

# Price Discrimination, Copyright Law, and Technological Innovation: Evidence from the Introduction of DVDs

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June 20, 2006

## Abstract

This paper examines firms' use of indirect price discrimination in response to U.S. copyright law, which effectively prevents direct price discrimination. I derive theoretical predictions about the use of indirect price discrimination in markets with vertically differentiated products. Using data covering VHS and DVD movie distribution, I explain firms' optimal pricing strategies under U.S. copyright law, and show that firms adopt price discrimination strategies as predicted by theory. I analyze how optimal pricing strategies differ for the same movie distributed on VHS technology versus the new DVD technology. I find that renting a movie on the DVD format delivers a smaller fraction of its total value, and that the DVD format loses its value more quickly over time, compared to the VHS format. After analyzing firms' optimal pricing strategies, I examine the welfare impacts of indirect price discrimination in the market. I find that firms' use of indirect price discrimination benefits consumers and harms retailers. Finally, I examine what optimal pricing strategies might look like in a legal environment that permits direct price discrimination. I reanalyze these issues assuming continued DVD adoption.

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<sup>†</sup>I thank John Asker, Steve Berry, Estelle Cantillon, Liran Einav, Gautam Gowrisankaran, Ali Hortacsu, Richard Mortimer, Ariel Pakes, Brian Viard, Paul Walsh, Mike Whinston, and four anonymous referees for helpful discussions and comments. I also thank seminar participants at the Bureau of Economic Analysis, Columbia University, Duke University, Harvard University, Indiana University, Johns Hopkins University, MIT, Northwestern University, the National Bureau of Economic Research Summer Institute, the Stanford Institute for Theoretical Economics, University of Pittsburgh, University of Virginia, University of Wisconsin-Madison, Yale University, and the 2002 Workshop for Business and Economics Scholars at Florida Atlantic University for helpful comments. Chris Conlon provided excellent research assistance. The data for this study were generously provided to me by Rentrak Corporation, and I thank Ellen Dannenberg and Amir Yazdani for their help in collecting the data. Jerilyn Kessel at Centris provided additional data, and Brad Hackley provided helpful comments from the Video Software Dealers Association. I visited the Center for the Study of Industrial Organization during the course of this research, and am grateful for their hospitality and financial support. I am also grateful to Robert Barro for financial support through the Warburg funds. Any remaining errors are my own.

# 1 Introduction

The effects of intellectual property protection depend on how firms respond to the legal environment created by intellectual property laws. An important aspect of intellectual property law in the U.S. is a restriction that copyright law places on firms' abilities to directly price discriminate based on a consumer's intended use of a product. Firms may attempt to mitigate the effect of this restriction through legal indirect price discrimination. To identify factors influencing firms' optimal pricing decisions under current U.S. copyright law, I empirically examine the outcomes of two pricing strategies (no price discrimination and indirect price discrimination) used by firms for products that are identical in content but distributed via an old established technology and a new emerging technology. The analysis uses a new dataset covering the distribution of movies on VHS and DVD formats to explain when different pricing strategies may be optimal, and to establish the welfare effects of price discrimination.

The U.S. Copyright Act of 1976 invokes copyright jurisdiction upon the first sale of a copyright-protected product only. Subsequent use, including resale and rental, does not generate income to the copyright holder.<sup>1</sup> This 'First Sale Doctrine' applies to all copyright-protected products and allows for legal markets in video rentals, used books, records/CDs, paintings, and other creative works.<sup>2</sup> In the home video market, the First Sale Doctrine effectively strips movie studios of the ability to directly price discriminate between institutional and individual users. In the face of these legal restrictions, copyright holders in this industry adopted a form of indirect price discrimination. When releasing a movie on the VHS format, a firm initially sets a very high price for the videocassettes (around \$100), during which time the buyers are typically video rental stores purchasing rental inventory. Subsequently, the firm lowers the price substantially (to around \$20), at which time the typical buyers are end-users. This strategy is commonly referred to in the industry as "rental pricing," and has been used for the vast majority of titles on the VHS format historically. For the remaining titles, the initial rental window is forgone in favor of generating early

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<sup>1</sup>See Childs (1992) for details of the 1984 Supreme Court case, *Universal v. Sony* upholding this restriction.

<sup>2</sup>The First Sale Doctrine is distinct from the Fair Use Doctrine, which addresses duplication of copyrighted materials for the purpose of fair use (such as photocopying articles for distribution to a class or public showings of copywritten content). It is still an open question as to how the First Sale Doctrine will be interpreted with respect to digital media, where transferring ownership of a legally-purchased copy, or allowing others to "rent" a legally-purchased copy generally requires duplication of the original.

(and potentially more) direct sales to consumers. For these titles, studios set a retail price in the range of \$19.99 - \$26.99 immediately upon the first release. This practice, referred to as “sell-through pricing,” is typically used for children’s titles, and occasionally for popular blockbuster titles, especially movies with teenager appeal. Examples of sell-through priced movies include *Blair Witch Project*, *Titanic*, and *Antz*.

With the introduction of the DVD format, studios have almost exclusively adopted sell-through pricing, even as they maintain a rental-pricing strategy for the same-day release of the movie’s VHS format. For example, *The Green Mile* was initially released with a VHS price of \$107.95 and a same-day DVD price of \$24.95. There are at least two possible explanations for this dramatic change in the pricing policy of the new format. On one hand, differences in the populations of consumers that adopt the DVD format in early years may lead to different optimal pricing choices. As late adopters enter the market, firms might again choose to adopt a rental-pricing strategy in order to discriminate between the institutional and individual purchasers. On the other hand, the DVD format may be inherently different from the VHS format, allowing for convenient viewing of movies on laptop computers and additional viewing features. These new uses potentially affect the relative quality of owning and renting, and may lead to different optimal pricing choices. In this case, one would expect that sell-through pricing will remain the standard for pricing in the DVD market.<sup>3</sup> The goal of this paper is to understand what factors influence a studio’s choice of sell-through and rental pricing strategies, and why the choice of pricing strategy may differ for the same movie on different formats. I also examine the welfare effects of price discrimination for firms and consumers in the context of different legal environments.

Other industries face similar challenges when pricing products. For example, book publishers price discriminate by sequentially releasing hardcover and paperback versions of a book. Markets for journal subscriptions, televised sporting events, live performances, and television shows all face similar challenges when pricing their products, and copyright holders in these markets employ a range of techniques to price discriminate among different types of consumers.

The paper proceeds as follows: section 2 discusses related literature and describes the

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<sup>3</sup>An alternative explanation may be that piracy is easier on the digital DVD format, and a sell-through pricing strategy is aimed at discouraging piracy. The effects of piracy, however, are complicated: they depend on the firm’s ability to monitor piracy both by individuals and by video rental stores. While piracy may be easier with the digital format, monitoring capabilities-especially for video rental stores-have also improved dramatically in recent years.

home video industry. In section 3, I describe the dataset and the timing of rentals and sales. Section 4 lays out a demand system for rentals and purchases of a movie on a particular format and describes the firm's choice of whether or not to price discriminate. Section 5 modifies the demand system to incorporate institutional details, describes the estimation strategy, and discusses results. Finally, section 6 provides the results of welfare analyses.

## 2 Related Literature and the Home Video Industry

### 2.1 Related Literature

A growing empirical literature addresses the topic of price discrimination, and a large literature addresses the theoretical implications of copyright provisions. However, to my knowledge, little empirical or theoretical literature addresses the implications of copyright law through its influence on price discrimination strategies or other static best responses in markets for copyrighted goods. A related previous study on price discrimination is Leslie (2004), which examines the welfare effects of both second- and third-degree price discrimination in Broadway theater.<sup>4</sup> Others have empirically studied the effects of price discrimination in the presence of competition.<sup>5</sup> Also related to this study, Clerides (2002) examines the implementation of intertemporal price discrimination in book sales, and Bergstrom (2001) examines institutional pricing of academic journals.<sup>6</sup>

In the home video industry, a strategy of no price discrimination can be more profitable than a strategy of indirect price discrimination because there is a cost to implementing indirect price discrimination (i.e., firms must reduce product quality by delaying the sell-through release to consumers). This is similar to treatments in the theoretical literature in which firms destroy quality in order to better sort consumers.<sup>7</sup>

The effects of intellectual property protection have been studied in other contexts, often focusing on the optimal theoretical level of copyright protection for the purpose of inducing

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<sup>4</sup>Previous empirical work on price discrimination primarily tested whether or not different instances of price dispersion had a cost-based explanation, or a price discrimination-based explanation. See Borenstein (1991), Shepard (1991), Borenstein and Rose (1994), among others. Leslie (2004) makes the point that in some cases we know that price dispersion is not cost-based. Thus, the question of interest is quantifying the welfare effects of price discrimination.

<sup>5</sup>See McManus (2001), Miravete (2002), and Busse and Rysman (2004).

<sup>6</sup>To the best of my knowledge, the difference between the pricing of VHS/DVD rentals and library subscriptions of academic journals (where direct price discrimination occurs) is based on the public availability of the content of printed goods.

<sup>7</sup>Mussa and Rosen (1978) is a seminal contribution; Maskin and Riley (1984) extend their model, and Deneckere and McAfee (1996) also model damaged goods.

investment in creative works<sup>8</sup>, or the theoretical effects of piracy or unauthorized copying on firm profits and social welfare.<sup>9</sup> The most closely related previous paper is Liebowitz (1986), which studies the impact of price discrimination by journal publishers on the working of copyright law. The treatment is primarily theoretical, although it reports some basic data on the prevalence of price discrimination in the market for academic journals and is based on work involving a Betamax court case. A much larger literature on intellectual property protection has focused on patent, rather than copyright, protection. An exception is McCalman (2004), which studies the governance structures and licensing behavior of movie studios across countries with different levels of intellectual property rights protection.<sup>10</sup> The role of purchase and rental markets to segment high- and low-value consumers has also been studied theoretically by Varian (2000), and an historical background of the video rental industry is provided in Varian and Roehl (2001). Varian (2000) derives conditions under which pricing exclusively for a rental market, or pricing exclusively for direct sale, will be more profitable for the owner of an information good.<sup>11</sup>

## 2.2 Industry Background

In 1999, the \$16 billion home video 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.<sup>12</sup> Approximately 20,000 home video retail outlets plus internet firms such as Netflix purchase movies on VHS or DVD format and rent their inventory to consumers. In addition, consumers may purchase movies on either format from video, non-specialized, or Internet retailers.

Under indirect price discrimination (i.e., "rental pricing") video retailers pay a wholesale price for each pre-recorded videocassette tape of around \$60 to \$70. After an initial period of rental activity (around five months), the distributor cuts the wholesale price from \$60 -

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<sup>8</sup>See Novos and Waldman (1984) and Yoon (2002).

<sup>9</sup>See Ordover and Willig (1978), Johnson (1985), Liebowitz (1985), and Takayama (1994 and 1997).

<sup>10</sup>Also related, McCalman (2001) studies the welfare effects of harmonizing patent protection across countries (via the TRIPs agreement of the Uruguay Round of GATT negotiations) by estimating a structural model of innovation using a modified version of the model in Eaton and Kortum (1996).

<sup>11</sup>Varian identifies three factors that play a role in determining the more profitable strategy: transactions costs of renting compared to the marginal cost of production, the number of times content is viewed, and the ability to use a rental market to segment high- and low-value consumers. The model I derive is very similar in spirit—the main difference is that my model also incorporates intertemporal segmentation. Thus, the choice becomes whether to price discriminate indirectly or not.

<sup>12</sup>VSDA Annual Report, 1999.

\$70 to \$10 - \$15, called “sell-through re-pricing.” At this time the movie is commonly sold to individual users. This two-tiered pricing strategy is a form of indirect price discrimination and helps to distinguish between individuals and institutional buyers (i.e., video stores). Exceptions to this pricing pattern are titles priced for “sell-through.” In this case, indirect price discrimination is discarded in favor of an immediate \$10 - \$15 wholesale price to stimulate early sales to individual users.

Tables 1 and 2 detail the use of sell-through pricing for the VHS and DVD formats respectively. These figures are compiled from the dataset described in the next section, and include all major titles released between January 2000 and December 2001. Titles are classified as “B” or “A” if they earned 15-40 million or more than 40 million respectively in theatrical box-office revenue. The incidence of sell-through pricing for all titles released on VHS is around 19 percent. Childrens and Family movies are always sell-through priced, while Romance, Suspense and Drama titles are almost never sell-through priced in the dataset. Science Fiction titles are likely to be sell-through priced if the title has a large theatrical box-office. Contrasting to this, table 2 shows the use of sell-through pricing for the same movies under the DVD format. With the exception of a single B title in the Drama genre, all titles are sell-through priced.

### **3 Data**

#### **3.1 Primary Data Sources**

The primary dataset used for this study is a new dataset of DVD and VHS rental and sales transactions at video retail stores provided by Rentrak Corporation.<sup>13</sup> The dataset contains transactions at 4,341 stores from January, 2000 through June, 2002. I eliminate 2,128 stores that did not carry most major titles because they exited the database at an early date or entered the database at a late date. This leaves 2,213 video retail stores. For all stores, I observe the zipcode location.

The stores in Rentrak’s database are video specialty retailers, but rentals and purchases can be made at other retail outlets. As I detail in the data appendix, about three-quarters of all VHS and DVD rentals occur at video retail outlets, but a greater proportion of

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<sup>13</sup>Over 10,000 retailers used Rentrak to process data between 1998 and 2001, 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. Blockbuster Video does not release their data, and Hollywood Video recently settled a lawsuit with Rentrak involving a dispute over data integrity.

sales occur through alternative distribution channels. I use auxiliary phone-survey data on purchases at all outlets to weight the sample of video retailers appropriately.

For each title released on video between January, 2000 and December, 2001, I observe theatrical box-office revenues, genre, and MPAA rating. I do not observe title names. I focus on titles with theatrical box office revenues of at least 55 million in order to ensure sufficient coverage of the sales market. I track the rental and sales activities of each title for at least 6 months on both formats. Finally, I limit my attention to titles that are not available on revenue-sharing contracts.<sup>14</sup> This leaves 41 major titles in the analysis. An observation is a store-title pair, which is constructed after summarizing over weekly transactions data.

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 and Hollywood Video stores, for 2000 through 2002. From these data, I identify the total number of video retail stores within the same zip code of each observed store in the Rentrak database. In addition, I utilize data from the 2000 US Census on the demographic characteristics of each zip code. Demographic data include the number of people, median income, and marginal distributions of race, education, age, gender, employment, family status, and the level of urbanization in each zip code. These three data sources (phone book listings, demographics, and transactions data) are merged by zip code.

To specify the portion of consumers that are active in a market for either the DVD or VHS format, I use data on monthly DVD hardware penetration rates for each state. I assume that after a household has purchased a DVD player, they rent and purchase newly released titles on the DVD format.<sup>15</sup>

Finally, there is substantial variation in the price paid by consumers, both across stores, and across titles within a store.<sup>16</sup> In addition to rental activity, most stores sell used tapes for the 41 titles in the analysis, and charge different prices. However, some stores have zero

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<sup>14</sup>Approximately half of the major studios offer revenue-sharing contracts at this time. Although I do not observe title or studio names, I do observe that many of the included titles come from two studios that are fairly large in terms of releases. The title and studio characteristics look quite representative of other titles in the database.

<sup>15</sup>I thank Pinar Karaca-Mandic for her help in acquiring these data, and Centris for providing them. I provide additional detail on these data in Appendix A.

<sup>16</sup>I focus on the average price of a store-title pair. Thus, variation across titles within a store comes from having different prices for different titles at any point in time, as well as from variation in how quickly a title is moved from a high-price “New Release” section to a low-price “Catalog” section. Price variation across stores is more extensive than variation within-store. See Mortimer (2006) for more detail on price variation for a similar dataset.

market share for new sales of a title.<sup>17</sup> When I observe a zero market share for new sales, I assume the local price is equal to the suggested retail price (SRP), with the exception that rental-priced VHS titles are assigned the wholesale price faced by a retailer before re-pricing, and they are assigned the re-priced SRP after re-pricing.

### 3.2 Timing of Rentals and Sales

Table 3 provides summary statistics from the data on both the quantity and timing of rentals and sales. For the 41 titles used in the analysis, I compute weekly totals of rentals and sales for each title based on the first week it appeared at a store. The top half of the table refers to titles with a rental priced VHS release. The bottom half of the table refers to titles with a sell-through priced VHS release. All titles (including those with a rental priced VHS format) are sell-through priced on the DVD format. Of the 41 titles, 12 are rental priced (in the top half) and 29 are sell-through priced. The left half of the table reports total rentals and sales, and cumulative monthly rental and sales activity for the VHS format, while DVD results are reported in the right half of the table.

Columns 1 and 4 provide information on the timing of rentals for VHS and DVD. Approximately two-thirds of all rentals occur during the first two months for both sets of titles and formats and at least 85 percent of all rentals occur in the first five months. Columns 2 and 5 examine used sales. Relatively few used sales occur during the first two months when the rental market is most active; however, by month five, roughly half of all used sales have occurred. Unlike rentals and new sales, the sales of used tapes are not as clearly delineated by the timing of purchases, which is similar across the four quadrants of table 3. Finally, columns 3 and 6 examine the timing of new sales. For rental priced VHS titles, relatively few sales of new tapes (less than 15 percent) occur during the first five months. In contrast, roughly three-fourths of all new sales take place in the first five months for sell-through priced VHS titles, and this figure is nearly 85 percent for DVD titles.

Monthly prices of rentals and sales are shown in Table 4. Rentals of DVDs are slightly more expensive than VHS; there are no significant differences in the price of a rental according to whether or not a film was rental priced. This is somewhat surprising: one might

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<sup>17</sup>An additional motivation for selecting titles with at least 55 million in theatrical box-office receipts is that there is broad coverage of the titles across many stores. This is especially important for shares of new sales, which are under-represented in my dataset.

expect that lower costs of inventory should yield lower rental prices to consumers. I say more about this in the discussion of retailer behavior later in the paper. Prices of rentals do not change after month 5, because I aggregate rental transactions that occur after week 21 and report the average price. Prices of used sales are slightly higher for DVDs, and there are no significant differences between prices of used tapes based on whether or not rental pricing was used. Prices of used tapes are fairly constant over time. Average prices of new tapes during the first five months (before sell-through re-pricing occurs) range from \$89 to \$100. In contrast, prices of new sales in months 6 and higher average between \$18 and \$27. For sell-through priced VHS and all DVDs, prices of new sales after month five are very similar to prices in the first five months, although there is a small reduction in price over time.

## 4 Model

In this section, I outline a model of consumer demand and firm behavior restricted by current copyright law that specifies the conditions under which indirect price discrimination is a more profitable pricing strategy than non-discriminatory pricing. I also compare these outcomes to the results under an alternative copyright law where firms are able to use direct price discrimination. The model consists of a demand system for consumers and a supply decision for the firm. Consumers consider a single product that is vertically-differentiated according to whether or not the product is rented or purchased, and the supply decision specifies the firm's profit function and examines the conditions that determine the optimal pricing strategy. The goal in this section is to provide intuition in the simplest setting; the goal in the empirical work to follow is to be as general as possible in specifying the problem.

### 4.1 Consumer Demand

Consider a standard model of consumer demand for two vertically-differentiated products: the rental or purchase of a given movie title on a particular format.<sup>18</sup> For each title, I assume that the firm has monopoly ownership.<sup>19</sup> Consumers' utility functions are specified

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<sup>18</sup>Bresnahan (1987) used a vertically-differentiated model to analyze the automobile industry; Song (2004) is a more recent example in which a vertically-differentiated model is estimated. Much of the notation used here follows that in Berry (1994).

<sup>19</sup>Studios attempt to avoid competing with each others' titles by choosing different release dates: the 41 titles analyzed here are released across 108 weeks to avoid direct competition between titles. The inclusion of competing titles, although a potentially attractive extension of the model, requires an alternative set of

by:

$$u_i = \begin{cases} \delta_{i,s} - \alpha_i p_s & \text{if purchase} \\ \delta_{i,r} - \alpha_i p_r & \text{if rent} \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

The parameters  $\delta_{i,s}$  and  $\delta_{i,r}$  represent the quality to consumer  $i$  of purchasing and renting respectively;  $p_s$  and  $p_r$  denote the prices for purchasing and renting. The parameter  $\alpha_i$  represents the consumer's marginal utility of income and differs across individuals according to their income level and their unobservable willingness to pay for movie quality. Note that the inclusion of unobservable differences in  $\alpha_i$  can accommodate differences in consumer's opportunity cost of time, or any other factor that affects willingness-to-pay for movie quality. The quality parameters can be interpreted quite generally. For example, suppose that quality differs across consumer characteristics, so that

$$\begin{aligned} \delta_{i,s} &= \delta_s + X_i \beta \\ \delta_{i,r} &= \delta_r + X_i \beta \end{aligned} \quad (2)$$

There is an average value of owning or renting given by  $\delta_s$  and  $\delta_r$ . Beyond that, consumers differ in their utility from owning or renting a movie if they differ in  $X_i$ .  $X_i$  could include the number of times a consumer has already seen the movie, her family status, where she lives, and so on.<sup>20</sup> Utility maximization implies that consumers for whom  $\alpha_i < (\delta_r - \delta_s)/(p_r - p_s)$  will purchase, those for whom  $\alpha_i > \delta_{i,r}/p_r$  will choose the outside good, and the remaining consumers will rent.

## 4.2 The Pricing Decision

Assuming retailer mark-ups are zero, the firm maximizes:

$$\max_{\{p_r^w, p_s^w\}} \pi = N[(F(\tilde{\alpha})) \cdot (p_s^w - c) + (F(\hat{\alpha}) - F(\tilde{\alpha})) \cdot (p_r^w/\tau - c/\tau)]$$

where  $\tilde{\alpha} = (\delta_r - \delta_s)/(p_r - p_s)$  and  $\hat{\alpha} = \delta_{i,r}/p_r$ , and  $N$  denotes the number of consumers.

The parameter  $c$  denotes production cost, and  $p_s^w$  and  $p_r^w$  represents wholesale price in the

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assumptions about the nature of competition over time as new movies are released.

<sup>20</sup>Note that unobserved consumer characteristics are contained in  $\alpha_i$  and their inclusion in the  $\delta_i$ 's is not separately identified (i.e., whether you receive lower unobserved quality from the good, or just have a lower willingness to pay for it is indistinguishable).

sales and rental market respectively. Assuming perfect competition in the retail sector and no additional costs,  $p_s = p_s^w$ . The presence of retailer mark-ups or costs (denoted  $\mu_s$ ) would lead to  $p_s = p_s^w + \mu_s$ . The price of renting a tape is specified as  $p_r = p_r^w/\tau$ , which assumes no retailer costs or markups, and allows for each tape or DVD to rent out a fixed number of times  $\tau$ . This accounts for the fact that multiple rentals may be produced from each copy of the movie. The addition of retailer mark-ups or costs would lead to  $p_r = p_r^w/\tau + \mu_r$ .

The presence of  $\tau$  introduces some complications into the model. Specifically, one worries that retailers have control over how intensively they use inventory and can influence  $\tau$ . In fact, one expects that retailers' decisions will depend on how the movie is priced, with more intensive use made of higher-priced tapes. When considering the pricing decision of the firm, I assume that  $\tau$  is fixed and known to the firm. However, I allow it to differ according to how tapes are priced in order to address differences in retailer behavior.<sup>21</sup> The presence of  $\tau$  also leads to the possibility that rentals are rationed in any particular week. This is an important reason for aggregating rentals over time, because consumers can return over a period of several months to rent the movie later if it is stocked out at any particular time.<sup>22</sup> More generally, retailer behavior (whether through inventory usage  $\tau$ , or the addition of mark-ups or costs) is important for conducting counterfactual experiments on the firm's pricing decision, and I return to a more extensive discussion of retailer variables (including  $\tau$  and the markups  $\mu_r$  and  $\mu_s$ ) in the section on counterfactual policy experiments.<sup>23</sup>

#### *Direct Price Discrimination*

Under direct price discrimination, the firm sets different prices in the rental and sales markets simultaneously. All rental stores pay  $p_r^w$ , all consumers pay  $p_s^w$ , and rental consumers pay  $p_r^w/\tau$  for a rental. This strategy is not feasible under current U.S. Copyright law because firms are not allowed to charge different prices for different uses of the product.

#### *No Price Discrimination*

In the absence of price discrimination, the firm sets a single wholesale price  $p^w$ . The relative price of a sale compared to a rental is no longer under the control of the firm,

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<sup>21</sup>I assume that there are limits to how intensively retailers can use a tape or DVD. Specifically, I rule out the possibility that a retailer can buy one tape to serve any level of rental demand. Technically, this requires an additional constraint, which is that sales realized by the retailer are given by  $\min((F(\hat{\alpha}) - F(\bar{\alpha}), \tau \cdot \text{Inventory})$ .

<sup>22</sup>For additional robustness tests of alternative modeling choices for the  $\tau$  variable in the context of revenue-sharing programs, see Mortimer (2006).

<sup>23</sup>Estimation uses demand-side conditions only. Thus, none of the supply conditions discussed here affect the estimation of the quality parameters. They do, however, impact the results of the counterfactual estimates.

because the sales price is always larger by a factor of  $\tau$ . While the no-price-discrimination strategy is consistent with U.S. copyright law and used for virtually all movies released on the DVD format, the restriction of only being able to set a single price can be costly to the firm.

### *Indirect Price Discrimination*

In the absence of direct price discrimination, it may be possible to discriminate indirectly. In the home video industry, firms do this by lowering price about five months after a title's initial video release. In principle, firms could adjust price at many points in time. In practice, however, firms in this industry consistently chose a single repricing date. Consequently, I assume that firms are able to commit to future price paths, and I focus on firms' decisions to either price discriminate over two periods or not price discriminate at all.

Suppose that the value of the good to consumers decays between the two periods, so that the value of purchasing in the later period is  $\delta_{s2} < \delta_s$ . This captures the erosion of word-of-mouth, movie reviews, theatrical advertising, the disutility of waiting, or other factors that influence the quality of purchasing a movie over time.<sup>24</sup> Also, I assume that the rental market is fully served in period one (i.e., there are no "second-run" video stores that delay purchasing titles until they have been re-priced.)

The use of indirect price discrimination introduces a third product into the choice set so that consumers maximize utility over:

$$\begin{aligned}
 u_i = & \begin{aligned} & \delta_{i,s} - \alpha_i p_s && \text{if purchase in period 1} \\ & \delta_{i,s2} - \alpha_i p_{s2} && \text{if purchase in period 2} \\ & \delta_{i,r} - \alpha_i p_r && \text{if rent in period 1} \\ & 0 && \text{otherwise} \end{aligned}
 \end{aligned} \tag{3}$$

where  $p_{s2}$  is the price of purchasing in period 2. The firm has more control over the relative prices of rentals and sales compared to no price discrimination, but they destroy value in order to sort consumers because  $\delta_{s2} < \delta_s$ .<sup>25</sup>

<sup>24</sup>The quality decay differs from a discount factor because it does not apply to price or cost. A more critical assumption is that firms do not choose the extent of decay (for example, by engaging in special sales-oriented advertising campaigns or other initiatives). It is difficult to identify such effects empirically, and I have no reason to believe that the 'choice' of quality decay is a first-order decision for the firm in this context.

<sup>25</sup>In the absence of direct price discrimination, non-discriminatory pricing is preferred to indirect price discrimination whenever the optimal second-period price exceeds the optimal first-period price because consumers cannot be prevented from purchasing in the first period, and will indeed choose to do so.

Conditional on the rental technology  $\tau$ , one can solve numerically for the firm's optimal choice of pricing strategy under current U.S. copyright law, and I provide numerical simulations of the optimal choice over a range of parameter values in appendix B. The simulations indicate that the decision to use indirect price discrimination or no price discrimination depends upon 1) the value of the good in the rental market compared to its value in the sales market, and 2) the decay rate of the quality of owning between the first and second periods. The results give the following two predictions.

**Prediction 1: All else equal, indirect price discrimination becomes relatively more attractive as the value of the good in the rental market increases (i.e., as  $\tau \cdot \delta_r$  rises).**

Intuition: There is a stronger incentive to price discriminate between institutional and individual buyers as the total value of the good in the rental market increases. In this case, institutional buyers are willing to pay more for their rental inventories, so the benefit of discriminating across types of buyers is higher. Conversely, if the value in the rental market is relatively low, the firm is more likely to forgo indirect price discrimination and sell directly to consumers in the first period. This could happen if, for example, consumers want to watch the movie many times (such as for children's titles).

**Prediction 2: All else equal, indirect price discrimination becomes relatively more attractive as the decay rate falls (i.e., as  $\delta_{s2}$  rises).**

Intuition: The cost to the firm of delaying sales falls with the decay rate. Thus, a higher  $\delta_{s2}$  makes indirect price discrimination more attractive. Several factors could result in a higher  $\delta_{s2}$  for one movie versus another: consumers of the movie may be relatively patient, or characteristics of the movie or its audience may lead to a slower rate of quality decay.

See appendix B for the results of the numerical simulation.

## 5 Estimation and Results

In this section, I describe the necessary extensions of the demand specification, distributional assumptions, and sources of identification that are used in estimation. I use only demand-side moment restrictions for the purpose of estimation. Supply-side information is used for additional modeling of the retail sector after confirming a reasonable fit of the model's parameters.

### 5.1 Estimation and Identification

In order to estimate demand, it is necessary to include an additional product: purchase of a used tape. I assume a used tape provides lower quality than a new tape, but higher quality than a rental (for a particular title). Markets are defined as a zipcode-title-format triple as described in the data appendix. I consider two time periods for rental-priced titles: before and after sell-through re-pricing. Thus, a market includes three (or four) products: the rental of a title, the purchase of a used tape, and the purchase of a new tape (either now or later). Consumers in a particular zipcode choose among these products for either the VHS or DVD format, depending on which hardware they own.

I specify a Weibull distribution for the parameter  $\alpha$ , which captures the marginal utility of income. The Weibull distribution has parameters  $(\lambda, \rho)$ , s.t.  $\lambda, \rho > 0$ , and  $\lambda \equiv \exp(Z'_m \gamma)$ , where  $Z_m$  contains a constant term and the log of median income. The predicted demand for rentals as a function of the model's parameters is then given by:

$$q_{r,m,j} = N \cdot \left( \exp \left( - \exp(Z_m \gamma) \left( \frac{\delta_{u,m,j} - \delta_{r,m,j}}{p_{u,m,j} - p_{r,m,j}} \right)^\rho \right) + \exp \left( - \exp(Z_m \gamma) \left( \frac{\delta_{r,m,j}}{p_{r,m,j}} \right)^\rho \right) \right) \quad (4)$$

where the definition of market size,  $N$ , is defined appropriately according to appendix A. Similar solutions apply for new and used sales. The subscripts denote variation across use, titles and geographic market areas. Thus,  $\delta_{r,m,j}$  represents the quality level of a rental ( $r$ ) of title  $j$  in market  $m$ . (The VHS and DVD formats are estimated separately, so that  $\delta_{r,m,j}$  takes the appropriate value for that format.) Solving recursively across all uses of the good, I can rewrite the demand expressions in terms of the quality parameters. The quality of renting, for example, is given by:

$$\delta_{r,m,j} = p_{r,m,j}[-\ln(s_{0,m,j}) \cdot \exp(-Z_m\gamma)]^{-(1/\rho)} \quad (5)$$

where  $s_{0,m,j}$  denotes the marketshare of the outside good. Similar expressions are solved recursively for the local quality of used and new purchases ( $\delta_{u,m,j}$ ,  $\delta_{s2,m,j}$  and  $\delta_{s,m,j}$ ). Local market shares are denoted by  $s_{\cdot,m,j}$ , etc., and are defined as  $\frac{q_{\cdot,m,j}}{N}$ .

I decompose market-specific quality of a rental as:

$$\delta_{r,m,j} = \delta_{r,j} + X_m\beta_j + \xi_{r,m,j}. \quad (6)$$

The quality of used and new sales are similarly defined. The term  $\delta_{r,j}$  denotes the national average quality of a rental of movie  $j$ . Note that for each movie, there are up to 7 free demand parameters: one each for the national average value of rental, used, and new purchases (either now or later) for each of the two formats (DVD and VHS). The ability to include so many free parameters comes from the large number of markets, and is an attractive feature for estimating demand when many of a product's important attributes (such as the quality of a star's acting) may be unobservable.

The effect of any observable  $X_m$  (i.e., the  $\beta_j$ 's) is allowed to differ across both titles and formats, but not across different uses. This allows for horizontal differentiation across geographic markets for different movie titles on the basis of observables. For example, movie  $j$  may be more valuable on the DVD format in market  $m$  because it appeals to the demographic characteristics of the local DVD population. Local demographic shifters ( $X_m$ ) include the percent of the area that is suburban, store size, the percent of families who are married with kids, and the local DVD penetration rate, which is measured at the state level in each month. The inclusion of the DVD penetration rate is intended to proxy for demographic effects that are otherwise difficult to capture. For example, DVD adoption happens earliest at both high and low income levels, but varies significantly across geographic areas. Finally,  $\xi_{\cdot,m,j}$  captures the unobserved quality of a use of title  $j$  in market  $m$ . For example, a rental of title  $j$  may be more valuable in market  $m$  because of unobservable promotions or community events. Prices vary by market and also apply separately to VHS and DVD formats.

#### *Instruments*

A cost of the unrestrictive specification of the  $\delta$  parameters is that the only price variation not collinear with the demand intercepts is variation across stores for the same movie

in the same format and use. Thus, one worries that the unobserved attributes  $\xi_{.,m,j}$  may be correlated with the local retail price,  $p_{.,m,j}$ , and any such correlation will bias the estimate of  $\gamma$ . A valid instrument for price must be uncorrelated with the unobserved attributes of the good, but still correlated with price. Thus, researchers often use an instrumental variable that is either correlated with costs, or correlated with competitive conditions from the supply side. These measures affect price, but are uncorrelated with tastes for unobserved features of the product. In this case, we need to instrument for all three uses of the good: rentals, used sales, and new sales.

One might be tempted to think that the variable cost of a rental is a good instrument for rental price. This cost may be calculated by dividing the wholesale price of a tape by the number of rentals per tape for that store-title pair, where the wholesale price assumes a 40 percent discount off the observed suggested retail price of each videocassette tape or DVD.<sup>26</sup> Variation in retailers' average costs of rentals (for a given title) thus arises because of variation in the number of rentals per tape for a title: some retailers purchase 10 tapes and produce 100 rentals from them, while others purchase 10 tapes and produce 200 rentals from them. Unfortunately, constructing this variable requires an ex-post measure of rental demand (through division by  $q$ ) and so, by construction, the instrument is correlated with tastes for unobserved attributes of the local rental use of that title, and thus invalid.

Alternatively, one can construct an *expected* average cost of a rental of a title at a store by essentially jackknifing the cost of other similarly-priced titles on the same format, where 'similarly priced' refers to rental or sell-through pricing. For example, of the 12 titles released under rental-pricing terms on the VHS format, the *expected* average cost of a rental at store A of title 12 is measured by the average cost of a rental at store A of titles 1 - 11. The *expected* average cost for title 1 may be constructed in a similar fashion, averaging over titles 2 - 12, etc. This measure captures common cost components that store A faces for rental-priced titles on the VHS format, but preserves the title-level variation within the store. Essentially, the instrument captures the retail store's strategy: high rationing (low quality) or low rationing (high quality), which is correlated with the price of the rental, but

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<sup>26</sup>The wholesale discount figure was obtained through interviews with studio executives and video retail owners. Other discounts (such as volume discounts, bundling discounts, or other 'copy-depth' programs may also apply. I assume that retailers pay the usual wholesale price when reselling tapes, but get a 20 percent discount on rental inventories that are acquired under rental-pricing contracts. These figures were derived from consultations with industry executives; the results are robust to reasonable alternative assumptions on these costs (such as the removal or extension of the additional 20 percent discount.)

not with unobserved quality of the title.

A second alternative would be to not instrument for rental price. One might argue that there is sufficient stickiness in price across titles at a retail location that instrumenting for price is not necessary. In the analysis that follows, I present results with instruments, but not instrumenting yields results that are qualitatively the same.

For used sales, one might consider using the total rental inventory that the retailer ordered for title  $j$  less one unit, which is by definition his available supply of the used product. However, one may worry that  $\xi_{r,j,m}$  need not be uncorrelated with  $\xi_{u,j,m}$ , and if they are correlated, the inventory of the title is not a valid instrument. Instead, I construct a second ‘jackknifed’ instrument, using the *expected* average inventory of other similar titles to instrument for the price in the used market.<sup>27</sup>

Instrumenting for new sales is more straightforward. The cost to the retailer of title  $j$  depends only on the wholesale price. Unfortunately, this does not vary across retailers. Therefore, I interact the wholesale price paid by retailers with their observed competitive conditions, which includes the number of video stores in the same zipcode.<sup>28</sup> This instrument captures both cost factors and market conditions and preserves variation across stores for a given title.

Having described the instruments, one can now use equation 6 to form moment conditions:

$$E(W'\xi_{.,m,j}) = 0 \tag{7}$$

where  $W$  includes  $Z_m$  and the instrumental variables. The parameters to be estimated are:  $\theta \equiv (\delta_r, \delta_u, \delta_s, \delta_{s2}, \beta, \gamma)$ . The parameters  $\delta_r, \delta_u$ , and  $\delta_s$  are all vectors of length  $J$  (the number of titles), while  $\delta_{s2}$  has length equal to the number of rental priced titles. Estimation proceeds using generalized method of moments, choosing  $\theta$  to minimize

$$\hat{\theta} = \operatorname{argmin} \left( \sum_i \psi(\theta, W_i) \right)' A \left( \sum_i \psi(\theta, W_i) \right),$$

where  $\psi(\theta, W_i)$  is the set of moment conditions,  $i$  is now used to denote format-title-use

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<sup>27</sup>This instrument is constructed analogously to the *expected* average cost in the rental market, but using inventory, not average cost.

<sup>28</sup>Note that the wholesale price set by the studio only depends on the national average quality, not local deviations from that. So any unobserved quality that is accounted for in the wholesale price is picked up by the demand intercepts  $\delta_{s,j}$ .

observations, and  $A$  is a weight matrix chosen to minimize variance according to Hansen (1982).

Direct estimation of  $\hat{\theta}$  is difficult because of the large number of demand parameters (258 parameters in the  $\delta$  vectors, plus 328 parameters in the  $\beta$  vector, plus 3 parameters in the  $\gamma$  and  $\rho$  vectors). However, all of the  $\delta$  and  $\beta$  parameters enter  $\xi$  linearly, which allows me to simplify the estimation by using a two-step procedure. I first guess values for the  $\delta$  and  $\beta$  vectors, then given those values, I minimize the objective function (which is non-linear) over values of  $\gamma$  and  $\rho$ . Given the new values of  $\gamma$  and  $\rho$ , I construct fitted values of  $\delta_{.,m,j}$ 's, which I then regress on title-use-format dummies and the  $X_m$ 's to recover new estimates of the  $\delta$  and  $\beta$  vectors. I iterate this procedure until convergence.

As utility functions are ordinal, I need to normalize at least one of the quality parameters. I normalize the value of the outside good for movie 1 on the VHS format such that  $E(X_m\beta_1)$  is equal to a constant.<sup>29</sup> The remaining  $\delta$  parameters are identified from market shares, both in levels and in relative terms. Specifically, better movies overall have higher market share for all uses, and movies with higher market share in the sales market relative to the rental market have a higher sales value. Market shares vary across movies, formats, and retail store locations for a given price. The  $\gamma$  and  $\rho$  parameters are identified from (1) the normalization of the quality of the first movie in the first market, (2) variation in income, and (3) variation across geographic markets in the relative market shares of rentals vs. sales (for all movies).

## 5.2 Estimation Results

Table 5 provides estimates of the parameters of the model. Rather than report 41 sets of quality parameters (one set for each title), I report means of the parameter estimates for each of the four format-pricing types (i.e., VHS and DVD formats, based on whether the VHS format was rental priced or sell-through priced.) After discussing the means, I provide scatter plots comparing the quality parameters for individual movies.

The  $\beta$  parameters affect the ‘local quality’ or local taste for movies, across all uses of a

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<sup>29</sup>I calculate the value of  $E(X_m\beta_1)$  by setting  $\alpha = 1$ , computing the  $\delta_{.,m,j}$ 's, and then regressing  $\delta_{.,m,j}$  on use dummies and  $X_m$ . The vector  $\beta_1$  from this regression (i.e., the value of the  $\beta$  vector for title 1, on VHS) was then used to normalize the outside good in each market for title 1. This was done to preserve geographic variation in the normalization for title 1. Normalizing the value of  $\beta_1$  to be zero in all geographic markets would be perfectly valid from an econometric point of view, but would give the same value of the outside good for all geographic markets. My method normalizes  $\beta_1$  to be equal to a vector of non-zero constants while preserving variation across markets.

title. Larger stores are located in neighborhoods with greater demand for movies regardless of format (the average  $\beta$  associated with store size is positive). A higher proportion of “married with children” households is associated with a lower demand on the VHS format, but with a higher demand on the DVD format, although this varies by movie and genre. Suburban areas have relatively lower demand for the DVD format compared to their non-suburban counterparts. This effect is often not statistically significantly different from zero for individual titles.

DVD hardware penetration rates are strongly correlated with tastes for movie watching. Neighborhoods with higher DVD penetration are estimated to have lower demand for the DVD format per household. This is consistent with an adoption pattern of DVD hardware in which high-value consumers adopt early, so that as later adopters enter the DVD market (and DVD penetration increases), the average demand falls. Finally, the parameters of the distribution of  $\alpha$  indicate that neighborhoods with higher median income are associated with a higher willingness to pay for movies on tape or DVD ( $\gamma_1 = 0.96$ ).

The average quality of a rental is slightly lower for the DVD format compared to VHS, while the used and new sale DVD quality parameters are higher. There is a larger difference between DVD sales qualities for the two groups of titles (rental vs. sell-through priced) than there is on the VHS format. This is primarily driven by lower average quality estimates for children’s titles on the DVD format, which drives down the sales quality estimates of DVD titles that were sell-through priced on VHS.<sup>30</sup>

The decay rate for the quality of a purchase is estimated as the ratio of the average quality of a purchase in the second period and the average quality of a purchase in the first period for rental priced VHS titles, and is 0.89. The relative value of renting versus owning is higher on the VHS format: I estimate that a consumer receives over 70 percent of the value of owning a VHS tape from renting it one time. The comparable figure for the DVD format is around 50 to 60 percent.

Table 5 also reports values for the parameters  $\tau$  and  $\mu$ , which are calculated directly from the data. The  $\tau$  parameter is the ratio of rentals to inventory, and differs considerably across the two pricing regimes. Table 5 indicates that VHS inventory is used more intensively for titles that are rental priced, producing 23.7 rentals per tape compared to 16.9 rentals per

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<sup>30</sup>Anecdotally, trade press articles cite the ease of use of the VHS format for children as one source of this difference, because VHS tapes can be inserted into a machine and automatically played without the need to press any additional buttons.

tape for sell-through priced titles. DVDs show almost no difference in the rental technology across the two sets of titles, producing 15.6 and 15.3 rentals respectively. The  $\mu$  parameter is the difference between the observed retail price and the observed variable cost of the rental. Retail mark-ups are higher for the sell-through priced VHS titles and for DVDs: around \$2 compared to \$-0.03 for rental priced titles on the VHS format, and between \$0.38 and \$0.90 for both sets of titles on the DVD format. Sales mark-ups by retailers are around \$40 in the first period for rental priced VHS, but are around \$4 after re-pricing. Mark-ups in the first period for sell-through priced VHS and titles on the DVD format range from \$8 - \$10. The retailer mark-up on sales of used tapes is assumed to be equal to the price.<sup>31</sup>

#### *Estimating Second Period Quality*

The quality of a second-period purchase is not identified directly for sell-through priced titles, because there are no data on any actual second-period purchases for those titles. I construct an estimate of second-period quality for these titles as follows. The average difference between the first-period new purchase quality and the used purchase quality is estimated for each genre from the 12 rental-priced titles in the top panel.<sup>32</sup> I then calculate the percentage split represented by the second-period purchase quality for these titles, and apply that percentage to the sell-through priced titles in the second panel. For example, if rental-priced dramas have average used, period 2, and period 1 qualities of 1, 1.5, and 2, respectively, and a sell-through priced drama has used and period 1 qualities of 2 and 4, then the period 2 quality assigned to that title is 3.

One downside to estimating second-period quality for sell-through priced titles in this way is that unobserved differences in the second-period quality may be the reason that the firm chose to do sell-through pricing. In fact, this is predicted by the theoretical model. Fortunately, it is straightforward to bound this parameter, because the second-period quality is presumably greater than the used quality (and also less than the period-one new quality).

### **5.3 Scatterplots of Quality Estimates**

Table 5 provides the mean quality estimates for each of the four movie-format groups, but does not show the variation across titles that the estimates are able to capture through the

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<sup>31</sup>Both  $\tau$  and  $\mu$  need to be modeled in any counterfactual analyses. I discuss this in the next section.

<sup>32</sup>For children’s titles, I used PG-rated “family” movies, which are primarily directed at the children’s market.

large number of free demand intercepts. Figures 1 through 4 provide some insight into the nature of this variation.

The theoretical model makes two predictions for the firm’s pricing decision based on the value of the rental and second-period sales markets: movies with (1) higher value in the rental market, and/or (2) slower decay in the sales market, should be more likely to be rental priced, all else equal. To test these predictions using our estimates, I need to scale each movie’s quality parameters by its value in the sales market to make movies comparable. Thus, I scale each movie’s estimated value in the rental and second-period sales markets by its value in the first-period sale market.<sup>33</sup>

Figure 1 provides a scatterplot of the estimated relative value of each movie in the rental market on the vertical axis. The estimated relative value of each movie in the second-period sales market is plotted on the horizontal axis.<sup>34</sup> The predictions of the theoretical model are that rental-priced movies should lie in the northeast part of the plane, with sell-through priced movies lying closer to the origin. Figure 1 shows that the first prediction clearly holds: movies for which the firm chose price discrimination are more valuable in the rental market. The result for the second prediction is more ambiguous: the theoretical model predicts that the rental-priced titles would lie to the right of sell-through priced titles, and this is not obviously true in figure 1. However, this prediction should be more difficult to show in the data because we do not directly observe second-period sales for sell-through priced titles, and estimates of these qualities are based on average values from the set of rental priced titles.

Figure 2 plots the quality parameters using the lower bound of second-period quality for the sell-through priced titles, calculated as  $\delta_{u,j} + .0001$ . This moves things in the expected direction: the results for sell-through priced movies are relatively closer to the origin now. A much clearer picture emerges if one compares the same set of movies on the two formats. Figure 3 displays estimated quality levels for the twelve movies that were rental-priced on their VHS format and simultaneously sell-through priced on their DVD format. Clearly,

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<sup>33</sup>I also need to map the estimated values into the positive number line, as the normalization in the demand specification is very unrestrictive, and only normalizes the value of the first movie in the first market. As a result of this unrestrictive normalization, some movies may have estimated quality parameters that are negative, making ratios of the qualities difficult to interpret across movies. I use the exponential function for mapping quality parameters to the positive number line. This is done only for displaying relative quality estimates across movies in the scatterplots. Counterfactual estimates use the actual quality parameters.

<sup>34</sup>The exact mappings are  $\tau \cdot \exp(\delta_r) / \exp(\delta_s)$  for the value in the rental market, and  $\exp(\delta_{s2}) / \exp(\delta_s)$  for the second-period sales market.

the two formats match the predictions of the theoretical model, with the VHS format being both (1) relatively more valuable in the rental market and (2) relatively more valuable in the second-period sales market. This separation is not evident when comparing movies on VHS and DVD formats that were sell-through priced for both format types (as in figure 4).<sup>35</sup>

## 6 Counterfactual Experiments and Welfare Analysis of Copyright Law

Using the estimated demand model I can also examine the welfare implications of price discrimination under current U.S. copyright law. I use the estimated parameters in table 5 to predict market shares, variable profits for studios and retailers, and consumer surplus assuming that studios choose the price or prices that maximize their profit for each title. I then recalculate market shares, variable profits and consumer surplus under the assumption that studios adopt the “other” pricing regime in each of the four groups of title-format pairs, allowing for the studio’s optimal price under the alternative regime. That is, I examine the outcomes if rental priced titles were instead sell-through priced and vice versa. This counterfactual yields the welfare implications of alternative pricing strategies under U.S. copyright law.

### 6.1 Additional Modeling for Counterfactual Experiments

#### *Retailer Markups and Inventory Use*

Theoretical predictions of a firm’s price discrimination strategy depend on its estimated benefits and costs. As I have shown, these benefits and costs depend on a movie’s value in the rental market and its rate of decay in the sales market. However, retailer behavior can also affect a movie’s value in the rental market, and may depend on the pricing strategy taken by the firm. One should take this into account when comparing the profitability of different pricing strategies.

There are two choices for how to handle changes in retailer parameters, which are  $\mu$  and  $\tau$ . On one hand, one could write down a model of retailer competition in which  $\mu$  and  $\tau$  are determined endogenously. One challenge with this approach is that many of the observable

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<sup>35</sup>Both figures 3 and 4 use the lower bound of the second-period sales quality estimates for sell-through priced titles, but the same qualitative patterns emerge if I use the average estimate of second-period sales quality.

competitive conditions at the retail level do not change across pricing types. Alternatively, one could adopt a less complete model of retailer competition, but use the rich structure of the data to predict changes in  $\mu$  and  $\tau$  empirically under counterfactual pricing strategies. The benefit of this approach is that it retains the focus on the pricing decision and allows for considerable flexibility within the set of prices that are observed. It also allows for flexibility across retailers that differ according to unobservable characteristics, but which have the same observable characteristics. The main drawback to this approach is that, while it may give quite accurate predictions about changes in  $\mu$  and  $\tau$  for pricing contracts that are observed, it is less informative about changes in  $\mu$  and  $\tau$  for prices for which we have no observations. In other words, out-of-sample predictions are more constrained. I adopt the second method.

For  $\mu$ , I assume that each retailer receives the average markup observed for its “other” priced movies when examining the effects of the “other” pricing strategy. For example, for a rental of title  $j$  at store  $k$ , I regress:

$$\mu_{rjk} = \mu_{0,rk}RP_j + \mu_{1,rk}STP_j + \epsilon_{rjk} \quad (8)$$

where  $\mu_{rjk}$  is the observed markup for rentals of title  $j$  at store  $k$ . This is calculated directly from the data, and I report the average  $\mu_{rjk}$  in table 5.  $RP_j$  is a dummy for whether or not title  $j$  was rental priced, and  $STP_j$  is a dummy for whether or not title  $j$  was sell-through priced. For retailer  $k$ , I use  $\hat{\mu}_{0,rk}$  for examining outcomes of a rental pricing strategy for titles that were actually priced for sell-through, and I use  $\hat{\mu}_{1,rk}$  for examining outcomes of a sell-through pricing strategy for titles that were actually rental priced. An analogous approach identifies markups of sales. Thus,

$$\mu_{sjk} = \mu_{0,sk}RP_j + \mu_{1,sk}STP_j + \zeta_{sjk} \quad (9)$$

gives counterfactual markups for sales. In addition to modeling retailer markups, I allow for a change in the intensity of inventory use under the counterfactual pricing regime. This is due to the difference in the cost of a tape for downstream retailers. In a method analogous to that used for retailer markups, I regress

$$\tau_{jk} = \tau_{0,k}RP_j + \tau_{1,k}STP_j + \eta_{jk} \quad (10)$$

where  $\tau_{jk}$  is the observed inventory usage of title  $j$  at store  $k$ . I use  $\hat{\tau}_{0,k}$  and  $\hat{\tau}_{1,k}$  to give counterfactual inventory use for titles that were actually sell-through or rental priced, respectively.<sup>36</sup> One could incorporate other variables in these predictions to allow for a smoother mapping over prices. For example, one could regress  $\mu$  and  $\tau$  on pricing indicators as well as on actual wholesale prices. In all of these methods, I assume that the regressors are orthogonal to the error terms.

One limitation to this method is that a higher  $\tau$  does not directly affect consumer utility. One worries about an effect like this if, for example, a higher  $\tau$  leads to longer (and less desirable) wait times for consumers because of rationing. Assuming that retailers use rental-priced tapes more intensively, and that consumers do not like waiting, consumer welfare would thus be lower for rental-pricing regimes. Furthermore, the effect of rationing may change if the pricing of all titles changed.<sup>37</sup>

#### *Durable Goods and Used Markets*

Finally, the demand for used tapes highlights an important issue for producers of durable goods. I assume that the market for used tapes is constrained by the level of inventory purchased by retailers. Thus, I assume that retailers can only sell used tapes up to the level of their inventory, less one tape to keep for future rental business. In many cases, this leads to rationing of used tapes. This effect is quite interesting, as it highlights the importance of price discrimination in markets for durable goods where the firm does not control the second-hand market.

## **6.2 Welfare Analyses**

The results of the counterfactual pricing decisions are contained in tables 6 - 8. I start with table 6, in which the first two columns give actual and estimated market shares for the VHS format. The table is divided into two panels, according to whether or not a title's VHS release was rental or sell-through priced. The first column lists actual prices, market shares, and variable profits for upstream and downstream firms. The reported profits are the average variable profits for a title, assuming that mark-ups and prices in the unobserved

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<sup>36</sup>I have also performed a number of robustness tests, such as calculating the average increase in inventory use for the two pricing regimes, and applying that to each store's actual  $\tau$  for each title. The average increase is around three (i.e., stores produce three times as many rentals from each tapes for rental-pricing titles, compared to sell-through priced titles). The results are not affected in any meaningful way.

<sup>37</sup>One could incorporate this type of effect with some additional assumptions on the utility functions. For example, one could allow the quality of a rental to decrease based on the estimated  $\tau$  that is relevant to the pricing counterfactual.

stores in each market are the same as the mark-ups and prices I do observe. Actual market shares are around 25 to 29 percent for rentals of titles on VHS. Column 2 solves for the optimal monopoly price, given the parameter values. In the top panel, covering rental priced VHS titles, the optimal price is estimated to be slightly lower than the actual price for this set of titles, with slightly higher profits to the studio and to retailers. Overall, the estimated prices indicate a reasonably good fit to the data. In the bottom panel, covering sell-through priced VHS titles, estimated prices and market shares are quite close to the actual. The demand model appears to predict the data quite well. Subsequent comparisons will be to the results in column two.

Column 3 gives predicted market shares and profits under the “other” pricing regime. For the top panel of table, which contains rental-priced movies, this corresponds to the adoption of sell-through pricing. I again solve for the optimal wholesale price. Markups and inventory use are modeled as described in the previous section. At these parameter values, the use of sell-through pricing results in a roughly 15 percent reduction in profits on average for the studio. Retailers would be 10 percent better off under this pricing regime, and consumers would be worse off under this scenario, with consumer surplus falling roughly 21 percent. In the lower panel, the third column corresponds to counterfactual outcomes under rental pricing. Both studios and retailers are worse off under rental pricing for this set of titles. This is consistent with reports in industry trade journals and interviews about the expected effects of rental pricing for such movies. Consumers are also worse off.

Note the effects of rental pricing strategies to limit the size of the used market. Studios receive no revenues from these sales, and price new tapes in order to shrink the supply of used tapes under the rental pricing strategy. The shrinking of this market also occurs because video stores are assumed to use inventories more intensively under rental pricing, thus carrying smaller inventories that can subsequently be re-sold.

Unlike the U.S. system, copyright laws in many other countries (most notably, the EU and Australia) permit copyright holders to control subsequent use of a copyrighted good. This has lead firms to adopt direct price discrimination in these markets. Column 4 gives results under market segmentation, similar to the pricing policies observed in countries with EU-type copyright laws. Under this regime, firms charge different prices to retailers and consumers on the first day of a movie’s video release, but I assume they do not engage

in intertemporal price discrimination.<sup>38</sup> I adopt parameter values of  $\mu_r$  and  $\tau$  that are appropriate to rental pricing in this exercise. I estimate that market segmentation makes firms worse off compared to rental pricing for movies in the upper panel. Consumer surplus decreases by 18 percent. The lower panel shows a positive effect for studios under EU-type pricing, although retailers receive lower profits than they would have under rental-pricing, and consumers are worse off.

Table 7 provides the same results for the DVD format. The comparison between the first two columns indicates a good fit of the model. Results of the experiment of adopting rental pricing for DVDs are shown in column three. Studios and retailers are estimated to be worse off under rental pricing for both groups of titles, as are consumers. Column four considers direct price discrimination (market segmentation). Studios are estimated to increase their profits by about 5 to 7 percent under this pricing regime compared to the sell-through pricing strategy used currently in the U.S. Consumers also benefit significantly under this policy. On the other hand, the use of market segmentation is estimated to make retailers worse off.<sup>39</sup>

Comparisons of ‘current’ versus ‘other’ results for tables 6 and 7 provide average results across titles, and indicate that firms choose the correct marketing scheme on average. Examining firms’ decisions for individual titles (not reported separately) shows that firms choose the correct marketing scheme for 35 of the 41 movies on the VHS format, and for 32 of the 41 movies on the DVD format. The estimated difference in profits across the two pricing regimes range from close to zero (there are 9 movies where the difference is less than 3 percent) to one movie with a 99 percent difference in profits. For the vast majority of titles, the difference in profits is between 20 and 40 percent. The difference in the estimated profits for movies that were priced ‘incorrectly’ was often small: of the 15 ‘wrong’ pricing decisions, 5 movies would have realized profits that were no more than 3 percent higher under the alternate regime. In other words, most of the bad calls were close calls. There is not an obvious pattern of mispricing by genre or rating classification across titles.

Table 8 examines the outcomes among current VHS participants under the assumption

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<sup>38</sup>The assumption of no intertemporal price discrimination follows the actual current practice of firms in these markets.

<sup>39</sup>Anecdotally, the average predicted prices under this scenario (\$40 for retailers and \$24 for consumers for the set of sell-through priced titles) are very close to some actual prices charged for recent sell-through priced DVD releases in the U.K.. For example, *Garfield - The Movie*, with U.S. theatrical box-office receipts of \$75 million, was released in the U.K. recently at prices of £15.99 and £11.99, or \$30.74 and \$23.05, for retailers and individuals respectively.

that everyone in the VHS market eventually adopts DVD technology. The outcomes are calculated by replacing the product quality parameters for each title-use pair under the VHS format with the quality parameters for the same title-use appropriate to the DVD format. Retailer mark-ups are assumed to be unchanged compared to the values in the equivalent columns in table 6, as are consumers' tastes for all uses of a movie (i.e., the  $\beta$  parameters, and all the  $x$ 's).<sup>40</sup> Production costs for the studio are adjusted to reflect production costs for DVDs.

The results in table 8 indicate that as the VHS market adopts DVD technology, rental-pricing becomes a more profitable strategy, compared to sell-through pricing. Despite the higher estimated quality of the DVD technology for owning compared to renting movies, the population that was using VHS technology in 2000 and 2001 differs from their DVD counterparts in the overall utility that it receives from watching movies (the  $\beta$ 's). As a result, studio profits are estimated to be 24 percent higher under a rental-pricing strategy for the group of titles that were rental priced on VHS. On the other hand, studio profits are estimated to be 5 percent lower under a rental-pricing strategy for titles that were sell-through priced. Retailers are worse off under the rental pricing regime than they would be under continued sell-through pricing policies, while consumers are made better off by the adoption of rental pricing. Market segmentation, or EU-style pricing, leads to higher studio profits than the profits expected with no price discrimination for both groups of titles. EU pricing also leaves retailers with lower profits than they would have earned under a sell-through pricing regime, while consumers benefit from a shift from sell-through pricing to EU pricing.

## 7 Conclusion

Firms respond strategically to the legal restrictions imposed upon them and the technologies they face. As a result, giving additional control to a copyright holder may affect pricing strategies and may also impact consumer surplus and producer surplus for firms that use copyrighted goods as inputs (e.g., retailers). To identify factors influencing firms' optimal responses to U.S. copyright law, I empirically examine the outcomes of two pricing strategies used by firms for products that are identical in content, but distributed via an old established

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<sup>40</sup>The DVD penetration variable is meant to serve as a proxy for other unobserved differences in the value of a movie for this population. Thus, I don't change  $x\beta$  for the VHS population when I conduct the experiment.

technology and a new emerging technology. I show that the decision to price discriminate depends on the expected costs and benefits of doing so, and I provide empirical evidence that firms account for the costs and benefits of indirect price discrimination when choosing their optimal pricing strategies. Using a new dataset covering the distribution of movies on VHS and DVD formats, I find that firms choose the more profitable pricing strategy across titles and formats. Across the two formats, consumers' tastes are different, but DVDs also differ in their relative quality levels: they aren't as valuable in the rental market, and their value in the sales market decays quickly. Thus, both demographic and technological differences matter for pricing the new format.

I also examine the welfare effects of the current price discrimination strategies used by firms in the U.S., and find that indirect price discrimination benefits copyright holders, but generally harms retailers. Consumer welfare is highest under the current price discrimination strategies in use; thus, for some titles, indirect price discrimination benefits consumers, while for other titles, consumers are made worse off by this form of price discrimination. I also estimate the welfare effects of an alternative form of copyright protection that would allow for direct price discrimination. I find that price discrimination under this law tends to benefit copyright holders and consumers at the expense of retailers.

Future research could examine the effects of indirect price discrimination when used in conjunction with revenue-sharing contracts. Such contracts were widely used for rental priced movies on the VHS format in the late 90s, and could affect social welfare in the future if indirect price discrimination were adopted for DVDs. By reducing some of the inefficiencies of indirect price discrimination, revenue-sharing may help to mitigate welfare losses due to copyright restrictions, and would make indirect price discrimination even more attractive.

## Appendix A: Data

The auxiliary data sources outlined in section 3 are used to define market size based on geographic size, format use and outlet market share (to weight the observations from video rental stores). Geographic market size is based on zip codes. Clearly, zip code areas are designed to provide convenient local areas for the purposes of delivering mail, rather than as definitions of local markets. However, zip code areas appear to be a reasonable demarcation between markets in this setting: the average zip code area contains approximately 24,000 people and 2.6 video retail stores. Larger areas, such as 4-digit zip code areas or Metropolitan Statistical Areas (MSA's) are also feasible ways of attaching local demographic and business listing information, but seem to cover too large a geographic area for most video store customers.

For format use, I use Centris data on DVD hardware penetration. Centris surveys consumers each month on whether or not they own a DVD console, and weights each consumer survey response according to a demographic weighting scheme.<sup>41</sup> The Centris data begin their coverage in the late 1990's and continue through June 2001. I aggregate the individual surveys in each state to calculate an implied state-level DVD hardware penetration rate. Due to the limitations of the survey size in each month, and the noisiness of the weighting scheme, I then fit a linear trend in each state across the eighteen months of January 2000 through June 2001. I use these fitted penetration rates in each month in each state as the actual penetration rates, and I assume that they are uniform within a state during that month.<sup>42</sup>

I denote  $N_{m,q}^{VHS}$  and  $N_{m,q}^{DVD}$  as the number of consumers in market  $m$  and month  $q$  that rent and purchase movies on VHS and DVD formats respectively. The estimates of  $N_{m,q}^{VHS}$  and  $N_{m,q}^{DVD}$  in each market are:

$$\begin{aligned} N_{m,q}^{VHS} &= [HH \cdot (0.90 - DVD_q)] / STORES_{m,y} \\ N_{m,q}^{DVD} &= [HH \cdot DVD_q] / STORES_{m,y} \end{aligned} \tag{B.1}$$

where 0.90 is the national penetration of VCRs, assumed to be constant across markets,

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<sup>41</sup>Karaca-Mandic (2003) provides more detail on the Centris data.

<sup>42</sup>One would of course like to have even more detailed information on these penetration rates, but these are the best data available to my knowledge.

the variable  $HH$  is the number of households in the zipcode from the 2000 U.S. Census, and the variable  $DVD_q$  is the penetration rate of DVD hardware in the relevant state and month.<sup>43</sup> The variable  $STORES_{m,y}$  is the number of video specialty stores listed in the phonebook for that zipcode in a particular year. I observe roughly 1 of 3 stores in each zipcode neighborhood. Unfortunately, I do not observe rentals and sales at other stores. Dividing  $N$  by the number of stores in the market inflates my observed sales and rentals at a single store to be representative of the local zip-code area, under the assumption that the unobserved stores have the same characteristics and sales as the observed store, and that phonebook listings represent the total population of video specialty stores.

The market for purchasing VHS tapes and DVDs also includes used tapes from stores' rental inventories. Unfortunately, the primary data source does not record sales transactions separately as used or new. The best definition I have for distinguishing between new and used products is on the basis of price. I estimate wholesale price as being equal to 60 percent of the suggested retail price. This estimate is also borne out by industry interviews. Thus, I classify a sale as 'used' if the average weekly price of sales for a title at a store is below the wholesale price of a new tape. This classification identifies approximately 80-85 percent of all sales at my observed video specialty stores as used. I checked these estimates with professionals in the industry and with more detailed tabulations of the phone-survey data in Table B.1. For purposes of weighting the sales and rental observations, I assume that all sales of used tapes occur through video specialty stores (and not, for example, through mass-merchandisers like Walmart).

In order to weight the observed rentals and sales according to the market share of the stores in my database, I use an auxiliary dataset on phone-survey data that asks respondents for information on where they purchased and rented videos. Table B.1 outlines market shares of rentals and purchases according to the type of retail outlet where rentals and purchases occurred.<sup>44</sup> Rentrak's data cover the population in the first row of table B.1, 'Video Specialty retailers,' and I make use of the data in the other rows of table B.1 to weight my estimated market shares. As shown in table B.1, Video Specialty retailers represent nearly 77 and 74 percent of all VHS and DVD *rentals* respectively. However,

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<sup>43</sup>I match up titles to the monthly state penetration figures based on the month in which a title was released. The figure for overall VCR penetration (0.90) is from the VSDA 2002 Annual Report.

<sup>44</sup>The table is constructed from data gathered on consumers' purchase and rental habits by Alexander and Associates, and reflect market shares as of the spring of 2002.

a greater proportion of *sales* occur through alternative distribution channels, including Internet and non-specialized retail outlets, and so it is important to weight the sample accordingly.

Table B.1: Market Shares of Alternative Distribution Channels: Rentals and Sales\*

Retail Outlet	VHS Rental	VHS Sales	DVD Rental	DVD Sales
Video Specialty	76.8%	22.9%	73.8%	10.0% (1)
Other brick&mortar/ grocery stores, etc.	23.2	10.7	17.1	30.0 (2)
Internet (Netflix, etc.)	0	1.9	9.1	10.0
Discount merchandiser (i.e., Walmart, etc)	0	55.1	0	40.0 (3)
Other (direct mail, etc)	0	9.4	0	10.0

\*Data Source: Alexander and Associates. Sales tabulations reflect activity for the second quarter of 2002; rental tabulations reflect activity for May 2002.

(1) Includes Blockbuster at 7 percent (mostly pre-viewed DVDs) and an allowance for other video specialty stores.

(2) Includes Best Buy at 20 percent, Circuit City at 5 percent, and an allowance for others at 5 percent.

(3) Includes Walmart at 29 percent, Target at 8 percent, and an allowance for others at 3 percent.

I assume that purchases from discount merchandisers and Internet firms, etc., occur with equal probability across zipcode areas, and that used tapes are only sold by video specialty stores. The phone-survey data include both used and new sales. Thus, the weight in table B.1 gives the weight to be applied for all sales (used plus new). In order to get the

correct weight for new sales, I calculate the total number of weighted sales, subtract used sales, and calculate the appropriate weight for new sales. I do this for each store-title pair on each format, using format-specific weights from table B.1. Now I can write down the relevant market size for each store-format-product as:

$$\begin{aligned}
N_{r,m,q}^{VHS} &= 0.768 \cdot N_{m,q}^{VHS} \\
N_{u,m,q}^{VHS} &= N_{m,q}^{VHS} \\
N_{s,m,q}^{VHS} &= W_{VHS} \cdot N_{m,q}^{VHS} \\
N_{r,m,q}^{DVD} &= 0.738 \cdot N_{m,q}^{DVD} \\
N_{u,m,q}^{DVD} &= N_{m,q}^{DVD} \\
N_{s,m,q}^{DVD} &= W_{DVD} \cdot N_{m,q}^{DVD}
\end{aligned} \tag{B.2}$$

where  $W_{VHS}$  and  $W_{DVD}$  are vectors of new sales weights for each store-title pair on VHS and DVD formats respectively. This definition of market size effectively weights the sample of stores appropriately to reflect the national market.<sup>45</sup> It would be wonderful to have data on new sales from other outlets, such as mass-merchandisers. Unfortunately, I do not observe title identity, so collecting and matching such data is not possible.

Table B.2 shows total activity levels in the data, as well as weighted totals. Most of the sales that occur in this population of stores are sales of used tapes. The weights applied to new sales are much larger, as I discuss in the estimation section. The ratio of total weighted sales to total weighted rentals across the four quadrants shows a higher overall level of weighted sales for DVDs compared to VHSs: 29.9 and 34.5 percent of rentals for DVDs versus 13.2 and 7.5 percent of rentals for the same titles on VHS format. Note that by comparing the different titles on the DVD format, one should get a sense of the importance of the endogeneity of the sell-through pricing decision. DVDs are priced the same for all titles, so the extent to which sell-through priced titles sell better on DVD than rental priced titles should be due to unobservable characteristics of the titles that make them relatively more desirable to own. This difference in the ratio of sales to rentals for these sets of titles is 4.6 percent for DVDs (34.5 versus 29.9 percent). Overall levels of DVD activity (including rentals) are higher for sell-through priced titles, but overall levels of VHS activity are higher for rental priced titles.

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<sup>45</sup>I have also estimated the model assuming that sell-through priced VHS titles have the same representation across video stores and mass merchandisers as DVDs. This does not change the results in any meaningful way.

Titles sell less often on the VHS format. This presumably reflects a relatively higher quality attached to owning DVDs compared to VHS tapes, perhaps because of the increased durability or flexibility for playing the DVDs on laptops, etc. It could also reflect differences in taste for quality across the population of consumers adopting DVD versus VHS. The difference between rental priced titles and sell-through priced titles on the VHS format reflects both unobservable differences in the desirability of owning that lead to a sell-through or rental-pricing decision, as well as the effect of delaying sales of the rental priced titles. The difference here is quite large: sales total 13.2 percent of rentals for sell-through priced titles, compared to 7.5 percent of rentals for rental priced titles. The difference is due to both lower levels of rentals as well as higher levels of sales.

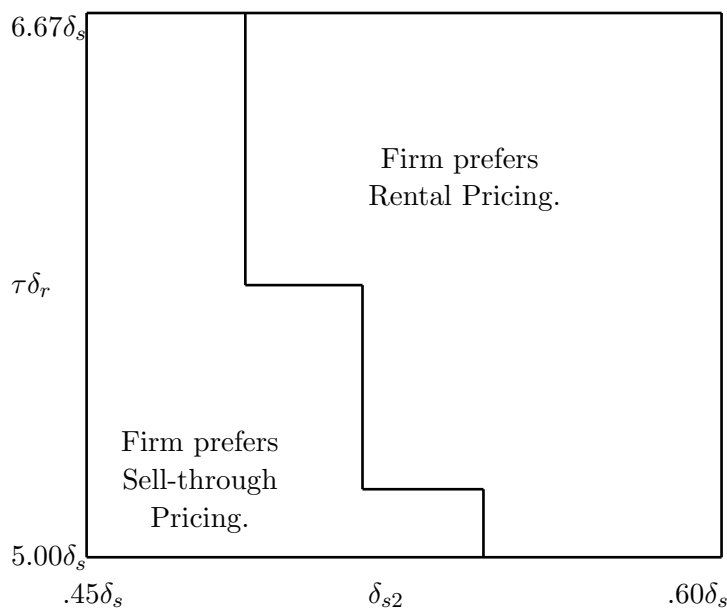
Table B.2: Weighted Quantities of Rentals and Sales

	VHS			DVD		
	Rentals	Used Sales	New Sales	Rentals	Used Sales	New Sales
Panel 1: Rental Priced Titles (N = 12):						
Total per						
Title ('000)	1112.2	20.3	0.2	129.6	3.7	1.5
Weighted Total						
per Title	4054.9	56.8	248.5	491.7	10.4	136.6
Ratio, Weighted						
Sales/Rentals			7.5%			29.9%
Panel 2: Sell-through Priced Titles (N = 29):						
Total per						
Title ('000)	910.5	39.2	0.5	131.8	5.0	0.9
Weighted Total						
per Title	3319.5	109.8	327.3	500.1	14.0	158.4
Ratio, Weighted						
Sales/Rentals			13.2%			34.5%

## Appendix B: Optimal Price Discrimination Strategies

For the model outlined in section 4, one can estimate prices, market shares and firm profits if the parameters of the model are specified (i.e.,  $N, \tau, c, \delta_{i,s}, \delta_{i,s2}, \delta_{i,r}$ , and any parameters of the distribution of  $\alpha$ ). To provide a simple example of the firm's pricing decision, I solve the firm's profit-maximization problem over a range of parameter values and provide results showing the values over which rental-pricing or sell-through pricing strategies are optimal. I assume that  $\alpha$  has a Weibull distribution with parameters  $(\lambda = 6, \rho = 1)$  and retailer mark-ups are zero (i.e.,  $\mu_r = \mu_s = 0$ ). I also assume  $N = 1, c = 2, \tau = 30, X_i\beta = 0$  for all  $i$ , and  $\delta_s = 2$ . I solve for the optimal pricing strategy over a range of values for  $\delta_r$  and  $\delta_{s2}$ . The values of  $\delta_{s2}$  that I consider range from 0.45 to 0.60 of the value of  $\delta_s$ , and the values of  $\tau \cdot \delta_r$  that I consider range from 5 to 6.67 times  $\delta_s$ .<sup>46</sup>

Figure A.1: Optimal Pricing Strategies for Simulated Parameter Values



<sup>46</sup>I compute results for discrete changes in the value of  $\delta_{s2}/\delta_s$  (in increments of 0.025) and  $\tau\delta_r/\delta_s$  ( $\delta_r$  increases from  $\delta_s/4.5$  to  $\delta_s/6$  in increments of 0.25 in the denominator).

Results are shown in figure A.1. The area down and to the left of the line represents the values of  $\delta_{s2}$  and  $\tau \cdot \delta_r$  for which the firm prefers sell-through pricing to rental pricing. The results confirm both predictions in section 4.

**Prediction 1: All else equal, indirect price discrimination becomes relatively more attractive as the decay rate falls (i.e., as  $\delta_{s2}$  rises).**

Indirect price discrimination is costly because, in order to sort buyers, the firm is forced to lower the quality of the good by delaying pricing targeted to the sales market. As the decay rate of the good falls,  $\delta_{s2}$  becomes large, and the cost of this delay is smaller. Thus, rental pricing is preferred over a large range of  $\tau \cdot \delta_r$ . This could happen if, for example, a movie's audience is relatively patient, or the movie has 'timeless' appeal.

**Prediction 2: All else equal, indirect price discrimination becomes relatively more attractive as the value of the good in the rental market increases (i.e., as  $\tau \cdot \delta_r$  rises).**

When the value of the good in the rental market is high compared to owning (a high  $\tau\delta_r$ ), rental pricing is preferred. The intuition is that, all else equal, there is a larger benefit to separating two markets intertemporally when the first market is more valuable. Conversely, if the value of renting represents a small fraction of the value of owning (perhaps because consumers watch the movie many times), a sell-through strategy is preferred. This accords well with the casual evidence that firms nearly always use sell-through pricing strategies for children's movies, and blockbuster hits.

## Bibliography

- Bergstrom, T., (2001), "Free Labor for Costly Journals?," *Journal of Economic Perspectives*, Autumn.
- Berry, S., (1994), "Estimating Discrete-Choice Models of Product Differentiation," *RAND Journal of Economics*, Vol. 25, pp. 242-62.
- Bresnahan, T., (1987), "Competition and Collusion in the American Automobile Industry: The 1955 Price War," *Journal of Industrial Economics*, Vol. 35, No. 4, pp. 457-82.
- Berry, S., Levinsohn, J., and A. Pakes, (1995), *Automobile Prices in Market Equilibrium*, *Econometrica*, Vol. 63, No. 4, pp. 841-90.
- Borenstein, S., (1991), "Selling Costs and Switching Costs: Explaining Retail Gasoline Margins," *RAND Journal of Economics*, Vol. 22, pp. 354-69.
- Borenstein, S. and N. Rose, (1994), "Competition and Price Dispersion in the U.S. Airline Industry," *Journal of Political Economy*, Vol. 102, pp. 653-83.
- Busse, M. and M. Rysman, (2004), "Competition and Price Discrimination Yellow Pages Advertising," *RAND Journal of Economics*, forthcoming.
- Cachon, G. and Lariviere, M., (2000), "Supply Chain Coordination with Revenue-Sharing Contracts: Strengths and Limitations," *working paper*.
- Childs, R., (1992), "Home Video," in *The Movie Business Book*, Second edition, edited by Jason E. Squires, New York, NY: Simon and Schuster.
- Clerides, S.K., (2002), "Book Value: Intertemporal Pricing and Quality Discrimination in the U.S. Market for Books," *International Journal of Industrial Organization*, Vol. 20, No. 10, pp. 1385-1408.
- Dana, J. and Spier, K., (2001), "Revenue Sharing, Demand Uncertainty, and Vertical Control of Competing Firms," *Journal of Industrial Economics*, Vol. 49, No. 3, pp. 223-45.
- Deneckere, R. and P. McAfee, (1996), "Damaged Goods," *Journal of Economics and Management Strategy*, Vol. 5, No. 2, pp. 149-74.
- Hansen, L., (1982), "Large Sample Properties of Generalized Method of Moments Estimators," *Econometrica*, Vol. 50, No. 4, pp. 1029-54.
- Hausman, J., (1997), *Valuation of New Goods under Perfect and Imperfect Competition*, *The Economics of New Goods*. Bresnahan, Tim and Gordon, Robert, eds., NBER Research Studies in Income and Wealth, Vol 58, Chicago and London: University of Chicago Press, pp 209-37.
- Karaca-Mandic, P., (2003), *Network Effects in Technology Adoption: The Case of DVD Players*, working paper.

- Eaton, J. and S. Kortum, (1996), "Trade in Ideas: Patenting and Productivity in the OECD," *Journal of International Economics*, Vol. 40, No. 2, pp. 251-78.
- Leslie, P., (2004), "Price Discrimination in Broadway Theater," *RAND Journal of Economics*, V. 35, No. 3, pp. 520 - 41.
- Liebowitz, S., (1985), "Copying and Indirect Appropriability: Photocopying of Journals," *Journal of Political Economics*, V. 93, No. 5, pp. 945 - 57.
- McCalman, Phillip, (2001), "Reaping What You Sow: An Empirical Analysis of International Patent Harmonization," *Journal of International Economics*, Vol. 55, No. 1, pp. 161-86.
- McCalman, Phillip, (2004), "Foreign Direct Investment and Intellectual Property Rights: Evidence from Hollywood's Global Distribution of Movies and Videos," *Journal of International Economics*, Vol. 62, No. 1, pp. 107-23.
- Maskin, E. and Riley, J., (1984), "Monopoly with Incomplete Information," *RAND Journal of Economics*, Vol. 15, No. 2, pp. 171-96.
- McManus, B., (2001), "Nonlinear Pricing in an Oligopoly Market: The Case of Specialty Coffee," *working paper*.
- Miravete, E., (2002), "Estimating Demand for Local Telephone Service with Asymmetric Information and Optional Calling Plans," *Review of Economic Studies* Vol. 69, pp. 943-71.
- Mortimer, J., (2001), *An Empirical Study of Contractual Arrangements and Inventory: The U.S. Video Rental Industry*, UCLA Dissertation.
- Mortimer, J., (2006), *Vertical Contracts in the Video Rental Industry*, working paper.
- Mussa, M. and Rosen, S., (1978), "Monopoly and Product Quality," *Journal of Economic Theory*, Vol. 18, No. 2, pp. 301-17.
- Nevo, A., (2000), *A Practitioner's Guide to Estimation of Random Coefficients Logit Models of Demand*, *Journal of Economics and Management Strategy*, Vol. 9, No. 4, pp. 513-548.
- Novos and Waldman, (1984), "The Effects of Increased Copyright Protection: An Analytic Approach," *Journal of Political Economy*, Vol. 92, pp. 236-46.
- Ordover and Willig, (1978), "On the Optimal Provision of Journals qua Sometimes Shared Goods," *American Economic Review*, Vol. 68, No. , pp. 324-38.
- Johnson, (1985), "The Economics of Copying," *Journal of Political Economy*, Vol. 93, pp. 158-74.
- Takayama, (1994), "The Welfare Implications of Unauthorized Reproduction of Intellectual Property in the Presence of Demand Network Externalities," *Journal of Industrial Economics*, Vol. 42, pp. 155-66.

- Takayama, (1997), "The Intertemporal Consequences of Unauthorized Reproduction of Intellectual Property," *Journal of Law and Economics*, Vol. 40, pp. 511-22.
- Roehl, R. and Varian, H., (2001), *Circulating Libraries and Video Rental Stores, First Monday*, Vol. 6, No. 5.
- Shepard, A., (1991), "Price Discrimination and Retail Configuration," *Journal of Political Economy*, Vol. 99, No. 1, pp. 30-53.
- Song, M., (2004), *Measuring Consumer Welfare in the CPU Market: An application of the pure characteristics demand model*, working paper.
- Tirole, J., (1995), *The Theory of Industrial Organization*, Cambridge, Massachusetts: The MIT Press.
- Varian, H., (2000), "Buying, Sharing and Renting Information Goods," *Journal of Industrial Economics*, Vol 48, No. 4, pp 473-88.
- Video Software Dealers Association*, various Annual Reports.
- [www.bva.org.uk](http://www.bva.org.uk), British Video Association.
- [www.copyright.gov](http://www.copyright.gov), Text of U.S. Copyright Act.
- [www.fipr.org/copyright/eucd.html](http://www.fipr.org/copyright/eucd.html), Text of Directive 2001/29/EC, *European Union Copyright Directive*, Section 6.
- [www.intellectual-property.gov.uk](http://www.intellectual-property.gov.uk)
- Wyatt, E., (2005), "Google Library Database is Delayed," *The New York Times*, August 13, p. D1.
- Yoon, K., (2002), "The Optimal Level of Copyright Protection," *Information Economics and Policy*, Vol 14, No. 3, pp 327-48.

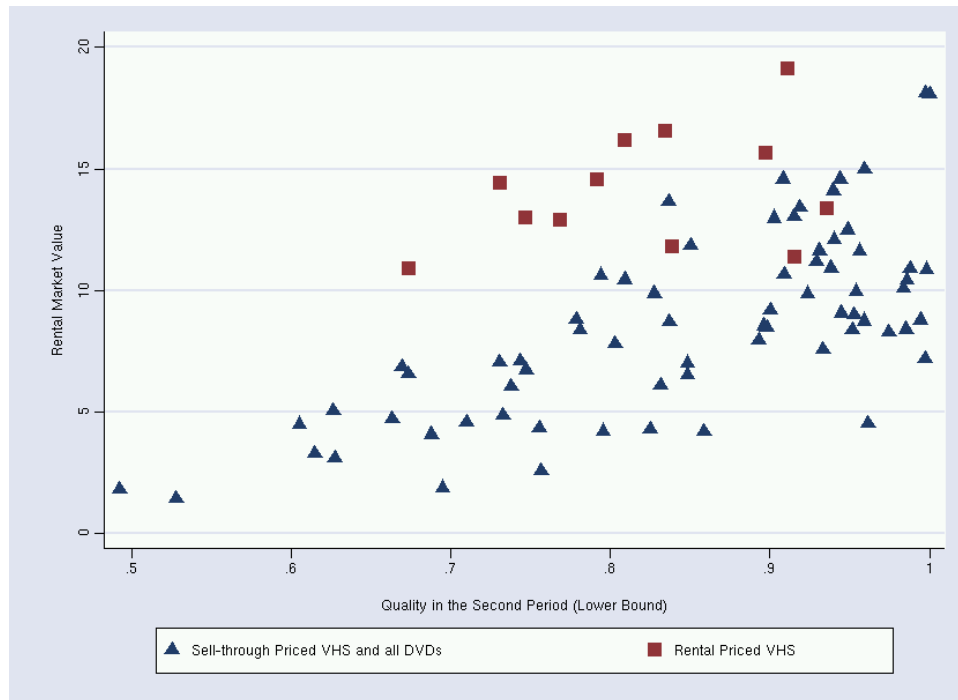


Figure 1: Estimated Quality Parameters, All Titles

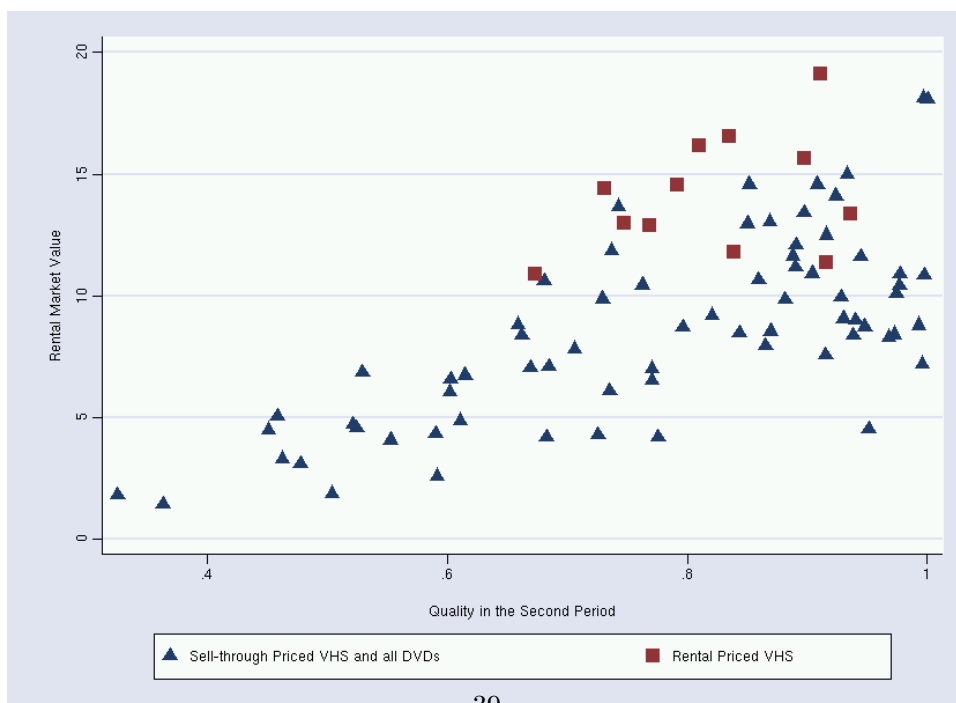


Figure 2: Estimated Quality Parameters (Using Lower Bound of Second-Period Quality for Sell-through Priced Titles), All Titles

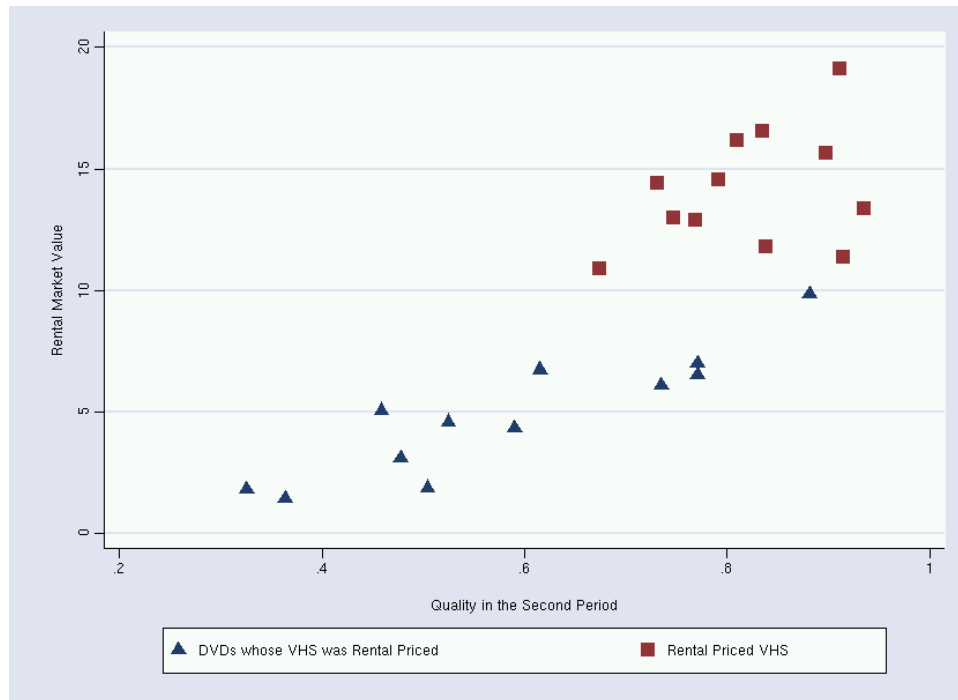


Figure 3: Estimated Quality Parameters (Using Lower Bound of Second-Period Quality for DVD format), Titles whose VHS was Rental-Priced

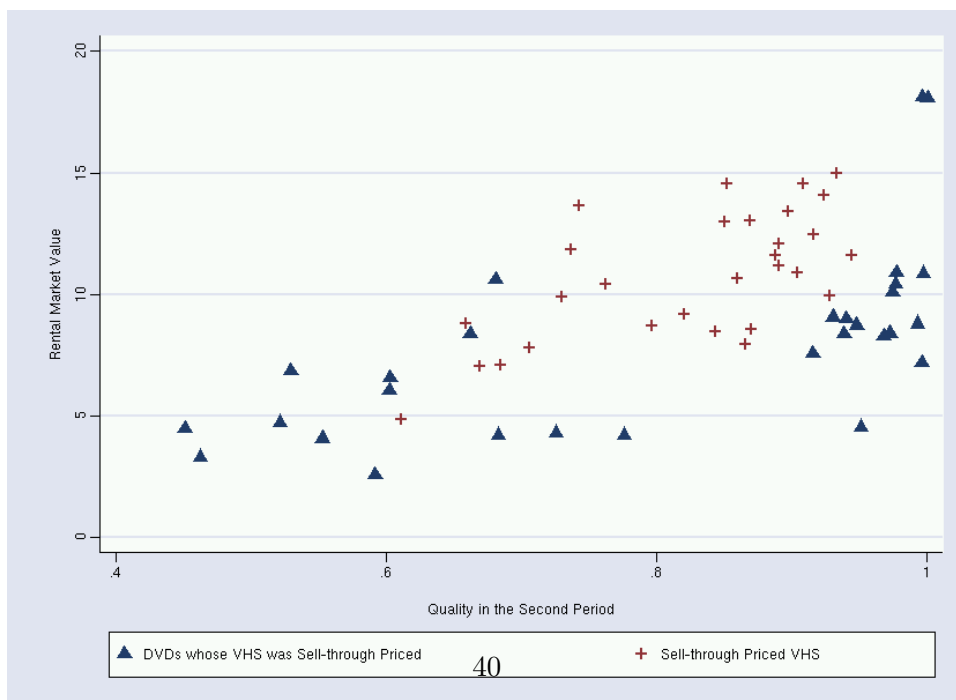


Figure 4: Estimated Quality Parameters (Using Lower Bound of Second-Period Quality), Titles whose VHS was Sell-through Priced

Table 1: All A and B Titles Released on VHS, Jan 00 - Dec 01\*

Genre	% VHS ST priced		Total Released	
	A	B	A	B
Act/Adv	22.2	0.0	27	11
Child/Fam	100.0	100.0	13	4
Comedy	29.4	2.7	34	37
Drama	15.8	0.0	19	24
Horror/Sus	0.0	0.0	17	15
Romance	0.0	0.0	4	5
Sci-Fi	75.0	16.7	4	6
Total	29.7	5.9	118	102

Table 2: All A and B Titles Released on DVD, Jan 00 - Dec 01\*

Genre	% DVD ST priced		Total Released	
	A	B	A	B
Act/Adv	100.0	100.0	27	11
Child/Fam	100.0	100.0	12	2
Comedy	100.0	100.0	27	37
Drama	100.0	96.0	19	25
Horror/Sus	100.0	100.0	13	16
Romance	100.0	100.0	4	5
Sci-Fi	100.0	100.0	4	7
Total	100.0	99.0	106	103

\*Tabulations compiled by author using data from Rentrak Corporation. A titles grossed at least 40 million dollars in theatrical revenues. B titles grossed between 15 and 40 million dollars in theatrical revenues. Table includes all A and B titles released during the relevant time period, including those available on revenue-sharing terms.

Table 3: Timing of Rentals and Sales: Cumulative Percentages by Month

	VHS			DVD		
	Rentals	Used Sales	New Sales	Rentals	Used Sales	New Sales
Panel 1: Rental Priced Titles (N = 12):						
Month 1	39.9	0.3	3.0	44.7	7.7	23.4
Month 2	62.2	1.2	7.5	63.6	20.8	46.1
Month 3	77.2	14.7	11.0	75.1	37.9	66.7
Month 4	83.7	29.6	13.3	80.3	48.3	76.6
Month 5	88.1	44.4	14.7	84.8	56.7	83.2
Month 6	94.7	57.1	37.5	93.3	71.3	90.9
Month 7	100.0	69.6	74.4	100.0	84.2	94.5
Month 8	100.0	79.5	89.4	100.0	91.4	96.2
Months 9+	100.0	100.0	100.0	100.0	100.0	100.0
Panel 2: Sell-through Priced Titles (N = 29):						
Month 1	44.1	1.8	50.1	44.4	5.9	17.4
Month 2	65.8	15.7	60.3	64.3	20.6	34.3
Month 3	76.9	38.5	65.2	77.7	42.2	61.3
Month 4	85.1	54.1	69.2	83.8	55.7	74.8
Month 5	88.1	65.8	71.4	88.2	67.6	84.2
Month 6	94.7	75.3	90.1	94.7	79.5	91.3
Month 7	100.0	84.6	95.7	100.0	87.3	94.1
Month 8	100.0	92.8	98.2	100.0	93.5	96.4
Months 9+	100.0	100.0	100.0	100.0	100.0	100.0

Table 4: Monthly Average Prices of Rentals and Sales

	VHS			DVD		
	Rentals	Used Sales	New Sales	Rentals	Used Sales	New Sales
Panel 1: Rental Priced Titles (N = 12):						
Month 1	3.00	11.84	97.74	3.04	8.45	16.87
Month 2	3.03	7.81	100.44	3.18	9.10	16.48
Month 3	3.01	7.92	97.65	3.29	8.33	16.53
Month 4	2.97	9.15	88.60	3.28	9.02	16.27
Month 5	3.03	8.44	96.40	3.23	9.28	15.60
Month 6	2.72	7.05	19.23	2.78	9.79	14.85
Month 7	2.72	6.29	18.80	2.78	9.93	14.90
Month 8	2.72	5.72	18.27	2.78	9.18	14.60
Months 9+	2.72	5.98	26.68	2.78	9.57	15.47
Panel 2: Sell-through Priced Titles (N = 29):						
Month 1	3.01	7.79	17.48	3.05	10.40	19.50
Month 2	3.17	7.70	18.85	3.53	11.36	17.08
Month 3	3.18	7.36	20.30	3.67	11.27	15.67
Month 4	3.15	7.11	18.47	3.86	10.96	15.47
Month 5	3.12	7.00	18.34	3.80	10.87	14.60
Month 6	2.74	6.42	13.53	3.09	9.87	13.23
Month 7	2.74	6.41	14.34	3.09	9.87	14.01
Month 8	2.74	6.29	14.24	3.09	9.46	12.54
Months 9+	2.74	6.00	15.19	3.09	9.87	11.61

Table 5: Estimated Parameter Values

	VHS				DVD (VHS was:)			
	Rental Priced		Sell-through Priced		Rental Priced		Sell-through Priced	
Avg. $\beta_j$ 's (se):								
Store Size	0.244	(0.011)	0.210	(0.009)	0.372	(0.016)	0.293	(0.012)
%Married/kids	-1.121	(0.333)	-0.975	(0.267)	0.879	(0.435)	0.814	(0.354)
% Suburban	0.075	(0.137)	0.249	(0.109)	-0.304	(0.176)	-0.198	(0.143)
% DVD Penetration	3.764	(1.037)	1.650	(0.936)	-10.492	(1.646)	-3.514	(1.199)
$E[X\beta]$	1.221		0.881		0.962		1.150	
Parameters of the Distribution of $\alpha$ (se):*								
Constant ( $\gamma_0$ )				-0.786	(0.054)			
Median Income( $\gamma_1$ )				0.958	(0.046)			
$\rho$ (shape parameter)				1.814	(0.008)			
Avg. Quality								
Parameters :								
$E(\delta_{r,m,j})$	1.293		1.209		1.267		1.118	
$E(\delta_{u,m,j})$	1.491		1.481		1.989		1.568	
$E(\delta_{s2,m,j})$	1.605		-		-		-	
$E(\delta_{s,m,j})$	1.802		1.679		2.588		1.831	
$E(\delta_{s2,m,j})/E(\delta_{s,m,j})$	0.891		-		-		-	
$E(\delta_r)/E(\delta_s)$	0.718		0.720		0.490		0.611	
Other Parameters:								
$\tau$	23.74		16.91		15.60		15.31	
$\mu_r$	-0.03		1.88		0.90		0.38	
$\mu_u$	8.45		7.71		10.29		11.57	
$\mu_s$ (period 1)	43.60		9.50		8.19		10.61	
$\mu_s$ (period 2)	4.09		-		-		-	
Local Mkt. Size (000s)	5.62		5.49		0.69		0.79	
No. Obs.	23,213		58,077		18,041		42,118	

\*Constant across titles.

Table 6: Counterfactual Exercises, VHS

	Actual	Current	“Other”	Mkt. Seg.
Rental Priced Titles (12):				
$p_r^w$	52.43	58.07	31.67	38.47
$p_s$ (per 1)	109.13	105.13	41.41	38.57
$p_s$ (per 2)	20.46	16.97	0	0
$p_u$	8.45	8.63	8.48	8.62
$p_r$	2.92	2.84	3.37	2.51
% New (per 1)	0.16	0.24	0.11	0.34
% New (per 2)	0.34	0.97	0	0
% Used	0.40	0.32	0.52	0.34
% Rent	29.35	31.84	25.19	37.98
Avg. $\pi_{stud}$ (Mil.)	5.77	5.68	4.86	4.24
Avg. $\pi_{ret}$ (Mil.)	3.01	3.10	3.41	2.40
% Change $\pi_{stud}$	–	-1.55	-14.45	-25.30
% Change $\pi_{ret}$	–	2.98	10.20	-22.44
% Change Con. Surplus	–	–	-21.42	-17.77
Sell-through Priced Titles (29):				
$p_r^w$	14.49	16.13	32.41	45.44
$p_s$ (per 1)	24.00	25.70	76.13	19.49
$p_s$ (per 2)	0	0	20.70	0
$p_u$	7.71	7.72	7.80	7.78
$p_r$	2.94	3.04	1.70	2.45
% New (per 1)	0.86	1.44	0.07	2.60
% New (per 2)	0	0	1.08	0
% Used	0.81	0.48	0.36	0.11
% Rent	25.43	24.08	46.65	29.74
Avg. $\pi_{stud}$ (Mil.)	3.53	4.70	3.32	4.86
Avg. $\pi_{ret}$ (Mil.)	6.41	6.31	1.99	2.47
% Change $\pi_{stud}$	–	33.09	-29.26	3.56
% Change $\pi_{ret}$	–	-1.51	-68.40	-60.86
% Change Con. Surplus	–	–	-11.15	-24.59

\*Retail and studio profits are weighted to include all outlets.

‘Current’ uses actual  $\mu$  and  $\tau$ .

‘Other’ uses counterfactual  $\mu$  and  $\tau$ .

‘Mkt. Segm.’ uses  $\mu_r$  and  $\tau$  from rental pricing;  $\mu_s$  from sell-through.

Table 7: Counterfactual Exercises, DVD

	Actual	Current	“Other”	Mkt. Seg.
VHS was Rental Priced (12):				
$p_r^w$	15.55	15.22	32.08	42.09
$p_s$ (per 1)	23.75	24.05	75.64	22.49
$p_s$ (per 2)	0	0	21.41	0
$p_u$	10.29	10.29	10.31	10.29
$p_r$	2.81	2.82	1.52	2.14
% New (per 1)	5.66	7.48	0.29	9.71
% New (per 2)	0	0	2.90	0
% Used	0.28	0.05	0.67	0.02
% Rent	24.47	26.49	54.16	33.00
Avg. $\pi_{stud}$ (Mil.)	0.96	1.15	0.72	1.22
Avg. $\pi_{ret}$ (Mil.)	0.58	0.63	0.35	0.32
% Change $\pi_{stud}$	–	20.29	-37.33	6.25
% Change $\pi_{ret}$	–	7.39	-44.84	-49.76
% Change Con. Surplus	–	–	-8.81	29.78
VHS was Sell-through Priced (29):				
$p_r^w$	17.16	17.77	36.03	42.83
$p_s$ (per 1)	27.77	28.86	79.80	24.03
$p_s$ (per 2)	0	0	23.48	0
$p_u$	11.57	11.39	11.45	11.46
$p_r$	2.81	2.95	1.72	2.31
% New (per 1)	2.62	3.93	0.08	5.35
% New (per 2)	0	0	2.87	0
% Used	0.34	0.24	0.36	0.08
% Rent	22.80	25.71	45.16	30.40
Avg. $\pi_{stud}$ (Mil.)	0.72	0.84	0.57	0.91
Avg. $\pi_{ret}$ (Mil.)	0.61	0.61	0.28	0.24
% Change $\pi_{stud}$	–	16.91	-32.57	7.53
% Change $\pi_{ret}$	–	0.19	-54.91	-60.71
% Change Con. Surplus	–	–	-7.21	9.18

\*Retail and studio profits are weighted to include all outlets.

‘Current’ uses actual  $\mu$  and  $\tau$ .

‘Other’ uses counterfactual  $\mu$  and  $\tau$ .

‘Mkt. Segm.’ uses  $\mu_r$  and  $\tau$  from rental pricing;  $\mu_s$  from sell-through.

Table 8: Counterfactual Exercises, Future DVD

	Sell-thru Priced	Rental Priced	Mkt. Segm.
VHS was Rental Priced (12):			
$p_r^w$	26.82	51.83	39.94
$p_s$ (per 1)	36.67	96.41	31.93
$p_s$ (per 2)	–	15.90	–
$p_u$	8.57	8.65	8.65
$p_r$	2.99	2.56	2.48
% New (per 1)	0.21	0.22	1.31
% New (per 2)	–	2.40	–
% Used	1.85	1.04	1.35
% Rent	34.69	41.14	43.27
Avg. $\pi_{stud}$ (Mil.)	5.51	6.81	6.02
Avg. $\pi_{ret}$ (Mil.)	4.97	4.11	3.54
% Change $\pi_{stud}$	–	23.59	9.26
% Change $\pi_{ret}$	–	-17.30	-28.77
% Change Con. Surplus	–	20.78	5.03
VHS was Sell-through Priced (29):			
$p_r^w$	15.01	29.87	35.79
$p_s$ (per 1)	24.91	74.27	22.91
$p_s$ (per 2)	–	20.51	–
$p_u$	7.75	7.74	7.72
$p_r$	3.00	1.56	2.03
% New (per 1)	1.45	0.07	2.34
% New (per 2)	–	1.26	–
% Used	0.70	0.80	0.56
% Rent	19.92	38.35	27.77
Avg. $\pi_{stud}$ (Mil.)	2.87	2.71	3.80
Avg. $\pi_{ret}$ (Mil.)	3.97	1.55	1.89
% Change $\pi_{stud}$	–	-5.53	32.36
% Change $\pi_{ret}$	–	-60.98	-52.44
% Change Con. Surplus	–	10.27	3.71

\*Retail and studio profits are weighted to include all outlets.

‘Current’ uses actual  $\mu$  and  $\tau$ .

‘Other’ uses counterfactual  $\mu$  and  $\tau$ .

‘Mkt. Segm.’ uses  $\mu_r$  and  $\tau$  from rental pricing;  $\mu_s$  from sell-through.