*_{V_h}) = \frac{(\overline{N}-1)(V_h - \overline{V})}{2(\overline{N}+1)\tau} \tag{22}$$

The number of firms is the same in all markets, so the upstream firm can mitigate this problem by setting a single maximum quantity for all retailers of $c_{max} = C^*_{V_h}/\overline{N}$ in order to prevent overstocking in the highest value market. In fact, depending on the distribution of V, the upstream firm may choose to set $c_{max} < C^*_{V_h}/\overline{N}$, creating understocking in the highest-value market, but reducing overstocking in other markets with $V_m \in [\overline{V}, V_h]$. Similarly, if the lowest value market has $V = V_l$, the upstream firm can set $c_{min} \geq C^*_{V_l}/\overline{N}$, which is the minimum amount of inventory the upstream firm wants retailers to hold in the lowest-value market. Recall that firms in the highest-value market pay too low an upfront

fee, and keep too high a percentage of revenue. Similarly, firms in the lowest-value market pay too high an upfront fee, and keep too little of subsequent revenue. Thus, when setting c_{min} and c_{max}, the upstream firm must take into account the potential effects of the quantity requirements on firms' contract selections and possible exit from the industry. By now, the upstream firm is solving a more complicated problem than the problem in equation 11. The upstream firm's profit maximization problem, taking into account the ability to set a single pair of quantity requirements, (c_{min}, c_{max}), is:

$$\max_{\{u,\gamma,c_{min},c_{max}\}} \rho(u,\gamma)\pi_s^{RS}(u,\gamma,c_{min},c_{max}) + (1-\rho(u,\gamma))\pi_s^{FF} \mid F,\tau,\eta,\overline{N},f(V) \tag{23}$$

At this point, I have only addressed the use of a single pair of quantity requirements: a uniform minimum and maximum quantity for all retailers. Clearly, this increases the upstream firm's profits relative to revenue-sharing terms with no quantity requirements. Empirically, however, one observes quantity requirements that vary by store size. Consider defining store size in market m as $V_m/\overline{N}$. Retail firms are assumed to be symmetric, so all stores in market m are the same size. Recall that for all markets with $V_m < \overline{V}$, understocking occurs because u^* is set uniformly. All markets with $V_m > \overline{V}$ overstock inventory for the same reason. By conditioning quantity requirements on store size, the upstream firm can induce the vertically-integrated inventory levels in each market because store size is perfectly correlated with V_m. Only a minimum quantity requirement is necessary for small stores, and only a maximum quantity requirement is necessary for large stores. Essentially, conditioning quantity requirements on store size allows the upstream firm to perfectly set C_m^* in each market.

Finally, why can the upstream firm not achieve the same results for fixed-fee pricing contracts when V varies? The salient impediment to imposing quantity restrictions in the fixed-fee contract is a practical one: retailers on fixed-fee contracts have the flexibility to resell inventory to other retailers, and inventory under these contracts is not monitored or controlled by the upstream firm in any way. One of the principle advantages of revenue sharing is precisely the ability to monitor inventory and fine-tune retailers' inventory choices in doing so.

In this section, I considered the usefulness of revenue sharing when market size varied, but competitive conditions, given by the number of stores, N, did not vary. It was shown that revenue-sharing increases the upstream firm's profits while leaving the downstream

firms just as well off. Revenue-sharing terms (u, γ) alone cannot achieve the maximum industry profits, but revenue sharing combined with quantity requirements achieve the highest attainable profit for the upstream firm. Allowing quantity requirements to vary by store size essentially allows the upstream firm to perfectly discriminate across markets. In Appendix A, I show that a similar result holds when only N varies. I also examine the case when both V and N vary. In this case, it is not possible for the upstream firm to perfectly discriminate across markets. However, by stipulating a pair of quantity requirements (a minimum and maximum) for each store size, the upstream firm can still increase profits.

5 Estimation

This section describes the estimation procedures and relates them to the behavioral model. The behavioral model gives specific predictions linking firms' contract and inventory choices to the competitive conditions and demand conditions in their markets. Specifically, these predictions relate the technology parameter (τ) and demand parameters (η and the parameters of the probability density function of V) to firms' contract and inventory choices. I use four principal equations from the behavioral model to generate a set of moment conditions that summarize the relationships between predicted parameter values and observed contract and inventory choices at the store-title level. The behavioral model assumes that all downstream retailers are identical; for estimation purposes, stores in a given market are assumed to be identical after conditioning on observable store characteristics.[16] Furthermore, I assume that the unobserved downstream retailers choose the same contract as the observed firm.[17] A market is defined as a zip code area, with approximately 24,000 people and 2.6 video retail stores in the average market.[18]

Data include the quantity and price of rentals (q and p), contract choice (RS), inventory (c), cost per unit of inventory (the upfront fee under revenue-sharing terms, u, or the wholesale price under fixed-fee terms, F), revenue-splits (γ), the number of retailers in each market (N), and a set of demographic and store characteristics (X). I do not observed

[16] This represents a strong simplifying assumption that no unobserved heterogeneity exists among stores within a market.

[17] One could consider generalizing the model somewhat to allow for and estimate probabilities of alternative equilibria in which the unobserved retailers in a market choose different contracts than the observed firm. I leave this to future work.

[18] Imposing this market definition allows me to observe the number of competitors faced by different retailers. I discuss more flexible specifications later in this section that would allow me to relax this assumption.

actual prices paid under fixed-fee terms, which could reflect additional volume discounts or bonus inventory from "copy-depth" programs. I provide evidence on the importance of this assumption in the section on robustness tests. I denote the full set of data as $Z = (q, p, RS, c, u, F, \gamma, N, X)$, where an observation is a store-title pair. Price is calculated as the average price over all weeks and quantity is given by the total number of rentals over all weeks. The data are used to estimate the set of parameters $\Theta = (\tau, \eta, \beta, \sigma_v, \sigma_\epsilon)$, where τ and η correspond to the parameters of the behavioral model, β and σ_v are parameters of the distribution of V, and σ_ϵ is the standard deviation of measurement error in inventory. I treat all store-title pairs as independent. A more general model could allow for correlations between titles for the same store, between stores for the same title, or between stores located in the same area.

The first moment condition is given by $E(q - \tau c) = 0$ and is generated from the technology equation (equation 3) of the behavioral model. The second moment condition is given by $E(\eta p + Nq - g_0(X, \Theta)) = 0$ and is associated with the demand equation (equation 1) from the behavioral model. Market level quantity, Q in equation 1, is calculated empirically as the number of firms (N) multiplied by the observed quantity of the representative store in the dataset (q). The conditional expectation of V is denoted here as $g_0(X, \Theta)$. In calculating $g_0(X, \Theta)$, I assume that V is distributed lognormally, with $\ln V \sim N(X'\beta, \sigma_v^2)$. Thus, V has expectation $g_0(X, \Theta) = e^{(X'\beta + \sigma_v^2/2)}$ and variance $e^{(2X'\beta + \sigma_v^2)}(e^{\sigma_v^2} - 1)$.

The remaining four moment conditions use the retailers' supply and profit equations (equations 6 and 8 respectively) to compute the conditional expectations of retailers' inventory and contract choices. First, consider the conditional expectation of RS, which is the probability that revenue-sharing terms are chosen by a retailer for a particular title. The retailer profit equation predicts that retailers with high market valuations for a title will not choose revenue-sharing terms. Specifically, retailers with $V > V^*(\tau, \eta, F, u, \gamma)$ will choose fixed-fee terms, where $V^*(\tau, \eta, F, u, \gamma)$ is defined in equation 10. Thus, the third moment condition is given by $E(RS - \int_0^{V^*(\tau,\eta,F,u,\gamma)} \frac{1}{\sqrt{2\pi}\sigma_v V} \exp -[(\ln V - X'\beta)^2]/(2\sigma_v^2)\, dV) = 0$, and comes directly from the retailer's profit equation in the behavioral model.

The behavioral model assumes that downstream retailers are identical, and thus predicts that all firms in the same market will choose the same contractual form for a given title. When estimating the model, however, I do not impose this restriction within a zip code market. Each store-title pair is treated as an independent observation and the expectation

of V is a function of both market and store characteristics.

Finally, retailers' inventory decisions are predicted by equation (8). The remaining three moments are of the form $E((c - E(c \mid u, F, \gamma, N, X, \Theta, RS = 1)) \cdot X \cdot RS) = 0$, $E((c - E(c \mid u, F, \gamma, N, X, \Theta, RS = 0)) \cdot X \cdot (1 - RS)) = 0$, and $E(c^2 - E(c^2 \mid u, F, \gamma, N, X, \Theta)) = 0$, where the conditional expectation of c is given by the retailer's supply equation in the behavioral model, equation 8. This equation again involves the unobserved V, so the three moment conditions here are based on the expectation of the lognormal distribution of V. The functions $g_1(X, \Theta)$ and $g_2(X, \Theta)$ give the expectation of V after conditioning on market and store characteristics and the observed contract choice, RS. The empirical moment conditions are written as $[(c - \frac{1}{(N+1)\tau}(g_1(X, \Theta) - \frac{\eta u}{\tau}))X \ RS]$ and $[(c - \frac{1}{(N+1)\tau}(g_2(X, \Theta) - \frac{\eta F}{\tau}))X \ (1 - RS)]$.

If only one pricing contract were available, calculating the expectation of V for each moment condition would be straightforward, based on the assumption of a lognormal distribution for V. Conditional on retailers having a choice of contracts, however, the distribution of V is truncated from below for titles taken on fixed-fee terms, and truncated from above for titles taken on revenue-sharing terms, as indicated in the retailer's profit function, equation 6 in the behavioral model. The truncation point is equal to $V^*(\tau, \eta, F, u, \gamma)$, which can be estimated. This gives the conditional expectation of V in the fourth and fifth moment conditions respectively as

$$\begin{aligned} g_1(X, \Theta) &= E(V \mid RS = 1, X) = E(V \mid V < V^*, X) \\ &= \exp(X'\beta + \sigma_v^2/2)\frac{\Phi((\ln V^* - X'\beta)/\sigma_v) - \sigma_v)}{\Phi((\ln V^* - X'\beta)/\sigma_v)} \end{aligned} \tag{24}$$

$$\begin{aligned} g_2(X, \Theta) &= E(V \mid RS = 0, X) = E(V \mid V > V^*, X) \\ &= \exp(X'\beta + \sigma_v^2/2)\frac{1 - \Phi((\ln V^* - X'\beta)/\sigma_v) - \sigma_v)}{1 - \Phi((\ln V^* - X'\beta)/\sigma_v)} \end{aligned}$$

where Φ denotes the standard normal cumulative density function.

The last moment condition, $E(c^2 - E(c^2 \mid u, F, \gamma, N, X, \Theta)) = 0$, also involves the conditional expectations of the unobserved V and V^2. I denote the conditional expectation of V^2 as $g_3(X, \Theta)$, where $g_3(X, \Theta) = \exp(2X'\beta - 2\sigma_v^2)$ because V is lognormally distributed. One final issue is that I allow for measurement error to affect the observed inventory choices. That is, I observe c where

$$c = c^* + \epsilon \tag{25}$$

and $\epsilon \mid c^* \sim N(0, \sigma_\epsilon^2)$. This error allows for dispersion in the relationship between the quantity of rentals and inventory (the τ parameter), but assumes that the error is uncorrelated with the choice of inventory. The measurement error does not affect the calculation of the moment conditions relating c to $E(c \mid Z, \Theta)$, but it does affect the last moment condition, since one must now account for the variance of the measurement error. Thus, the final moment condition is calculated empirically as $c^2 - \frac{1}{(N+1)^2\tau^2}(g_3(X,\Theta) - \frac{2\eta w}{\tau} g_0(X,\Theta) + \left(\frac{\eta w}{\tau}\right)^2) - \sigma_\epsilon^2$ where the payment per unit of inventory, $w = uRS + F(1 - RS)$.

The parameters Θ are estimated using generalized method of moments (GMM) to solve:

$$\Theta = \text{argmin} \left(\sum_i \psi(\Theta, Z_i) \right)' \quad A \quad \left(\sum_i \psi(\Theta, Z_i) \right)$$

where $\psi(\Theta, Z_i)$ is the set of moment conditions and A is a weight matrix. Formally, the moment conditions are $E(\psi) = 0$, where

$$\psi(\Theta, Z_i) \equiv \begin{pmatrix} q_i - \tau c_i \\ \eta p_i - g_0(X_i, \Theta) + N_i q_i \\ RS_i - \int_0^{V^*(\tau,\eta,F,u,\gamma)} \frac{1}{\sqrt{2\pi}\sigma V} \exp -[(\ln V - X_i\beta)^2]/(2\sigma_v^2)\, dV \\ (c_i - \frac{1}{(N_i+1)\tau}(g_1(X_i,\Theta) - \frac{\eta u}{\tau}))X_i \; RS_i \\ (c_i - \frac{1}{(N_i+1)\tau}(g_2(X_i,\Theta) - \frac{\eta F}{\tau}))X_i \; (1 - RS_i) \\ c_i^2 - \frac{1}{(N_i+1)^2\tau^2}(g_3(X_i,\Theta) - \frac{2\eta w}{\tau} g_0(X_i,\Theta) + \left(\frac{\eta w}{\tau}\right)^2) - \sigma_\epsilon^2 \end{pmatrix} \tag{26}$$

The weight matrix A is not chosen optimally as in Hansen (1982). As reported in the section on robustness tests, the results change modestly when Hansen's estimate of A is used. Here, A is chosen to ensure that the parameters τ and η exactly satisfy the first two moment conditions. Thus, the estimation of these parameters is not affected by misspecification of the additional moment conditions generated from the retailers' first order conditions. The construction of the weight matrix and the calculation of standard errors for the estimated parameter values are both discussed in Appendix B.

Two additional issues are worthy of discussion. First, in the structural model of firm behavior, I assume Cournot competition between symmetric firms. The measure of competition here, taken as observable, is the number of video retailers listed in the phone book

for a market. Clearly, one may worry that observing the number of video retailers in a market is not perfectly informative of the competitive conditions in a market. For example, competition may be stronger in a market in which firms are located very close to each other geographically, compared to a market in which the same number of firms are located further apart. More generally, one may worry that despite observing the number of firms in a market, unobservable heterogeneity in the strength of competition across markets may still play an important role in firms' decisions. Introducing unobservable heterogeneity into the model may be accomplished by re-writing the moment conditions as a function of R_i and specifying $R_i = N_i + \zeta_i$. Allowing for two dimensions of unobservable heterogeneity in the moment conditions (V_i and R_i) is computationally more intensive, but is conceptually the same problem as the one solved here.

The second issue is the fact that inventory restrictions are binding for many of the observed store-title pairs taken under revenue-sharing terms. The truncation point given by $V^*(\tau, \eta, F, u, \gamma)$ in equation 10 applies when inventory is chosen optimally. Thus, when a retailer is constrained by inventory minimums or maximums for a particular title, the implied truncation point changes. I incorporate the correct truncation point in these cases, and provide further detail on the truncation adjustments in Appendix B.[19]

6 Estimation Results

The GMM estimation is conducted separately for A, B, and C titles. Table 7 gives the estimated parameters of the distribution of V using a limited set of demographic and store characteristics. Column 1 gives results from estimating the model for A titles. These indicate that store characteristics, and store size in particular, are correlated with V. Comparisons across the two types of movies indicate that store size has a relatively larger effect for B titles than for A titles. Exposure to greater numbers of customers in the store may have a relatively larger effect for these types of titles than for A titles, which receive more extensive national advertising at both the theatrical and video release. Demographic characteristics are only weakly correlated with the estimate of $E(V)$.

The behavioral model excludes cross-title demand elasticities and assumes that firms' profits are additively separable across products. The set of covariates includes a variable identifying the total number of A, B, and C titles purchased by the store between January

[19]The use of simulation methods here can account directly for the inventory restrictions.

1998 and July 1999 for rental. This variable, "Number of Titles," gives some measure of the variety of products offered by the retailer. The results indicate that the effect of this variable on $E(V)$ is not different from zero. However, the presence of endogeneity in retailers' choices of titles limits inference about the true effect of this variable.

Although I do not have data from Blockbuster Video stores, I can identify how many Blockbuster Video stores exist in any given zip code market. Results including the full set of covariates in Table 7 indicate that the presence of a Blockbuster store in a retailer's market has a positive effect on $E(V)$. Industry sources often identify the positive effect as the result of spillovers from Blockbuster's extensive advertising campaigns; Blockbuster increased advertising significantly with the introduction of its own revenue-sharing agreements in early 1998.

Finally, the price coefficient η from Table 7 indicates that a \$1.00 increase in the price of a rental would result in roughly 242 fewer rentals for A titles, 188 fewer rentals for B titles, and 39 fewer rentals for C titles in the average market. Based on the observed average number of rentals and observed average price, the estimated η yields price elasticities for the average market demand curve of roughly -0.5 for A titles, and -0.7 for B titles, and -0.6 for C titles. Price elasticities less than unity result from the fact that the first order conditions of the upstream firm (the movie studio) are not used in estimation. Such price elasticities are possible when downstream firms compete in a Cournot game without imposing upstream monopoly. The fact that the elasticities are low is an indication that video retailing is a relatively competitive industry.

7 Counterfactual Experiments and Welfare Analysis

Based on the parameter values in Table 7, I conduct several counterfactual experiments. Table 8 presents results for A, B, and C titles from three such exercises. First, I consider the effect of introducing revenue-sharing in its current form, relative to the situation in which firms only use a fixed-fee contract. Second, I consider the effect of removing quantity restrictions from the current revenue-sharing contracts. Finally, I consider the effect of switching completely to revenue-sharing contracts within the industry.

The first four columns of Table 8 give predicted average levels of inventories, prices, revenue-sharing take-up rates, and retailer and distributor profits based on the estimated parameters of the demand system. The last column of Table 8 lists the actual values

constructed from the data for each of these variables. Comparing the first column of Table 8 to the last column gives some indication of the goodness-of-fit of the estimated behavioral model. The portion of retailers accepting revenue-sharing terms is estimated reasonably well, as is inventory. Price tends to be slightly overestimated, and computed profits for A, B, and C titles also appear to be over-estimated as a result. While these values give some indication of the goodness-of-fit of the estimated demand system, they cannot be used for calculations of consumer surplus, and they do not account for the adverse selection problem facing upstream firms as a result of retailers' ability to choose between contractual forms. Conclusions about the relative effects of different pricing policies are drawn by comparing columns 1 - 4.

7.1 Introduction of Current Revenue-Sharing Contracts

The first experiment considers the effect of introducing revenue sharing in its current form, relative to the use of only fixed-fee contracts. This is essentially what happened in the industry in early 1998 when Blockbuster and other retailers began adopting revenue-sharing contracts widely. Comparing columns 1 and 2 of Table 8 shows the effect of this contractual change. For A titles, average inventory increases from 19.0 to 24.9 for the average store-title pair, reflecting the alleviation of the double-marginalization problem under fixed-fee contracting. I predict that approximately 55 percent of firms accept revenue-sharing terms, and average price drops from \$4.88 to \$3.98. Average retailer profits increase by 12 percent, although distributor profits are two percent lower. Consumers benefit the most, as consumer surplus increases by 21 percent for A titles. Examining the B titles shows that inventory again increases from 9.2 to 11.0, as 42 percent of retailers accept revenue-sharing terms. The change is accompanied by a reduction in price from \$3.73 to \$3.24. Retailer profits increase by 4.6 percent, and distributor profits are unchanged. Consumer surplus increases by 15.4 percent. Similar results hold for C titles.

7.2 Elimination of Inventory Restrictions

Next, I consider the effect of inventory restrictions in the revenue-sharing contracts. Under these conditions, retailers face the same monetary revenue-sharing contract terms (i.e., the same upfront fee u and revenue-split γ), but are subject to inventory restrictions. The results of this exercise must be interpreted carefully: one does not necessarily expect that

the distributor would optimally charge the same upfront fee and revenue-split in the absence of inventory restrictions as they charge with inventory restrictions. In other words, while I allow retailers to fully re-optimize in this scenario, I do not allow the same opportunity for distributors. In the last exercise, empirical evidence suggests that fixed-fee prices did not change upon the introduction of revenue-sharing contracts. Thus, one might view the absence of distributor re-optimization as a less serious concern than in the current exercise. Even so, the lack of such re-optimization places limitations on our interpretations of the results.

Under the assumption that distributors do not change the contract terms u and γ, the effect of eliminating inventory restrictions is seen by comparing columns 1 and 3 in Table 8. In the absence of inventory restrictions, more retailers accept revenue-sharing terms: 71 percent, 56 percent, and 55 percent for A, B and C titles respectively. With higher revenue-sharing take-up rates, average inventories increase, and price falls relative to the current environment. Retailer profit increases by one to three percent (across the three types of movies), and distributor profit falls by the same percentage. Consumers gain the most from the elimination of inventory restrictions and the associated higher rates of revenue-sharing: consumer surplus increases by seven to nine percent relative to the current environment.

7.3 Revenue-Sharing Contracts Only

Recently, one major studio began distributing products directly to retailers, managing the distribution and retailer accounts internally. This has been viewed by some industry members as possibly laying the groundwork for adopting revenue-sharing terms more widely among retailers. Furthermore, Rentrak currently offers a few "output" programs in which a retailer agrees to accept revenue-sharing terms for a bundle of titles. In this third exercise, I consider the effect of moving to an environment in which only revenue-sharing terms are offered, but retailers are not bound by inventory restrictions. Again, I do not allow distributors to re-optimize, although it is unlikely that distributors would not change the observed contractual terms of the revenue-sharing contracts. Thus, one must be cautious when interpreting the results of this exercise.

If distributors do not change the terms of the revenue-sharing contracts, then the effect of implementing revenue-sharing for all retailers is given by comparing columns 1 and 4 in Table 8. In this exercise, retailers cannot choose fixed-fee terms. Inventories increase, and

price falls for all three classes of titles. Retailer profit decreases by size to eight percent, but distributor profits increase by three to four percent. Consumer surplus also increases substantially, relative to the current environment.

8 Robustness Tests

8.1 Choice of Weight Matrix

Tables 9 and 10 present parameter estimates and the results of counterfactual experiments when Hansen's (1982) weight matrix is chosen. (To be completed.)

8.2 Discounts Under Fixed-Fee Contract

(To be completed.)

9 Conclusion

This study considers the effect of a contractual change in the vertically-separated video rental industry. The contractual change involves the introduction of revenue-sharing contracts in addition to traditional fixed, linear pricing contracts. The nature of the contractual change itself is unique: not only do downstream retailers have a choice of contracts for each product, but they also face both minimum and maximum inventory restrictions under revenue-sharing terms. Casual evidence indicates that this contractual change had an important and substantial impact on firms' inventory decisions. However, to my knowledge, no theoretical study of revenue-sharing contracts considers a contracting environment of this type, and the existence of both minimum and maximum restrictions presents a puzzle for the standard analysis of revenue-sharing contracts.

The data in this study provide an unusually rich source of information on firms' decisions in such an environment. An important component to the study is the development of a model of firm behavior that rationalizes the existence of the inventory restrictions observed in revenue-sharing contracts. The model explains the use of inventory restrictions on the basis of an upstream firm's inability to discriminate among heterogeneous downstream markets when the upstream firm is constrained to offer the same upfront fees and revenue-splits to all retailers. The structural model is estimated empirically using the panel dataset of firms' decisions for a large set of products. Based on the estimated parameters of the

structural model, I conduct several counter-factual experiments. First, I examine the effect of adopting revenue-sharing terms, and find that total upstream and downstream profits increase by as much as seven percent relative to the use of fixed-fee pricing contracts. I also examine the potential effects of eliminating inventory restrictions and fixed-fee pricing contracts. I find that downstream firms benefit from the elimination of inventory restrictions, but upstream firm profits decrease. Eliminating both the inventory restrictions and the fixed-fee contracts leaves the upstream firm's profits virtually unchanged from the current environment and lowers downstream firms' profits.

Appendix A: Quantity Requirements with Additional Sources of Heterogeneity

A.1 The Use of Quantity Requirements when N Varies

In this section, I examine the use of revenue sharing in downstream markets where $V = \overline{V}$ for all markets, but N_m varies across markets. Recall the optimal upfront fee for the upstream firm to charge per unit of inventory given by equation 20:

$$u^* = \frac{(\overline{N} - 1)\tau E(V)}{2\overline{N}\eta} + \frac{(\overline{N} + 1)l}{2\overline{N}}$$

when N varies, rather than V, the upstream firm sets u^* as:

$$u^* = \frac{(E(N) - 1)\tau \overline{V}}{2E(N)\eta} + \frac{(E(N) + 1)l}{2E(N)} \tag{27}$$

The upstream firm once again faces problems of under- and over-stocking because u^* depends on N. In particular, markets with many firms, $N_m > \overline{N}$, have "too much" competition, and inventory will be overstocked in these markets. On the other hand, markets with fewer than $\overline{N}$ firms have too little competition, which results in an under-supply of inventory. In this case, it is difficult to set a single pair of minimum and maximum quantity requirements for all firms. Setting a single quantity requirement can be difficult because store size will be small in markets with large N (and overstocking), while store size will be large in markets with small N (and understocking). Thus, it is possible that the maximum quantity requirement for all firms may be less than the minimum quantity requirement. Allowing the upstream firm to condition quantity requirements on store size, however, solves the problem. Once again, the upstream firm can achieve the maximum attainable industry profits by setting quantity requirements by store size because store size is perfectly informative of N_m. Essentially, the upstream firm can perfectly discriminate across markets if allowed to condition quantity requirements on store size.

A.2 The Use of Quantity Requirements when Both V and N Vary

In this section, I consider the upstream firm's problem when both V and N vary across markets. Once again, setting a single u and γ solves the inventory problem for the average market, but induces some markets to understock and some markets to overstock inventory. However, when both V and N vary across markets, it is less clear which markets will overstock and which will understock because both measures are varying. For example, consider a market with a low draw of V and large N. The low draw of V would induce retailers to understock, while large N would tend to lead to overstocking. The offsetting effects may induce retailers to stock the correct amount.

Now the use of store size for conditioning quantity requirements is very useful. Recall that store size was defined as V/N. Thus, when V does not vary, store size is perfectly informative of N, and when N does not vary, store size is perfectly informative of V. Conditional on store size, the upstream firm knows the optimal level of inventory exactly under these conditions. When both V and N vary, store size is no longer perfectly informative of the competitive conditions or size of a market. For example, two similarly-sized stores may exist in markets with a high draw of V and many firms, or with a low draw of V and few firms, respectively. The first store in the high-value market, will tend to overstock inventory. However, the second store will tend to understock inventory. Thus, it is no longer possible to stipulate an exact level of inventory, conditional on store size. However, the upstream firm can set bounds on inventory choices by setting minimum and maximum quantity requirements according to store size. The use of both minimum and maximum requirements arise because both V and N vary. Although it is not possible to perfectly discriminate across markets when both V and N vary, the firm achieves the highest attainable level of profits by setting minimum and maximum requirements in this way.

Appendix B: Construction of Weight Matrix, Standard Errors, and Truncation Adjustments for GMM Estimates

In this appendix, I describe the construction of the weight matrix, A, the calculation of the standard errors for the parameters Θ, and the truncation adjustments used in the GMM estimates.

B.1 Construction of the Weight Matrix

The parameters Θ are estimated using GMM to solve

$$\Theta = \text{argmin} \left(\sum_i \psi(\Theta, Z_i) \right)' \quad A \quad \left(\sum_i \psi(\Theta, Z_i) \right)$$

where $\psi(\Theta, Z_i)$ is the set of moment conditions discussed in the estimation section, equation 26. In practice, the first two moments, $E(q - \tau c) = 0$ and $E(\eta p - g_0(X, \Theta) + Nq) = 0$ are estimated separately, essentially giving more weight to the calculation of the parameters τ and η, and requiring the parameters to fit these equations exactly. This can be incorporated in the GMM strategy by setting the weights corresponding to these moments arbitrarily high. For each of the remaining moments, the weight matrix A is constructed optimally using the two-step procedure outlined in Hansen (1982).

B.2 Calculation of Covariance Matrix

For a given weight matrix, Hansen (1982) shows that $\hat{\Theta}$ converges in distribution to

$$\sqrt{I}(\hat{\Theta} - \Theta_0) \xrightarrow{d} N(0, (\Gamma' A \Gamma)^{-1} (\Gamma' A \Delta A \Gamma)(\Gamma' A \Gamma)^{-1})$$

where Θ_0 is the vector of true parameter values, and Γ and Δ are defined as

$$\Gamma = E\left[\frac{\partial \psi}{\partial \Theta'}(Z, \Theta_0) \right], \quad \text{and} \quad \Delta = E\left[\psi(Z, \Theta_0) \cdot \psi(Z, \Theta_0)' \right].$$

I denote the number of observations as I to avoid confusion with the data on a retailer's number of competitors, N. The matrices Γ and Δ are estimated empirically as

$$\hat{\Gamma} = \frac{1}{I}\sum_i \frac{\partial \psi}{\partial \Theta'}(Z, \hat{\Theta}), \quad \text{and} \quad \hat{\Delta} = \frac{1}{I}\sum_i \psi(Z, \hat{\Theta}) \cdot \psi(Z, \hat{\Theta})'.$$

The standard errors account for the separate estimation of the first two moments by specifying A as

$$A \equiv \begin{bmatrix} 100a_{11} & 0 & 0 \cdots 0 \\ 0 & 100a_{22} & 0 \cdots 0 \\ 0 & 0 & a_{33} \cdots a_{36} \\ \vdots & \vdots & \vdots \\ 0 & 0 & a_{63} \cdots a_{66} \end{bmatrix}$$

where a_{ij} is the ij^{th} element of $\hat{\Delta}^{-1}$. The practice of estimating the first two moments separately corresponds to a GMM strategy in which the weight associated with these moments is arbitrarily high. Specifying A as above reflects this practice in the estimation of the standard errors. The covariance matrix for $\hat{\Theta}$ is then estimated as $(\hat{\Gamma}' A \hat{\Gamma})^{-1}(\hat{\Gamma}' A \hat{\Delta} A \hat{\Gamma})(\hat{\Gamma}' A \hat{\Gamma})^{-1}$.

B.3 Truncation Adjustments

Conditional on retailers having a choice of contracts, the distribution of V is truncated from below for titles taken on fixed-fee terms, and truncated from above for titles taken on revenue-sharing terms, as indicated in the retailer's profit function in the behavioral model. The truncation point is equal to $V^*(\tau, \eta, F, u, \gamma)$, which is given in equation 10 and also shown here as

$$V^*(\tau, \eta, F, u, \gamma) = \frac{\eta(F - \gamma u + \sqrt{\gamma}(F - u))}{(1-\gamma)\tau}.$$

This gives the conditional expectation of V in the fourth and fifth moment conditions respectively as

$$\begin{aligned} g_1(X, \Theta) &= E(V \mid RS = 1, X) = E(V \mid V < V^*, X) \\ &= \exp(X'\beta + \sigma_v^2/2)\frac{\Phi((\ln V^* - X'\beta)/\sigma_v) - \sigma_v)}{\Phi((\ln V^* - X'\beta)/\sigma_v)} \end{aligned} \tag{28}$$

$$\begin{aligned} g_2(X, \Theta) &= E(V \mid RS = 0, X) = E(V \mid V > V^*, X) \\ &= \exp(X'\beta + \sigma_v^2/2)\frac{1 - \Phi((\ln V^* - X'\beta)/\sigma_v) - \sigma_v)}{1 - \Phi((\ln V^* - X'\beta)/\sigma_v)} \end{aligned}$$

where Φ denotes the standard normal cumulative density function.

The truncation point given by $V^*(\tau, \eta, F, u, \gamma)$ applies when inventory is chosen optimally, and is derived by equating retailer profits (evaluated at the optimal inventory levels) under each contractual form. When a retailer is constrained by inventory minimums or maximums for a particular title, the implied truncation point changes. For store-title pairs for which minimum or maximum inventory restrictions are binding under revenue-sharing terms, I denote the truncation point as $V_m^*(\tau, \eta, F, u, \gamma, N)$, which is given by:

$$V_m^*(\tau, \eta, F, u, \gamma, N) = \frac{1}{2\tau}\left(\gamma c_m \tau^2 (N+1)^2 + 2\eta F + \sqrt{c_m \tau^2(\gamma(N+1)^2 - 4N) + 4(F-u)\eta}\right)$$
$$\text{where } c_m = \begin{cases} c_{min} \text{ if the minimum inventory restriction is binding} \\ c_{max} \text{ if the maximum inventory restriction is binding} \end{cases} \tag{29}$$

Just as in the calculation of V^*, the truncation point V_m^* is derived by equating retailer profits under both contractual forms, except that retailer profit under revenue-sharing terms is now computed at c_m rather than at the optimal inventory choice, c^*. Adjusting $E(V)$ to account for the implied truncation of the distribution of V when quantity restrictions apply occurs as above in equation 28, but evaluated at V_m^* rather than at V^*. Similar adjustments are made to account for truncation when calculating $E(V^2)$.

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Table 1: Revenue-Sharing vs. Fixed-fee Contracts: A Titles, Differences Between Stores for the Same Title*

	Stores accepting Revenue-Sharing	(S.D.)	Stores accepting Fixed-Fee	(S.D.)	T-stat of Diff.
No. People ('000s)	23.32	(0.79)	23.84	(1.17)	[0.8]
No. Households ('000s)	8.65	(0.30)	8.92	(0.44)	[1.1]
Median Income ('000s)	31.28	(0.57)	31.84	(0.88)	[1.2]
Percent Urban	49.43	(2.17)	51.13	(3.86)	[0.8]
Percent Age 25-39	25.10	(0.18)	25.35	(0.27)	[1.7]
No. Competitors	2.63	(0.08)	2.58	(0.07)	[-0.8]
No. Blockbusters	1.06	(0.01)	1.06	(0.01)	[1.0]
Store Size[1]	3.74	(0.40)	4.56	(0.24)	[3.9]
Variety of Titles	658.46	(31.78)	589.68	(68.63)	[-2.0]
Copies	30.11	(9.97)	15.89	(7.21)	[-2.5]
Rentals (Q)	472.92	(174.95)	485.82	(160.81)	[0.1]
Price (P)	2.72	(0.07)	2.73	(0.07)	[0.2]
Revenue	1,306.07	(498.86)	1,347.48	(458.92)	[0.1]
Retailer Profit	371.80	(204.85)	298.24	(273.70)	[-0.5]
Distributor Profit	843.94	(309.56)	1,001.61	(480.82)	[0.6]
Observations	23		23		

*An observation in this table is a title. For each title, mean store characteristics are computed for the set of stores accepting each type of contract. The source of demographic data is 1990 U.S. Census data. Data on competing retailers is gathered from 1998 and 1999 phone book listings.
1) Stores are categorized into 10 separate groups by monthly revenue size. Larger group numbers correspond to larger store revenues.

Table 2: Revenue-Sharing vs. Fixed-fee Contracts: B Titles, Differences Between Stores for the Same Title*

	Stores accepting Revenue-Sharing	(S.D.)	Stores accepting Fixed-Fee	(S.D.)	T-stat of Diff.
No. People ('000s)	22.94	(0.54)	23.68	(0.73)	[2.0]
No. Households ('000s)	8.50	(0.22)	8.85	(0.27)	[2.5]
Median Income ('000s)	31.34	(0.77)	31.58	(0.53)	[0.6]
Percent Urban	49.53	(2.68)	49.91	(2.69)	[0.2]
Percent Age 25-39	25.16	(0.25)	25.21	(0.20)	[0.3]
No. Competitors	2.66	(0.07)	2.55	(0.05)	[-3.0]
No. Blockbusters	1.06	(0.01)	1.06	(0.01)	[-1.0]
Store Size[1]	3.30	(0.33)	4.79	(0.17)	[9.7]
Variety of Titles	697.70	(24.69)	608.56	(48.90)	[-3.9]
Copies	12.99	(4.05)	7.29	(2.46)	[-2.9]
Rentals (Q)	235.45	(106.81)	291.80	(124.41)	[0.8]
Price (P)	2.68	(0.08)	2.73	(0.05)	[1.2]
Revenue	638.92	(286.17)	801.66	(343.89)	[0.9]
Retailer Profit	188.11	(117.30)	310.61	(292.54)	[0.9]
Distributor Profit	411.84	(170.18)	469.16	(182.77)	[0.6]
Observations	35		35		

*An observation in this table is a title. For each title, mean store characteristics are computed for the set of stores accepting each type of contract. The source of demographic data is 1990 U.S. Census data. Data on competing retailers is gathered from 1998 and 1999 phone book listings.
1) Stores are categorized into 10 separate groups by monthly revenue size. Larger group numbers correspond to larger store revenues.

Table 3: Revenue-Sharing vs. Fixed-fee Contracts: C Titles, Differences Between Stores for the Same Title*

	Stores accepting Revenue-Sharing	(S.D.)	Stores accepting Fixed-Fee	(S.D.)	T-stat of Diff.
No. People ('000s)	25.86	(7.03)	26.98	(7.27)	[0.6]
No. Households ('000s)	9.37	(2.19)	9.89	(2.41)	[0.9]
Median Income ('000s)	30.66	(3.01)	30.84	(4.77)	[0.2]
Percent Urban	54.70	(14.52)	57.42	(19.59)	[0.6]
Percent Age 25-39	25.47	(1.23)	25.61	(1.99)	[0.3]
No. Competitors	2.58	(0.42)	2.73	(0.92)	[0.8]
No. Blockbusters	1.06	(0.05)	1.08	(0.11)	[0.9]
Store Size[1]	3.39	(0.51)	4.78	(1.25)	[5.8]
Variety of Titles	958.66	(151.89)	761.41	(189.93)	[-4.6]
Copies	2.25	(1.43)	1.74	(1.22)	[-1.6]
Rentals (Q)	24.94	(28.66)	33.41	(39.19)	[1.0]
Price (P)	2.51	(0.21)	2.38	(0.52)	[-1.3]
Revenue	63.80	(77.08)	84.29	(105.35)	[0.9]
Retailer Profit	19.92	(28.11)	-12.00	(79.36)	[-2.1]
Distributor Profit	37.12	(49.14)	91.08	(82.86)	[3.2]
Observations	1,055		991		

*An observation in this table is a title. For each title, mean store characteristics are computed for the set of stores accepting each type of contract. The source of demographic data is 1990 U.S. Census data. Data on competing retailers is gathered from 1998 and 1999 phone book listings.

1) Stores are categorized into 10 separate groups by monthly revenue size. Larger group numbers correspond to larger store revenues.

Table 4: Revenue-Sharing vs. Fixed-fee Contracts: A Titles, Differences Between Titles Within a Store*

	Titles taken on Revenue-Sharing	(S.D.)	Titles taken on Fixed-Fee	(S.D.)	T-stat of Diff.
Upfront Fee[1]	7.87	(0.85)	8.32	(0.89)	[3.1]
Revenue Kept by Retailer[1]	0.45	(0.01)	0.45	(0.01)	[0.6]
Minimum Inventory[1]	25.09	(16.19)	25.37	(14.57)	[0.1]
Maximum Inventory[1]	56.88	(31.88)	51.16	(26.27)	[-1.2]
% At Minimum	0.34	(0.34)	–	–	–
% At Maximum	0.13	(0.20)	–	–	–
Copies	35.49	(27.69)	13.58	(13.02)	[-6.1]
Rentals (Q)	589.39	(531.87)	402.75	(375.12)	[-2.5]
Price (P)	2.73	(0.40)	2.74	(0.43)	[0.1]
Revenue	1,640.49	(1,583.51)	1,118.78	(1,111.34)	[-2.3]
Retailer Profit	490.89	(578.14)	229.20	(477.67)	[-3.0]
Distributor Profit	1,043.12	(963.37)	848.84	(829.28)	[-1.3]
Observations	5,511		5,035		

*An observation in this table is a store. For each store, mean title characteristics are computed for the set of titles taken under each type of contract. If a store chose revenue-sharing (fixed-fee) terms every time an A title was purchased, the store is not included as an observation in the column containing information on fixed-fee (revenue-sharing) terms. 1) For titles accepted on revenue-sharing terms, the averages of the upfront fee, revenue-split, and the minimum and maximum inventory restrictions represent the actual fees paid by the retailer (or adhered to, in the case of inventory restrictions). For titles accepted on fixed-fee terms, the averages of the upfront fee, revenue-split, and the minimum and maximum inventory restrictions represent the revenue-sharing terms available to the retailer when choosing between pricing contracts, but not actually paid. Under fixed-fee terms, retailers pay $70 per tape and face no revenue-split or inventory restrictions. A few titles are priced for "sell-through," with the fixed price per tape around $35.

Table 5: Revenue-Sharing vs. Fixed-fee Contracts: B Titles, Differences Between Titles Within a Store*

	Titles taken on Revenue-Sharing	(S.D.)	Titles taken on Fixed-Fee	(S.D.)	T-stat of Diff.
Upfront Fee[1]	8.43	(0.62)	8.66	(0.48)	[2.5]
Revenue Kept by Retailer[1]	0.45	(0.01)	0.45	(0.01)	[-1.2]
Minimum Inventory[1]	12.93	(8.23)	13.04	(7.49)	[0.1]
Maximum Inventory[1]	31.55	(17.08)	30.93	(15.94)	[-0.2]
% At Minimum	0.43	(0.38)	–	–	–
% At Maximum	0.09	(0.21)	–	–	–
Copies	18.09	(15.23)	6.05	(5.64)	[-6.3]
Rentals (Q)	386.53	(421.87)	228.40	(211.32)	[-2.9]
Price (P)	2.73	(0.42)	2.72	(0.44)	[-0.2]
Revenue	1,076.69	(1,242.39)	628.48	(607.28)	[-2.8]
Retailer Profit	350.35	(487.98)	223.74	(323.83)	[-1.8]
Distributor Profit	672.06	(730.36)	386.58	(364.06)	[-3.0]
Observations	5,260		5,309		

*An observation in this table is a store. For each store, mean title characteristics are computed for the set of titles taken under each type of contract. If a store chose revenue-sharing (fixed-fee) terms every time a B title was purchased, the store is not included as an observation in the column containing information on fixed-fee (revenue-sharing) terms.
1) For titles accepted on revenue-sharing terms, the averages of the upfront fee, revenue-split, and the minimum and maximum inventory restrictions represent the actual fees paid by the retailer (or adhered to, in the case of inventory restrictions). For titles accepted on fixed-fee terms, the averages of the upfront fee, revenue-split, and the minimum and maximum inventory restrictions represent the revenue-sharing terms available to the retailer when choosing between pricing contracts, but not actually paid. Under fixed-fee terms, retailers pay $70 per tape and face no revenue-split or inventory restrictions. A few titles are priced for "sell-through," with the fixed price per tape around $35.

Table 6: Revenue-Sharing vs. Fixed-fee Contracts: C Titles, Differences Between Titles Within a Store*

	Titles taken on Revenue-Sharing	(S.D.)	Titles taken on Fixed-Fee	(S.D.)	T-stat of Diff.
Upfront Fee[1]	7.84	(1.10)	7.71	(0.90)	[-0.7]
Revenue Kept by Retailer[1]	0.49	(0.04)	0.51	(0.03)	[3.7]
Minimum Inventory[1]	3.74	(3.58)	3.12	(1.66)	[-1.3]
Maximum Inventory[1]	12.37	(8.09)	12.14	(5.12)	[-0.2]
% At Minimum	0.41	(0.33)	–	–	–
% At Maximum	0.07	(0.17)	–	–	–
Copies	5.95	(6.98)	2.06	(1.03)	[-4.7]
Rentals (Q)	124.95	(180.51)	53.79	(37.96)	[-3.3]
Price (P)	2.65	(0.42)	2.56	(0.46)	[-1.2]
Revenue	339.08	(545.92)	140.90	(103.31)	[-3.0]
Retailer Profit	111.20	(195.51)	22.96	(82.56)	[-3.6]
Distributor Profit	210.03	(340.04)	111.75	(58.78)	[-2.4]
Observations	5,314		5,554		

*An observation in this table is a store. For each store, mean title characteristics are computed for the set of titles taken under each type of contract. If a store chose revenue-sharing (fixed-fee) terms every time a C title was purchased, the store is not included as an observation in the column containing information on fixed-fee (revenue-sharing) terms.
1) For titles accepted on revenue-sharing terms, the averages of the upfront fee, revenue-split, and the minimum and maximum inventory restrictions represent the actual fees paid by the retailer (or adhered to, in the case of inventory restrictions). For titles accepted on fixed-fee terms, the averages of the upfront fee, revenue-split, and the minimum and maximum inventory restrictions represent the revenue-sharing terms available to the retailer when choosing between pricing contracts, but not actually paid. Under fixed-fee terms, retailers pay $70 per tape and face no revenue-split or inventory restrictions. A few titles are priced for "sell-through," with the fixed price per tape around $35.

Table 7: Estimated Parameter Values from GMM Estimation

$\partial \ln V / \partial X (*1000)$	A Titles	B Titles	C Titles
People	2.4	-0.7	-0.9
	(3.0)	(1.9)	(1.2)
Households	-1.0	6.0	3.1
	(8.3)	(5.3)	(3.4)
Median Income	2.7	-3.1	-0.8
	(0.8)	(0.6)	(0.4)
% Female	606.9	-15.1	-2.6
	(496.4)	(333.4)	(247.4)
% Age 25-39	296.9	21.2	0.6
	(234.8)	(162.5)	(111.4)
% Employed	0.3	1.8	-0.0
	(0.3)	(0.2)	(0.1)
Number of Titles	0.0	-0.0	-0.0
	(0.0)	(0.0)	(0.0)
Number of Blockbusters	41.7	65.6	9.3
	(17.9)	(11.4)	(9.0)
Chain Size	0.2	-0.0	0.0
	(0.0)	(0.0)	(0.0)
Store Size	74.2	49.4	4.7
	(4.4)	(3.0)	(2.3)
$\hat{\tau}$	20.40	28.97	21.19
	(0.05)	(0.07)	(0.03)
$\hat{\eta}$	242.39	188.10	38.94
	(1.86)	(0.98)	(0.19)
$\hat{\sigma}_{\ln v}$	0.25	0.26	0.26
	(0.01)	(0.00)	(0.01)
$\hat{\sigma}_{\epsilon}$	33.60	16.59	10.20
	(0.09)	(0.03)	(0.01)
Price Elasticity at Observed Q, P	-0.51	-0.70	-0.61
Observations	99,976	146,623	649,413

Standard errors in parentheses.

Table 8: Counter-factual Experiments

Variable	Current	Fixed-fee Only	No Inven. Restrict.	Rev-Share Only	Actual
Panel 1: A titles					
Inventory	24.90	18.99	27.59	30.49	24.01
Price	3.98	4.88	3.46	2.96	2.72
% Revenue-Sharing	55	0	71	100	53
Retailer Profit	932.89	819.37	953.54	873.94	356.20
Dist. Profit	1,171.62	1,195.80	1,154.41	1,209.12	925.29
% Change Ret. Profit		-12.2	2.2	-6.3	
% Change Dist. Profit		2.3	-1.5	3.2	
% Change CS		-20.5	9.3	23.7	
Panel 2: B titles					
Inventory	11.03	9.16	11.86	13.56	9.50
Price	3.24	3.73	2.95	2.39	2.71
% Revenue-Sharing	42	0	56	100	38
Retailer Profit	463.54	442.40	468.23	428.77	273.18
Dist. Profit	580.07	582.63	574.42	594.88	450.24
% Change Ret. Profit		-4.6	1.0	-7.5	
% Change Dist. Profit		0.0	-1.0	2.6	
% Change CS		-15.4	6.9	24.2	
Panel 3: C titles					
Inventory	3.38	2.65	3.61	3.96	2.93
Price	3.25	3.93	2.91	2.52	2.56
% Revenue-Sharing	39	0	55	100	47
Retailer Profit	113.92	96.32	117.80	106.68	48.63
Dist. Profit	115.63	122.98	112.50	119.77	105.52
% Change Ret. Profit		-15.4	3.3	-6.4	
% Change Dist. Profit		6.4	-2.7	3.7	
% Change CS		-21.6	7.0	17.6	

Results based on the fullest specification in Table 7.

Table 9: Estimated Parameter Values from GMM Estimation, Weight Matrix as in Hansen (1982)

$\partial \ln V / \partial X (*1000)$	A Titles	B Titles	C Titles
People	1.2	-4.1	-1.6
	(3.3)	(1.6)	(1.0)
Households	2.1	18.7	7.6
	(9.1)	(4.3)	(2.9)
Median Income	-0.5	-1.5	-0.7
	(1.0)	(0.5)	(0.4)
% Female	-323.7	-132.9	5.8
	(606.9)	(296.1)	(224.9)
% Age 25-39	-73.1	-515.1	0.4
	(298.2)	(143.2)	(100.1)
% Employed	0.2	1.4	-0.0
	(0.4)	(0.2)	(0.1)
Number of Titles	0.1	-0.0	-0.1
	(0.0)	(0.0)	(0.0)
Number of Blockbusters	26.7	68.6	41.4
	(23.7)	(10.5)	(7.7)
Chain Size	0.2	-0.2	-0.0
	(0.0)	(0.0)	(0.0)
Store Size	30.7	79.5	31.2
	(6.2)	(2.6)	(2.1)
$\hat{\tau}$	21.72	30.81	21.70
	(0.04)	(0.06)	(0.03)
$\hat{\eta}$	217.37	138.92	29.45
	(1.31)	(0.77)	(0.14)
$\hat{\sigma}_{\ln v}$	0.19	0.26	0.26
	(0.01)	(0.01)	(0.01)
$\hat{\sigma}_{\epsilon}$	11.26	3.71	0.97
	(0.26)	(0.12)	(0.05)
Price Elasticity at Observed Q, P	-0.45	-0.51	-0.46
Observations	99,976	146,623	649,413

Standard errors in parentheses.

Table 10: Counter-factual Experiments, Weight Matrix as in Hansen (1982)

Variable	Current	Fixed-fee Only	No Inven. Restrict.	Rev-Share Only	Actual
Panel 1: A titles					
Inventory	20.61	16.25	23.33	25.34	24.01
Price	3.95	4.71	3.30	2.90	2.72
% Revenue-Sharing	49	0	74	100	53
Retailer Profit	760.98	689.73	782.08	736.02	356.20
Dist. Profit	1,011.75	1,024.08	979.29	1,016.32	925.29
% Change Ret. Profit		-9.4	2.8	-3.3	
% Change Dist. Profit		1.2	-3.2	0.4	
% Change CS		-19.9	12.6	23.9	
Panel 2: B titles					
Inventory	7.85	6.96	8.19	9.83	9.50
Price	3.43	3.73	3.23	2.46	2.71
% Revenue-Sharing	26	0	38	100	38
Retailer Profit	413.93	404.38	416.04	351.49	273.18
Dist. Profit	447.33	443.17	440.75	480.75	450.24
% Change Ret. Profit		-2.3	0.5	-15.1	
% Change Dist. Profit		-4.2	-1.5	7.4	
% Change CS		-9.2	3.7	26.4	
Panel 3: C titles					
Inventory	2.57	2.09	2.76	3.03	2.93
Price	3.38	3.96	2.99	2.59	2.56
% Revenue-Sharing	32	0	53	100	47
Retailer Profit	94.30	82.70	97.30	86.63	48.63
Dist. Profit	92.60	97.26	89.41	96.51	105.52
% Change Ret. Profit		-12.3	3.2	-8.1	
% Change Dist. Profit		5.1	-3.4	4.2	
% Change CS		-18.6	7.9	18.7	

Results based on the fullest specification in Table 9.