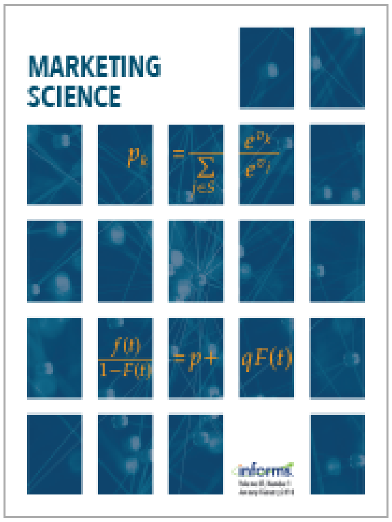

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Online Content Pricing: Purchase and Rental Markets

Anita Rao
Booth School of Business, University of Chicago, Chicago, Illinois 60637, anita.rao@chicagobooth.edu

Digitization of content is changing how consumers and firms use purchase and rental markets. Low transaction costs make accessing content easier for consumers. Digital technology enables firms to create nondurable "rental" versions of their content and to restrict content to the purchasing consumer, effectively shutting down resale markets. To empirically analyze the interaction of purchase and rental markets, I design a preference measurement tool to recover consumers' intertemporal preferences through current-period choices alone. I then use these preferences to solve for a dynamic equilibrium between consumers and the firm. In the context of the online home video market, I find that when the firm is able to commit to holding prices fixed forever, providing content through the purchase market alone is sufficient. However, when the firm is unable to commit, it should serve both purchase and rental markets. Canonical theory models would predict exclusive rentals, but the purchase option enables indirect price discrimination in practice. I also find that when consumers place a premium on accessing new content, they are less likely to intertemporally substitute, thereby increasing the firm's pricing power. Consistent with theory, commitment to future prices increases profits considerably. This finding supports the rigid pricing structure of such retailers as Apple, despite studios' push toward more pricing flexibility.

Keywords: purchase and rental markets; durable good pricing; online content; experiment design; conjoint analysis
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1. Introduction

A firm selling a durable good may consider options such as renting, reduced durability, and price commitments to mitigate competition between current and future offerings of its product. The recent digitization of content such as books, movies, and music has led to a reconsideration of each of these options. Firms offer online rental options that are essentially goods designed to fully depreciate by the end of the lending period, for example, movie rentals that expire 24 hours after the user hits play, and textbook rentals that expire after the publisher-set period. Rigid pricing structures, across both time and content offerings, adopted mainly for user friendliness, resemble price commitment. Songs restricted to a price of \$1.29 and movies at \$14.99/\$3.99 for purchase/rent on iTunes and Amazon highlight this platform-established rigid structure. Furthermore, Digital Rights Management (DRM) technology makes it possible to provide each user her unique copy, which, if purchased, cannot be transferred, thereby enabling the shutdown of resale markets.

Whereas online content shares many features of durable goods, because they can be enjoyed repeatedly (e.g., listening to a favorite song every day), unlike typical durable goods, most online content faces diminishing returns to marginal consumption (e.g., a book read the second time is not as enjoyable). Moreover, this rate of diminishing returns can be heterogeneous, with some consumers experiencing a more gradual rate than others (e.g., children like watching the same movies repeatedly). From a consumer's and firm's perspective, these differences make treating online content as purely durable goods, inadequate.

This paper poses two questions related to the supply and demand side, respectively, of the digital marketplace: What product configuration should firms use in the digital space? How can we infer consumers' preferences for content that can be consumed now or in the future?

Related to the first question, theory provides us with contradicting predictions depending on the modeling motivations in place. On one hand, durable goods theory predicts that a firm without a commitment mechanism is better off exclusively renting its product rather than making it available for purchase (Coase 1972, Stokey 1981, Bulow 1982), and that a firm with a commitment device will be indifferent between making all of its sales exclusively through the purchase market at the first sales date and renting forever (Stokey 1979). On the other hand, indirect price discrimination arguments contend that the firm is better off keeping both purchase and rental markets open to cater to different segments of the market (Varian 2000). These differences arise mainly because the durable goods literature does not allow for diminishing returns to consumption, and the indirect price discrimination literature does not account for the intertemporal link between the two types of consumption.

Without accounting for all of these factors in conjunction, i.e., preferences for repeat consumption (i.e., durability), diminishing returns to consumption, and heterogeneity in the rates of diminishing returns, a monopolist's profit-maximizing product configuration is not obvious. Furthermore, consumers can have time-dependent preferences for content that result in declining valuations as the product becomes "old news". To resolve which configuration firms should use in the digital space, I empirically analyze the interaction of purchase and rental markets. I evaluate a monopolist's configuration both in the presence and absence of a commitment mechanism. I perform these evaluations because, although Apple through its rigid pricing structure is able to provide a commitment-like device, this ability is changing as content providers are pushing for pricing flexibility.

The second question this paper asks is methodological and aims to design a conjoint experiment using only current-period choices to infer consumers' intertemporal preferences: Do consumers value the content for a one-time use or repeated use, and are they likely to postpone their purchase or rental occasions to later periods? Inferring these preferences through revealed-preference data alone is difficult due to the lack of price variation in the digital world.

The choice task in the design involves a consumer making a trade-off between Buying, Renting, and Postponing consumption of a particular content. The basic premise underlying this design is that if a consumer (1) prefers Buying over Renting, it reveals her preference for future consumption of the product, and (2) if she prefers Consuming Now over Postponing, it reveals her time-dependent preferences.

The empirical application of this paper focuses on digitally downloadable movies. This is a valuable empirical setting to study the interaction of purchase and rental markets primarily because DRM makes this a market characterized by the absence of resale markets. Whereas in the hardcopy world, the First Sale Doctrine permitted anyone who owned an original copy to rent or resell it as they chose, this doctrine does not translate easily to the digital world for two reasons. First, a digital product is almost impossible to rent or resell without first making a copy of it, which would result in copyright infringement. Second, firms can create locks through DRM, circumvention of which is prohibited by the Digital Millennium Copyright Act. For example, movies purchased through Apple's iTunes store can be played on multiple devices belonging to a user but cannot be transferred, sold or rented to other users; movies rented through the store expire 24 hours after the user hits play. DRM thus enables the shutdown of resale markets and makes incorporating planned obsolescence easier.

In addition, Apple and Amazon, two of the leading online video retailers,[1] maintain a relatively uniform pricing policy: \$14.99/\$3.99 to purchase/rent their new movies and \$9.99/\$2.99 to purchase/rent their catalog titles. This policy has the semblance of a commitment device because prices are held fixed over a relatively long period of time. The only real flexibility of the content provider is perhaps when to switch from the new-release classification to catalog. Therefore, even if it is not a perfect commitment device, it is a highly restricted pricing structure.

Under the demand parameters estimated, I find that if the firm has a commitment device, it is better off making the product available exclusively for purchase. Keeping both markets open would serve as a price discrimination mechanism if consumers differed more substantially (than recovered from the data) in their repeat-consumption preferences.

If the firm does not have a commitment device, it should keep both markets open. Even if the high-valuation consumers shift to rental markets, the firm can capture their residual repeat-consumption value by either a re-rent (at a lower price) or a purchase at a later time. (Note that under the commitment device described above, the firm is limited in its ability to change prices over time.) However, profitability when the firm is unable to commit is lower than when the firm is able to commit. The ability to commit increases firm profitability substantially (by 41%–45%). This finding is consistent with the durable goods theory.

I find that preferences for repeat consumption and preferences for the new-release period play in opposing directions. If consumers' preferences only differ in how much they value repeat consumption, purchase and rental markets distinguish between these different consumers. However, when the high-valuation consumers' new-release-period utility is sufficiently high, they substitute to the (cheaper) rental market, preventing the monopolist from price discriminating.

[1] Most retailers currently charge a fixed margin (around 30%). As studios explore different platforms it is likely that increasing retailer competition will drive this margin down. My model assumes away the studio-retailer relationship and takes into account only the studio in determining the best product and pricing strategy.

Similarly, in the absence of time-dependent preferences and in line with the durable goods literature, the firm would engage in intertemporal price discrimination. However, intertemporal discrimination is harder to achieve when the low-valuation consumers' utility drops quickly over time, in which case the firm is better off catering to them up front rather than losing them. This same phenomenon makes delaying rent, a practice the digital world has largely followed from 2008 to 2010, less profitable. The reasoning is that the firm loses out on consumers who would have rented in the new-release period but who are unlikely to be interested in the movie after that period.

To the extent that consumers value the new-release period, the firm is able to maintain its market power because consumers have fewer incentives to engage in intertemporal substitution. On the other hand, if consumers are willing to wait, that is, if their willingness to pay for consuming the good for the first time does not change over time, firm profitability in equilibrium decreases by 18%–21%. This decrease occurs because, as Coase (1972) conjectures, rational consumers anticipate that the firm is going to drop prices in the future and thus choose to wait for cheaper prices, causing the firm to lower its first-period prices.

1.1. Contribution

This paper contributes to the durable goods literature (see Waldman 2003 for a review) by empirically showing that rental and purchase markets can be used to price discriminate if one allows for diminishing returns to consumption, and for heterogeneity in this rate of diminishing returns across consumers. Existing work has shown that purchase and rental markets can co-exist under different degrees of depreciation (Desai and Purohit 1998) and quality or production cost differences (Kuhn 1998). However, these differences are unlikely to be applicable in the digital world where no product asymmetries exist between the digital purchase and rental versions. Desai and Purohit (1999) show that incorporating competition can also explain the co-existence of purchase and rental markets. Unlike in extant theoretical work, this paper shows that allowing for heterogeneity in consumers' rate of diminishing returns introduces an incentive for the monopolistic firm to use rental versus purchase markets to price discriminate across consumers with different rates of diminishing marginal returns.

The durable goods literature predicts that a monopolist without a commitment device is better off renting his product. Selling creates a time-inconsistency problem in which the seller, facing a changing demand curve, has an incentive to cut prices in future periods to cater to the lower-valuation consumers. Rational consumers, anticipating this price fall, prefer to wait thus weakening the monopolist's market power. Renting, on the other hand, is equivalent to a nondurable goods problem in which the seller faces the same demand curve every period, thereby enabling the monopolist to avoid the time-inconsistency problem. However, allowing for diminishing returns to consumption changes the dynamics of the resulting equilibrium: Rental markets themselves face the time-inconsistency problem and can no longer solve the durable goods problem. Moreover, the firm can use rental and purchase markets as a means to price discriminate across consumers with different rates of diminishing marginal returns. This aspect relates the problem to those considered in the indirect price discrimination literature (e.g., Varian 2000, Dasgupta et al. 2007, Mortimer 2007). This literature accommodates heterogeneous tastes by treating the two as vertically differentiated products, but ignores the intertemporal link in consumption. An exception is Calzada and Valletti (2012), who allow for this link in a two-period model analyzing studios' versioning strategies.

To my knowledge, empirical work on durable goods has largely focused on purchase markets (e.g., Song and Chintagunta 2003, Nair 2007, Gowrisankaran and Rysman 2012) and more recently on incorporating secondary markets (e.g., Chen et al. 2013, and Ishihara and Ching 2012), with very little work that considers both purchase and rental markets.

On the demand side, this paper is related to the conjoint literature, which starting with Green and Rao (1971), has seen many developments in measuring consumer preferences. More recently, this literature has incorporated the underlying structure governing consumers' decision processes in a static (e.g., Gilbride and Allenby 2004, Iyengar et al. 2008) as well as dynamic setting (Dubé et al. 2014). Dubé et al. (2014) measure intertemporal preferences by asking consumers to choose when they would purchase a durable good. By contrast, this paper infers these preferences through consumers' current-period choices over options with differing degrees of durability, i.e., purchase and rental options. This paper contributes to this literature by providing a method for inferring consumers' preferences for the future using current-period choices alone.

This paper is also closely related to the literature that has analyzed movie performance based on box office data (e.g., Elberse and Eliashberg 2003, Sawhney and Eliashberg 1996). However, box office data alone, even if available at the individual level, are insufficient to recover a consumer's repeat-consumption preference. For this one needs at least two observations at the individual-movie level. Observing individual preferences across two channels can help to some degree (e.g., box office and successive DVD market data as studied in Luan and Sudhir 2006). However, sequential market data are unavailable before the product's launch. This paper provides a method that content providers can easily apply to determine the best product/pricing strategy before releasing their content online.

In §2, I describe the model that forms the basis of my experimental design as well as my supply-side policy evaluations. Section 3 sets up the experiment to recover the relevant parameters of interest. Section 4 describes the demand-estimation procedure, followed by the results (§5). Section 6 evaluates the optimal pricing policy, and §7 evaluates various counterfactual policies. Section 8 provides summarizing remarks and addresses avenues for future research.

2. Model

This section describes the model that governs consumers' consumption decisions as well as firms' pricing decisions. I use this model to design the experiment to identify the relevant parameters in a realistic setting (demand side) as well as to determine the content-specific optimal pricing strategy (supply side).

I first describe the model set-up in the general case where commitment is not possible because evidence suggests that the industry is moving toward this scenario. Although Apple, through its push for simplicity, is able to maintain a relatively simple pricing policy, studios are beginning to demand pricing flexibility and are exploring and using other platforms to distribute their movies (e.g., Facebook, YouTube, studio websites). To some extent, Apple's current policy gives studios (although they are likely unaware of it) a credible commitment mechanism. When studios have relative pricing flexibility, they will have incentives to cut prices, much as we have seen with DVDs, thus leading to a world in which commitment may no longer be possible. Concomitantly, Purohit (1995) shows that the presence of intermediaries causes quantities to be naturally restricted moderating the time inconsistency problem.

In the no-commitment framework, I assume consumers have rational expectations about how the aggregate state space will evolve and how these states will impact future prices. In §2.2, I describe the model set-up when commitment is possible. I use this idea in demand estimation, which takes advantage of the commitment mechanism prevalent in the digital world at the time of the survey. In this case, consumers do not need to form rational expectations on how the aggregate states evolve because prices are made known to them up front.

2.1. No Commitment

2.1.1. States. A consumer can be in one of three states: (1) Not Consumed the content, (2) Consumed and Does Not Own the content, and (3) Consumed and Owns the content. A consumer will be in state 1 if she has not yet purchased or rented, state 2 if she has rented but not purchased, and state 3 if she has purchased the content. I distinguish between whether a consumer has consumed the content or not to allow for the fact that her valuations in the two states might be very different due to diminishing returns to consumption. This distinction is especially important in the case of movies and books, where consumers anticipate that once they have watched the movie or read the book, they may no longer be interested in it. To account for preferences related to newness or recency of the content, the time since release t is also a state in the model.

In this no-commitment scenario, the aggregate of these states also affects consumers because they affect the prices the firm charges. Here, I assume consumers have rational expectations about how the aggregate states evolve. I use the rational expectations assumption, because consumers are likely to have faced many situations involving buying or renting a movie. Although prices are currently held constant over the first few years of a movie's release, once the online-world moves to the no-commitment scenario, consumers are likely to quickly learn how prices fall over time, and begin to form expectations on future prices based on experiences gained across different movies. Cyert and DeGroot (1974) show that by allowing learning to occur when agents repeatedly face similar situations, the market will converge to an equilibrium. As a result, when consumers face this situation repeatedly, and because buying/renting is a reasonably frequent task for many consumers, they will begin to form rational expectations on the evolution of the price paths.

Assuming that M discrete-types[2] are present in the population, the state space can be expressed as (s^i, S, t), where

$$s^i = \begin{cases} 1 & \text{if } \mathit{NotConsumed} \\ 2 & \text{if } \mathit{Consumed}, \mathit{NotOwn} \\ 3 & \text{if } \mathit{Own} \end{cases}$$

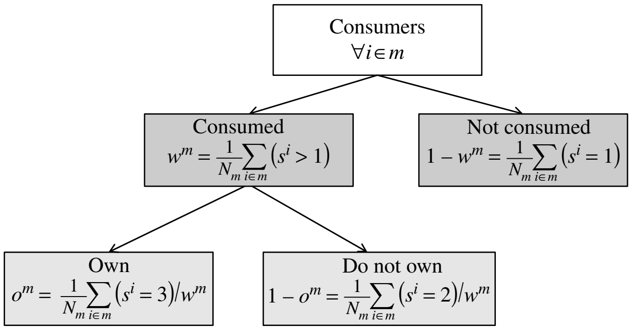
is individual i's state at time t, $i \in \{1, \ldots, M\}$;

$S = S^1, \ldots, S^m, \ldots, S^M$ is the aggregate state vector consisting of the aggregate state-space for each type of consumer; and

$S^m = (w^m, o^m)$ where w^m is the share of the N_m type-m consumers who have already consumed the content at the beginning of period t, and o^m is the percentage of w^m who own the content. This allows me to keep both w^m and o^m between 0 and 1. Figure 1 depicts this aggregate state.

[2] I assume a discrete type rather than a continuous distribution of heterogeneity, largely to limit the state space. With M types, the state space is $(|D| \times |D|)^M$, where D is the number of points into which the continuous states w, o have been discretized.

Figure 1 Aggregate State Space



2.1.2. Per-Period Utility. The type superscript M is suppressed in the following equations (all coefficients are type specific).

The utility functions for those who do not own the content ($s < 3$) are given by

$$U_{\text{buy}}(s<3, HD, t) = \gamma + \kappa(t)\cdot 1(s=1) + \beta HD + \varepsilon_{\text{buy},\,t}; \quad (1)$$

$$U_{\text{rent}}(s<3, HD, t) = \gamma + \kappa(t)\cdot 1(s=1) + \beta HD + \varepsilon_{\text{rent},\,t}; \quad (2)$$

$$U_{\text{opt}}(s<3, t) = 0 + \varepsilon_{opt,\,t}. \quad (3)$$

The type-specific per-period utility consists of a base component that does not change with the number of watches, i.e., γ; and a component that reduces with repeat viewing, i.e., κ. Specific to this application, I restrict κ to be 0 after the first watch. The parameter γ is analogous to the durability of the content because it captures the consumer's value for repeat consumption. The parameter κ captures the difference in a consumer's valuation when she has not previously consumed the content ($s=1$) relative to when she has ($s=2$). The drop from $\kappa+\gamma$ to γ captures a consumer's diminishing returns to consumption. If no drop occurs, the product is completely durable. In the context of movies, suspense thrillers may have a very high κ, whereby consumers watching it for the first time do not know how the story will unfold, but once they have seen the ending, they no longer get the initial thrill watching the movie again. Conversely, timeless movies that can be watched repeatedly and deliver the same amount of satisfaction every time are likely to have κ close to 0 and a high repeat-utility γ.

I also allow the first-time watch bonus κ to change with the time since release t. This allows the excitement associated with consuming the content for the first time when it is new to be different from when it is older. I operationalize $\kappa(t)$ as $\kappa(t) = \kappa(1)\cdot(1-\eta)^{t-1}$, where η is the decay parameter. The parameter β captures any additional utility the consumer might get from watching the HD version of the content.

Those who own the content ($s=3$) have an option of consuming the content again in the future or not. Their per-period utility functions are given by

$$U_{\text{consume}}(s=3, t) = \gamma + \varepsilon_{\text{consume},\,t}; \quad (4)$$

$$U_{\text{notConsume}}(s=3, t) = 0 + \varepsilon_{\text{notConsume},\,t}. \quad (5)$$

State $s=3$ is an absorbing state because consumers who own the content continue to remain in this state. Typical models (e.g., Song and Chintagunta 2003) account for this state by summing up the lifetime value of owning through the term $\gamma/(1-\delta)$. Doing so in my model will lead to an artificial asymmetry between purchase and rent: Consumers who choose to rent will have the option of choosing to watch again, whereas consumers who own the movie will not have this option (i.e., it will be assumed that they watch the movie every period). I relieve this asymmetry by allowing for the fact that even consumers who own the content have an option value associated with choosing to watch it again (Equations (4) and (5)).

In Equations (1)–(5), ε's are the unobserved (to the researcher) shocks assumed to be independent across time and across all options[3] available to an individual in state s.

I assume a consumer knows only her ε's in the current time period and that her knowledge of the ε's in the future time periods is limited to their distribution.[4] Thus a consumer cannot predict her choices in any future time period; she can only form expectations around them, and these expectations inform her of the value of waiting in the current time period. This aspect forms an important part of the experiment design, whereby respondents will deliberately not be asked to make choices in the future periods.

2.1.3. Value Functions for the Consumer. All actions a consumer can take are intertemporally linked: Choosing to consume today affects a consumer's utility tomorrow if she has diminishing returns to consumption because once a consumer has seen the movie the first time, she no longer gets κ. Buying has the additional intertemporal implication (for the firm) of consumers exiting the market. Being inactive is intertemporally connected through postponement and facing older content tomorrow.

[3] The unobserved shocks, $\varepsilon_{\text{buy},\,t}$ and $\varepsilon_{\text{rent},\,t}$, might be correlated because an individual who gets a shock that makes her more likely to consume the content in period t might be more likely to buy as well as rent the content. I estimated a nested logit specification with both buy and rent options nested within a consume option. However, the nesting parameter was not significantly different from zero, indicating that $\varepsilon_{\text{buy},\,t}$ and $\varepsilon_{\text{rent},\,t}$ are not correlated in the data.

[4] This assumption is typical in models analyzing dynamic demand.

I now specify the choice-specific value functions. Separate value functions exist for each type of consumer and depend on her state s. For simplicity, I suppress HD in the state space. Those who purchase the content get a per-period utility associated with buying the content today and an option value of consuming the content in the future. Thus the value function associated with owning the content can be written as

$$V_{\text{buy}}(s<3,S,t)=U_{\text{buy}}(s,t)-\alpha P_b(S,t)+\delta \mathrm{E}\max_{\varepsilon'}\begin{pmatrix}V_{\text{consume}}(s'=3,S',t+1\mid s,S),\\ V_{\text{notConsume}}(s'=3,S',t+1\mid s,S)\end{pmatrix},\quad (6)$$

where α is the price-sensitivity coefficient associated with the purchase and rental prices $[P_b, P_r]$;

E is the expectation operator, with the expectation taken over the future ε's and

$$V_{\text{consume}}(s=3,S,t)=U_{\text{consume}}(s,t)+\delta \mathrm{E}\max_{\varepsilon'}\begin{pmatrix}V_{\text{consume}}(s'=s,S',t+1\mid s,S),\\ V_{\text{notConsume}}(s'=s,S',t+1\mid s,S)\end{pmatrix},\quad (7)$$

$$V_{\text{notConsume}}(s=3,S,t)=U_{\text{notConsume}}(s,t)+\delta \mathrm{E}\max_{\varepsilon'}\begin{pmatrix}V_{\text{consume}}(s'=s,S',t+1\mid s,S),\\ V_{\text{notConsume}}(s'=s,S',t+1\mid s,S)\end{pmatrix}.\quad (8)$$

Those who rent the content get a per-period utility associated with renting today and an option value of choosing to buy, rent or opt out in the future:

$$V_{\text{rent}}(s<3,S,t)=U_{\text{rent}}(s,t)-\alpha P_r(S,t)+\delta \mathrm{E}\max_{\varepsilon'}\begin{pmatrix}V_{\text{buy}}(s'=2,S',t+1\mid s,S),\\ V_{\text{rent}}(s'=2,S',t+1\mid s,S),\\ V_{\text{opt}}(s'=2,S',t+1\mid s,S)\end{pmatrix}.\quad (9)$$

Those who choose to opt out have an option value of choosing to buy, rent or opt out in the future

$$V_{\text{opt}}(s<3,S,t)=U_{\text{opt}}(s,t)+\delta \mathrm{E}\max_{\varepsilon'}\begin{pmatrix}V_{\text{buy}}(s'=s,S',t+1\mid s,S),\\ V_{\text{rent}}(s'=s,S',t+1\mid s,S),\\ V_{\text{opt}}(s'=s,S',t+1\mid s,S)\end{pmatrix}.\quad (10)$$

The difference between those who buy and those who rent the movie enters through γ, the repeat utility. Holding all else fixed, the probability that one will buy is higher in consumers with a high γ. The difference between those who choose to buy or rent and those who wait enters through $\kappa+\gamma$, the utility of a first watch. All else equal, those with a low $\kappa+\gamma$ are more likely to wait. These differences will form an important part of the identification strategy detailed in §3.[5]

2.1.4. Market Share and Endogenous State Evolution. Assuming that the unobserved (to the researcher) shocks follow a Type-I extreme-value distribution, the share of those consumers who have not previously consumed the content and choose to buy and rent can be written as

$$s_{\text{buy}}(s,S,t)=\frac{e^{\bar V_{\text{buy}}(s,S,t)}}{e^{\bar V_{\text{buy}}(s,S,t)}+e^{\bar V_{\text{rent}}(s,S,t)}+e^{\bar V_{\text{opt}}(s,S,t)}}\quad (11)$$

$$s_{\text{rent}}(s,S,t)=\frac{e^{\bar V_{\text{rent}}(s,S,t)}}{e^{\bar V_{\text{buy}}(s,S,t)}+e^{\bar V_{\text{rent}}(s,S,t)}+e^{\bar V_{\text{opt}}(s,S,t)}}\quad (12)$$

where

$$\bar V_j(s,S,t)=V_j(s,S,t)-\varepsilon_{j,t}\quad j\in\{buy, rent, opt\}.$$

The aggregate share of people who end up buying and renting the product each period can then be given as

$$Buy(S,t)=(1-w)s_{\text{buy}}(s=1,S,t)+w(1-o)s_{\text{buy}}(s=2,S,t),\quad (13)$$

$$Rent(S,t)=(1-w)s_{\text{rent}}(s=1,S,t)+w(1-o)s_{\text{rent}}(s=2,S,t).\quad (14)$$

The first term corresponds to those consumers who had not purchased or rented the content at the beginning of period t; the second term corresponds to those who had rented but not purchased.

The next period's state can be computed given the current state and the share of people who purchase and rent in the current period

$$w'=w+(1-w)(s_{\text{buy}}(s=1,S,t)+s_{\text{rent}}(s=1,S,t)),\quad (15)$$

$$o'=\frac{w.o+(1-w)s_{\text{buy}}(s=1,S,t)+w(1-o)s_{\text{buy}}(s=2,S,t)}{w'}\quad (16)$$

Equation (15) takes the share of all consumers who had consumed the content at the beginning of period t, and adds the share of those consumers who consumed for the first time this period by either buying or renting. Equation (16) takes the share of all consumers who were owners at the beginning of period t, and adds the share of new owners who bought the content this period.

[5] Ishihara and Ching (2012) also allow for and separately identify satiation-based and freshness-based depreciation based on the length of ownership period and the time since week of release. Here, I identify the drops in utility based on the extra willingness to pay for purchase versus rent and the extra willingness to pay for watching now versus later.

2.1.5. Profit Functions for the Firm. The monopolist firm gains from both the purchase and rental markets. The cannibalization between the purchase and rental markets, if any, is accounted for in the share equations. Note that despite the absence of resale markets, sold goods still compete with next-period sales because the firm cannot sell additional units to consumers who already own the product, and thus has an incentive to cut prices to cater to the remaining consumers. Rational consumers, anticipating this, wait for lower future prices, which causes the monopolist to further lower his first-period prices. Similarly, to the extent that consumers have high diminishing returns to consumption, the monopolist will face the same problem in rental markets as well.

The current-period profit for a firm that makes its content available for purchase and rent can be written as

$$\pi(S,t) = \sum_{m=1}^{M} q^m \big(Buy^m(S,t)P_b(S,t) + Rent^m(S,t)P_r(S,t)\big), \tag{17}$$

where q^m is the share of type-m consumers in the population.

The firm's optimal strategy is to choose the purchase and rental price at period t that maximizes the discounted value of its current and future stream of profits

$$W(S,t) = \max_{P(S,t)} \{\pi(S,t) + \delta W(S', t+1 \mid S)\}. \tag{18}$$

2.1.6. Equilibrium. The equilibrium I consider is Markov perfect, whereby the firm's and consumers' strategies depend only on the current state variables. An equilibrium in this model is attained when (1) consumers maximize their utility, having rational expectations about the firm's pricing policy and the evolution of the state space, and (2) the firm behaves optimally, having rational expectations about the evolution of the state space.[6] I also assume that consumers are infinitely lived.

An equilibrium at any given state (S,t) consists of type-specific consumer value functions $V^m = \{V_{\text{buy}}, V_{\text{rent}}, V_{\text{opt}}, V_{\text{consume}}, V_{\text{notConsume}}\}$, the firm value function W, and the pricing policy P. An equilibrium is attained when consumers' value functions satisfy Equations (6)–(10) for each consumer type, the firm's value function satisfies Equation (18), the price maximizes the right-hand side of Equation (18), and both the firm and consumers have rational beliefs about the evolution of the state space as given by Equations (15) and (16). This implies that when consumers are deciding between buying, renting or postponing, they anticipate the effect of their current decisions on the future aggregate state $S' = (w', o')$ as given by Equations (15) and (16), and know the prices the firm will charge at those states. Similarly, when the firm decides its optimal purchase and rental price, it takes into account the effect these prices will have on the future state of the market.

[6] I assume that no aggregate demand shocks exist. This assumption implies that consumers and the firm know future prices and demand with certainty.

Relationship Between Purchase and Rental Prices. In the durable goods literature, the purchase price is the net present value of the future expected rents. If the firm charges a higher purchase price, individual rationality constraints are not met and the consumer does not participate in the purchase market. If the firm charges a lower purchase price, it creates arbitrage opportunities whereby consumers have incentives to resell/re-rent the good at higher prices.

Similarly, charging a higher purchase price is unattractive in my setting because the consumer will prefer to opt out or rent repeatedly than buy. However, charging a lower purchase price is both attractive and feasible. It is attractive because (1) unlike in the durable goods setting, the presence of diminishing returns to consumption and heterogeneity in this rate of diminishing returns creates an incentive for the firm to use selling versus renting as a means to price discriminate across consumers with different rates of diminishing returns, and (2) consumers are willing to pay more for renting repeatedly than buying because of the option value associated with renting, which lets them defer buying to a later date when they might get a better draw of the random utility shock $\varepsilon_{\text{buy},t}$. Charging a lower purchase price is feasible in the digital setting because digital locks created through DRM technology prevent a consumer from re-renting/reselling content thus circumventing all arbitrage opportunities.

2.2. Commitment

In this section, I specify the model when commitment is possible. The model described above simplifies because the aggregate states are no longer relevant to consumers' expectation formations, because prices are made known upfront, and the firm is able to credibly commit to holding these prices fixed. In this case, consumers are expected to take as given this commitment policy. In the digital world, this credibility is achieved by virtue of Apple, which is well known for its simple pricing policy.

2.2.1. Demand-Estimation Set-up. In the context of movies, consumers are currently accustomed to seeing one price point for new titles and another for old titles (e.g., online movies for rent are priced at \$3.99 for new-release titles and \$2.99 for older catalog titles). I draw on this "commitment" mechanism in the design of the survey in which I present respondents with a "new-release price" and a "future price". In this case, the time since release t is the only relevant state variable. Moreover, by design, everyone in the survey will be in the *notSeen* state. I assume consumers take as given the prices that are effective at t, given by the following equation:

$$P = \begin{cases} P_{\text{new}} & \text{if } t < \bar{T}, \\ P_{\text{old}} & \text{otherwise}, \end{cases}$$

where $P = [P_b, P_r]$ and $\bar{T}$ is the time of the price-drop.

Equations (6)–(10) then simplify, with the aggregate state S no longer a relevant state variable for the consumer's value functions.

2.2.2. Supply-Side Setup. In §6.2, I evaluate a studio's profit-maximizing strategy, assuming it has a commitment device that allows it to hold prices fixed forever. The studio's pricing problem in this case is to choose the time-invariant purchase and rental price that maximizes its net profit

$$[P_b, P_r] = \arg\max_{P_b, P_r} \sum_{t=1}^{T} \delta^t \sum_{m=1}^{M} q^m \big(Buy^m(S, t) P_b + Rent^m(S, t) P_r\big). \quad (19)$$

2.3. Discussion

Buyers or Collectors. Certain consumers may have a high propensity to buy, irrespective of their future valuation, for example "collectors" who want a large library of titles. However, this paper assumes that the future valuation forms an important part of the decision to buy and ignores any "collector" effect. One could argue that collectors do so because they think they may watch the movie sometime in the future and highly value that option. Moreover, although in the hardcopy world, a consumer might get additional utility from displaying a large collection, she is less likely to get such utility in a digital world where everything is stored in a cloud.

Theater-Goers. A consumer's decision to watch a movie in a theater is likely determined to some extent by the same structural parameters that govern her decision to buy or rent the movie. For example, consumers who have a high premium associated with the new-release period are more likely to have some amount of substitutability between watching the movie in the theater and at home.

I accommodate consumers who have previously seen the movie in theaters by treating them as a separate type who are in the *Seen* ($s = 2$) state.[7] The current model takes the consumer's decision to watch a movie in the theater or not as exogenously given. Modeling her choice to go to the theater or not and how this decision affects home video consumption is an interesting question in itself. From a firm's perspective, this adds the strategic decision of when to release the movie for home video. This is currently beyond the scope of this paper and is a suggestion for future work.

[7] This is done only for the movie Harry Potter in Survey 1 where a large proportion (34%) of the respondents had already seen the movie, prior to its home video release, in theaters.

3. Experiment Design, Methodology, and Data

To measure consumer preferences, this paper designs an experimental study using the conjoint setting while incorporating the inherent dynamics that govern a consumer's purchase, rent or postponement behavior. This means of collecting data falls under the broad category of preference measurement. See Netzer et al. (2008) for an overview on recent advances in preference measurement; and Green and Srinivasan (1978, 1990) and Orme (2006) for an overview of conjoint analysis.

This paper uses the conjoint setting to collect data relevant to the potential market for a specific movie for two main reasons. First, studios as well as firms in many markets do not have access to consumer-preference data before launching their product in the market. Although studios do have access to box office performance data before launching their movies in the home video market, recovering consumers' repeat-consumption preferences from one observation alone is not possible. Second, lack of price variation in the digital home video market makes identification hard even if we had access to individual-level demand data from similar movies (e.g., older movies in the same genre) and were to make the relatively strong assumption that the parameters for the movie of interest are identical to the older movies. I illustrate the identification problem with a simple example. Currently, the choices available to a consumer are (1) Buy Now at \$14.99, (2) Rent Now at \$3.99, (3) Buy after three years at \$9.99, (4) Rent after three years at \$2.99, and (5) Opt out. Observing two consumers choose the buy option at \$14.99 can only inform us that their willingness to pay is weakly greater than \$14.99. It cannot tell us if this choice was due to a high repeat-watch utility or a low price sensitivity as both can lead to the same observed behavior. Observing a consumer purchase the movie at \$9.99 after three years cannot inform us if she was price sensitive and hence chose to wait for the cheaper option, or if she did not have a strong preference for early consumption of the movie.

The experiment aims at recovering consumers' (1) repeat-consumption utility, (2) time-period-specific first-time consumption utility (which allows consumers' valuation to be different the first time they consume it), and (3) price sensitivity. The only requirement is that the content be amenable to both purchase and rental markets.

This section describes the experiment, which is designed to identify the parameters in the preceding model. This section also describes the methodology used to gather the relevant data and summarizes the collected data.

3.1. Design and Identification

The experimental design builds on the important features of §2.

First, I assume respondents only know their demand shocks in the current period. Therefore, I ask them to make trade-offs only in the current period. Because respondents do not know what shocks they may receive in the future, they are not asked to specify their choices in future periods. This approach contrasts with Dubé et al. (2014), who ask consumers to choose when they would purchase a durable good. All relevant parameters are identified by asking consumers to choose between Buy, Rent, and Postpone at varying current and future prices as well as HD availability across 12 choice tasks. Next I discuss how the various structural parameters are identified.

γ (***Repeat-consumption utility***). Each individual's γ can be identified by observing her relative buy versus rent shares across all choice tasks. This identification takes advantage of the fact that although buying and renting have identical values in the current period, they have very different implications for the future. Knox and Eliashberg (2009) incorporate this link between purchase and rental markets by considering the expected number of viewings in a consumer's buy versus rent decision.

Consider the example of an individual deciding to buy or rent when $P_b = P_r = P$. Her indirect utility from both options in the current period is identical. However, if she has a high γ, her expected future value in the buy option will be higher because she would have to incur an additional rental payment in the future if she chose the rental option

$$V_{\text{buy}}(notSeen, t) = \overbrace{\kappa(t)+\gamma}^{\text{Consumption}} - \overbrace{\alpha P}^{\text{Payment}} + \overbrace{\varepsilon_{\text{buy},\,t}}^{\text{RandomShock}} \\ + \underbrace{\delta \mathrm{E}\max_{\varepsilon'}\begin{pmatrix} V_{\text{consume}}(own, t+1), \\ V_{\text{notConsume}}(own, t+1) \end{pmatrix}}_{\text{FutureUtility}},$$

$$V_{\text{rent}}(notSeen, t) = \kappa(t)+\gamma-\alpha P+\varepsilon_{\text{rent},\,t} \\ +\delta \mathrm{E}\max_{\varepsilon'}\begin{pmatrix} V_{\text{buy}}(seen, t+1), \\ V_{\text{rent}}(seen, t+1), \\ V_{\text{opt}}(seen, t+1). \end{pmatrix}$$

This idea, along with the structural form assumption on the error terms, translates to observing different buy versus rent shares at different values of γ.

Thus I recover preferences relevant to a consumer's future valuations without asking her to specify choices in the future periods.[8]

$\kappa(1)$ (***First-time consumption bonus at*** $T = 1$). $\kappa(t)$ is the additional utility a consumer gets from consuming the content at time t for the first time. Here the relative rent versus postpone shares help identify $\kappa(1)$ in the new-release period relative to $\kappa(2)$. In this case, the identification uses the fact that the current-period-consumption values are different for the two options. If she rents today, her current-period consumption utility is $\kappa(1) + \gamma$ and is 0 if she chooses to postpone. Knowing γ and holding $\kappa(t+1)$ fixed identifies $\kappa(1)$

$$V_{\text{rent}}(notSeen, t=1) = \kappa(1) + \gamma - \alpha P + \varepsilon_{\text{rent},\,t} \\ + \delta \mathrm{E}\max_{\varepsilon'}\begin{pmatrix} V_{\text{buy}}(seen, t+1), \\ V_{\text{rent}}(seen, t+1), \\ V_{\text{opt}}(seen, t+1) \end{pmatrix},$$

$$V_{\text{opt}}(notSeen, t=1) \\ = 0 + \varepsilon_{\text{opt},\,t} + \underbrace{\delta \mathrm{E}\max_{\varepsilon'}\begin{pmatrix} V_{\text{buy}}(notSeen, t+1), \\ V_{\text{rent}}(notSeen, t+1), \\ V_{\text{opt}}(notSeen, t+1) \end{pmatrix}}_{\text{FutureUtility: } f(\kappa(t+1))}.$$

Note that the Postpone option here is different from the None option typical in surveys. The Postpone option gives the consumer the option of buying or renting in the future.

η (***Decline in*** $\kappa(1)$). I restrict $\kappa(t)$ such that $\kappa(t) = \kappa(1) \cdot (1-\eta)^{t-1}$. The closer η is to 0, the slower the decline in the first-time watch bonus over time. Varying the time t at which the future price comes into effect identifies η. In the experiment, t is allowed to take on two values: 1 month or 1 year. I allow t to take on the specific values of 1 month and 1 year

[8] I assume consumers have accurate beliefs about their preferences. This assumption is likely to be true for movies after theatrical release due to the reviews and existing buzz. However, consumers might update their beliefs after seeing the movie. Identifying this "learning" behavior in the current setting is difficult. As a robustness check, I ask consumers in Survey 2, "How many times do you think you will watch this movie?" with one of the possible answers being "I'll know only after I have seen it at least once." Only 7%–14% of the respondents chose this option, which indicates that learning might not explain a majority of consumer behavior. Identifying learning may require multiple observations from the same consumer at different states. For example, Shin et al (2012) use stated and revealed preference data to disentangle preference heterogeneity from learning.

Table 1 **Attributes and Their Range of Values in the Survey**

Conjoint variable	Possible values
Purchase price	\$9.99, \$12.99, \$14.99
Rental price	\$3.99, \$5.99, \$7.99
HD	Yes, no
Future discount[a]	0%, 10%, 25%[b]
Time future discount is applied	1 month, 1 year

[a]As applied to the purchase and rental price.
[b]The price is displayed in \$ amount, rounded to the nearest \$0.49 or \$0.99.

because respondents taking the survey can single them out more clearly, as opposed to varying t on a monthly basis. Allowing t to take on more than two values in the experiment can help recover a more flexible decline function.[9]

α (***Price sensitivity***) ***and HD sensitivity.*** Last, variation in the absolute values of the purchase and rental prices across choice tasks identifies the consumer's price-sensitivity parameter α. Variation in whether the content is available in high definition across choice tasks identifies how important HD availability is for an individual.

Thus, the choice task presented to a respondent consists of Buy, Rent, and Postpone choices, and is similar to the task an iTunes or Amazon consumer would face while deciding whether to purchase or rent a particular movie. Figure 3 shows an example of a choice task screen. Table 1 gives the attributes and their range of values.

Identification of γ and $\kappa(t=1)$ in a two-period model is illustrated in Online Appendix A (available as supplemental material at http://dx.doi.org/10.1287/mksc.2014.0896).

Discussion on Discount Factors. The same variation that identifies η in the experiment can identify a discount factor instead. However, I fix the discount factor such that consumers have the same discount factor as the firm ($\delta_c = \delta_f$) for the following reason related to the supply-side analysis. If consumers have lower discount factors than the firm, in equilibrium, the firm will exclusively rent to consumers because consumers will have lower ownership utilities and will be willing to pay lower amounts to own the content. However, if they rent, the amount they are willing to pay will remain the same when they arrive at the next period (due to constant discounting). The firm, due to its higher patience, will effectively rent the product to consumers to exploit their shortsightedness. This is explained through a simple model in Online Appendix B. Concomitantly, Barro (1972) shows that when consumers have lower discount factors than firms, they will be less sensitive to shifts in durability, which implies that the firm will have incentives to provide less durable products.

By restricting $\delta_c = \delta_f$ when consumers have lower discount factors than the firm, the reduced preference for the future will be picked up in how much the customer accelerates her current consumption ($\kappa(1)$ versus $\kappa(2)$) and how much less she values repeat consumption (γ). In other words, the fact that she cares less about the future will be reflected in her consumption values related to the future periods (both repeat and first-time consumption). Thus the only restriction is that they would trade off dollar values of discount at current interest rates.

3.2. Methodology

I design the survey to be movie specific because different movies can have different parameters. For example, animated movies may have a high utility of repeat consumption, whereas action-thriller movies may be associated with a high new-release-period premium.

The survey first asked respondents to select, from a set of predetermined movies, all of the movies they might consider watching at home now or in the future. The list of predetermined movies consists of those that had not yet been released for home video, so that by design, none of the respondents owned or would have watched the movie at home. Ideally, only one movie would be shown and all respondents asked to make trade-off decisions about the same movie.

Because my main focus is to recover consumers' preference parameters by exploiting the setting of the digital world (no secondary markets and low transaction costs), I restricted the consumer's consideration set to the digital world by setting expectations accordingly. Respondents in the survey were told, "The movie studios are considering moving entirely to digital offerings through the Internet and stopping production of physical copies of movies" and "The movies you will see in this study will be available for online digital download only—they will not be available in the DVD or Blu-Ray format. In other words you can download the movie electronically but cannot own a physical copy or rent it from a kiosk or brick-and-mortar store. Due to exclusivity contracts these movies will also not be available through subscription services like Netflix."

An instruction screen with an example choice task informed respondents of the choice tasks they would face. Respondents were then asked, about the specific movie to which they were randomly assigned,

[9] An alternate functional form fixing $\kappa(T=1\ \textit{year})$ such that $\kappa(T=1\ \textit{year})=\kappa(t=2)$ was also implemented. This identifies $\kappa(t=1)$ and $\kappa(t=2)$. Whereas this assumption infers the parameters directly from the underlying moments ($\kappa(1)$ versus $\kappa(2)$ and $\kappa(1)$ versus $\kappa(12)$), it creates a discrete jump in market share from $t=1$ to $t>1$. The substantive nature of the results remain the same.

to make trade-off decisions between three options: Buy Now, Rent Now, and Postpone Decision, each of which is described in detail below. The order of the choices was randomly rotated across tasks. Each respondent faced 12 such tasks.

Buy Now. This choice is associated with a purchase price and represents a decision to purchase in the current period. Respondents were told that if they were to Buy the movie Now, they could enjoy it forever but could not resell or rent it to others.

Rent Now. This choice is associated with a rental price and represents a decision to rent in the current period. Respondents were told that if they were to Rent the movie Now, they would have 48 hours to watch it and would have the option to re-rent it in the future at the applicable prices.

Postpone Decision. This choice is associated with deferring an option until a later time period and includes the option to opt out completely. The purchase and rental prices in the future are either lower than or equal to the current prices. The time the lower prices take effect can either be 1 month or 1 year.

This choice was specifically designed to be different from the None option, giving respondents the option of purchasing or renting in the future. This is because without knowledge of their future demand shocks, it is unlikely that respondents can commit to a None option. Note, however, that the None option is nested within this choice, and respondents were made aware of this fact before beginning the survey.

3.2.1. Survey 1. This survey was released on December 11, 2010 to the online national pool available to the business school lab at a major U.S. university on the west coast. The recruitment screen invited respondents to participate in a consumer choice study. They were told that they would be asked to evaluate a series of choice tasks involving digitally downloadable/streamable movies and that their participation would take approximately 10 minutes. They were told that all participants would be automatically entered into a prize drawing for four $50 Apple iTunes gift certificates. The survey was left open until February 3, 2011. During this time, none of the movies were released for home video.

Respondents could select from four movies in the list: Harry Potter, Megamind, Unstoppable, and Tangled. I chose these movies based on the criterion that they had not yet been released for home video.

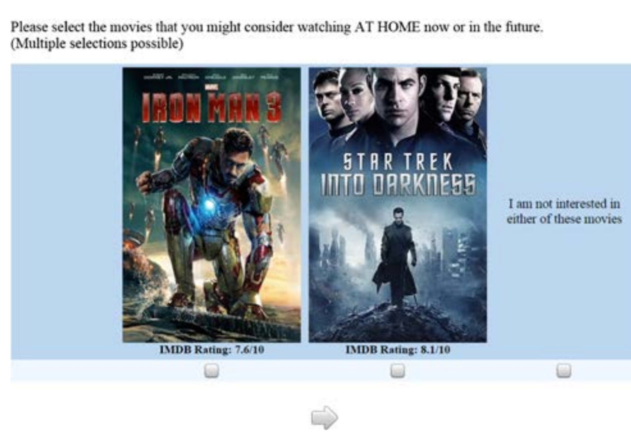
3.2.2. Survey 2. In addition to the above survey, I ran another survey that included incentive-compatible constraints and validated the results obtained from the conjoint choice tasks. I ran this survey in August 2013 and used Amazon's Mechanical Turk to recruit respondents. At the recruitment stage, respondents were asked not to take the survey if they had no intention of watching a movie via the Internet (e.g., via Apple iTunes). The compensation rate before any bonus was applied was $1.00 per respondent.

I selected two movies based on the same criteria used in the previous survey, with the additional constraint that the movie be released for online home video consumption within one to three weeks of the survey's completion. I added this constraint so that respondents could be awarded the movie immediately, in line with the nature of the incentive-compatible task. Iron Man 3 and Star Trek Into Darkness satisfied these criteria.

Figure 2 shows the movie selection screen. Respondents were randomly assigned to one of the movies from their selections. Note that randomization gives us the entire distribution of consumers with an interest in the movie. If respondents were asked to choose only one movie among the list of predetermined movies, we would get only the right side of the distribution, consisting of people with an extremely high interest in the movie. Allowing for multiple selections and randomly assigning respondents to one movie from their selected set helps achieve the complete distribution.

For each movie, respondents were randomly assigned to a control condition or an incentive-compatible condition. In the incentive-compatible condition, respondents were told that their responses to the choice tasks would be used to infer their willingness to pay for a particular configuration of the movie, which would be revealed after the survey. Similar to respondents in the incentive-compatible condition used in Ding (2007), they were told that a random price would be chosen for this configuration and if this price were less than or equal to what they were willing to pay, they would get this option at the randomly drawn price. Otherwise, they would be unable

Figure 2 (Color online) Selection Task



to get the movie. They had a 1 in 15 chance of receiving this bonus worth $20. Online Appendix C shows the exact screen seen by respondents. In the control condition, respondents performed the choice tasks with no such incentive.

Figure 3 shows an example choice task. In this survey, all prices were lower than the prices charged on iTunes and Amazon. The rental prices that are higher than $3.99 in the survey are still lower than the available price on these platforms because both movies were not available to "rent now" in the first month after release. As of July 2014, these movies were still unavailable to rent making the future rental prices in the survey lower than the practically available prices.

Charging a lower price ensures participation in the choice tasks especially if respondents are likely to be price sensitive. The only bias this might create is that respondents choose the Postpone option, when they wish to treat it as a None option, less frequently because they are effectively getting a deal in the survey compared to the real world. This would translate into a downward bias on the consumers' price-sensitivity coefficient. However, given the online sample this bias is unlikely to be large. In practice, a studio would conduct this survey before home video release and determine the price afterwards to avoid any such bias.

After answering the choice tasks, respondents in both conditions (incentive-compatible and control) were asked to answer a "Real Task" in which their chosen option would be implemented if they won the lottery. Online Appendix C shows the instruction screen they saw before responding to the real choice task. Responses from this task were used to validate the predicted shares from the conjoint task. This idea is similar in spirit to the validation exercise implemented in Ding (2007) and Ding et al. (2005). A respondent could either see a choice task in which (1) all options (Buy, Rent, and Postpone) were available or (2) only Buy and Postpone were available (respondents were randomly assigned to one of the two). Both types of tasks are possible in reality. Figures 4 and 5 show both of these tasks. Respondents were told that if they won the lottery, their exact choice would be implemented (if they chose Postpone, I would infer their preferred choice from their choices in the conjoint tasks: None, Buy 1 Year from now, and Rent 1 Year from now, and reward them accordingly).

To further validate the results, I asked respondents two additional questions: (1) Do you think you will watch this movie more than once? Possible answers: Yes/No, and (2) How many times do you think you will watch this movie? Possible answers: Not

Figure 3 (Color online) Example of a Choice Task Faced by a Respondent

Iron Man 3 is and will be available for purchase or rent via online digital download only. If these were your only options, which would you choose?

Option	Buy Now	Rent Now	Postpone Decision
New-release Price	$9.99	$3.99	
HD	Yes	Yes	
Future Buy Price			Option to Buy at $8.99 after 30 days
Future Rent Price			Option to Rent at $3.49 after 30 days

Choose by clicking one of the buttons above. Please take your time in carefully evaluating the options presented in this screen.

Figure 4 (Color online) Real Task 1

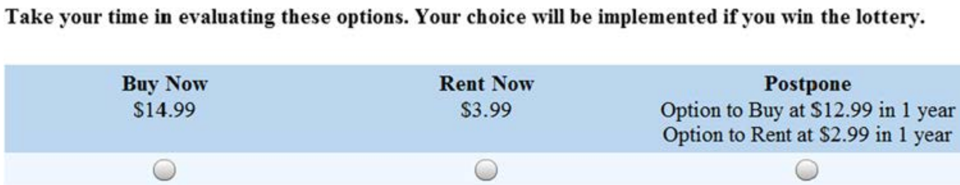
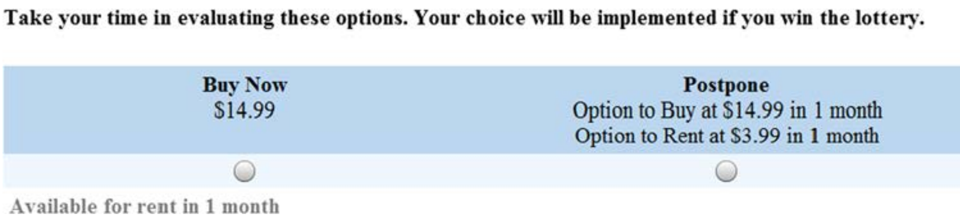


Figure 5 (Color online) Real Task 2



more than once/2–5 times/More than 5 times/I'll know only after I have seen it at least once.[10] I used responses to these questions as a consistency check for the repeat-consumption preferences recovered through demand estimation.

Next I describe the summary statistics, demand estimation, and supply-side analysis for movies in Survey 2.[11]

3.3. Summary Statistics

The median respondent took 2.1 minutes to evaluate the set of 12 choice tasks. Sufficient variation in respondents' choice behavior is crucial in estimating the parameters of interest. About 1%–6% of the respondents always choose the postpone option and 16%–29% never choose the postpone option (this number includes the respondents who either choose to always buy or always rent). I eliminate these respondents from the data while estimating the structural demand parameters. Having a wider range of prices in the choice tasks can mitigate this occurrence. To the extent that I eliminate those who never (always) postpone, my estimated parameters will be biased downward (upward) indicating a lower (higher) willingness to pay. For reference, Online Appendix D presents demand estimates including all respondents.

Table 2 shows the results of an MNL model with the variates of the conjoint design serving as the independent variables. The results show that, in general, an increase in the current price increases the propensity to postpone, whereas an increase in the future price decreases the propensity to postpone. Similarly, an increase in the time the discount is applied decreases the propensity to postpone; that is, the further away the discount, the higher the likelihood of purchasing or renting now. These findings provide preliminary evidence that respondents are taking into account the future prices as well as the time the discounted future price comes into effect in their tradeoff choices.

Table 2 Reduced-Form MNL Model (Postpone is the Base Option)—Survey 2

	Star Trek IC		Star Trek Control		Iron Man IC		Iron Man Control	
	U_{buy}	U_{rent}	U_{buy}	U_{rent}	U_{buy}	U_{rent}	U_{buy}	U_{rent}
P_{buy}	−0.65**	0.11	−0.35	−0.13	−0.35	−0.28	−0.64**	−0.20
P_{rent}	−0.26	−1.56**	−0.69	−0.77*	−0.89**	−0.95**	−0.37	−1.08**
HD	−0.63**	−0.20	−0.57**	−0.31	−0.82**	−0.38**	−0.65**	−0.36**
P'_{buy}	0.33	−0.07	0.08	0.20	0.10	0.43**	0.37	0.22
P'_{rent}	0.38	1.28**	0.83	0.35	1.03**	0.48	0.37	0.61
T	0.07**	0.09**	0.10**	0.09**	0.08**	0.10**	0.05**	0.04**
Cons	4.03**	1.72**	3.12**	1.95**	3.76**	2.24**	4.35**	3.70**
LL	−859.27		−666.14		−1,014.87		−785.85	
N	78		59		96		71	

Notes. P'_{buy}, P'_{rent} are the discounted purchase and rental prices. If there is no discount, $P' = P$.

**Significant at the 95% level, *significant at the 90% level.

Respondents' descriptive statistics related to demographics and access and familiarity with digital download are provided in Online Appendix E.

4. Demand Estimation

I now recover the structural parameters governing a consumer's decision to Buy, Rent or Postpone in a dynamic setting. The data collected are at the individual level with each individual having responded to 12 choice tasks. I estimate a type-specific heterogeneous distribution assuming that M discrete types exist in the population. I perform estimation separately for each movie.

[10] I thank an anonymous reviewer for this suggestion.

[11] The details for Survey 1 are available from the author on request. The qualitative nature of the results from Survey 1 is the same.

Table 3 Demand Estimates—Incentive-Compatible and Control Surveys

Parameter	Star Trek IC Coeff	Star Trek IC t-stat	Star Trek Control Coeff	Star Trek Control t-stat	Iron Man IC Coeff	Iron Man IC t-stat	Iron Man Control Coeff	Iron Man Control t-stat
				Type-1				
Repeat-watch, γ	−1.19**	−3.48	−1.47**	−3.92	−1.86**	−13.29	−1.50**	−8.21
First-time watch premium $T = 1$, $\kappa(1)$	4.20*	1.92	6.16**	5.66	12.30**	2.93	4.90**	4.25
Decay, η	0.52	0.81	0.26	1.29	0.11**	2.35	0.39**	1.97
HD	−0.25	−0.48	0.08	0.07	−1.25**	−2.00	−0.07	−0.13
Price-sensitivity, α	0.80**	3.86	0.81**	8.96	0.62**	6.94	0.68**	6.28
				Type-2				
Repeat-watch, γ	−2.19**	−16.71	−2.80*	−1.71	−2.41**	−15.05	−2.44**	−10.13
First-time watch premium $T = 1$, $\kappa(1)$	9.29**	11.81	9.33**	2.13	12.25**	6.46	9.40**	6.34
Decay, η	0.17**	5.40	0.19	1.20	0.15**	6.45	0.26**	4.85
HD	0.22	0.47	0.74	0.26	0.33	0.74	0.48*	1.87
Price-sensitivity, α	0.90**	8.33	0.93**	4.83	1.31**	5.76	1.02**	5.57
Log likelihood		−1,000.55		−783.16		−1,289.92		−970.95
% type-1		0.37		0.56		0.49		0.50
% type-2		0.63		0.54		0.51		0.50
N		78		59		96		71

**Significant at the 95% level, *significant at the 90% level.

4.1. Likelihood Function

The probability that an individual i of type m chooses option j in choice task c is given as follows:

$$p_{i,c}(\beta_m) = \frac{\sum_j e^{\bar{V}_j(x_c,\beta_m)} I_{i,c}(j)}{\sum_j e^{\bar{V}_j(x_c,\beta_m)}}, \tag{20}$$

where

$j = \{Buy, Rent, Postpone\}$,

$I_{i,c}(j)$ are indicator functions reflecting individual i's choice in choice task c,

$\bar{V}_{\text{buy}}, \bar{V}_{\text{rent}}, \bar{V}_{\text{opt}}$ are the value functions (without the error term) associated with buying, renting, and waiting in period 1 under the scenario presented in choice task c,

β_m is the set of type-specific structural parameters $\{\gamma_m, \kappa_m(t), \alpha_m\}$ governing a consumer's decision,

x_c are the variates of the conjoint choice task (the vector of purchase and rental prices

$$P = \begin{cases} P_{\text{new}} & \text{if } t < \bar{T}, \\ P_{\text{old}} & \text{otherwise}, \end{cases} \quad \text{; HD availability).}$$

To arrive at Period 1 value functions, I first solve the nested fixed-point for the post-discount periods $T > \bar{T}$. Because prices do not fall after $\bar{T}$, the individual's value functions can be obtained through a contraction iteration. Knowing these value functions, I solve backward for the time-specific value functions. I assume a discount factor of 0.975 for estimation.

Aggregating the probabilities over choices, the type-specific individual-level probability is

$$p_i(\beta_m) = \prod_{c=1}^{C} p_{i,c}(\beta_m), \tag{21}$$

where C is the total number of choice tasks completed by an individual in the survey.

Because we do not know which type an individual belongs to, her individual-level probability is the weighted average of her type-specific individual-level probability across all types and can be written as

$$p_i(\theta) = \sum_{m=1}^{M} \pi_m p_i(\beta_m), \tag{22}$$

where π_m is the percentage of Type-m consumers in the population and $\theta = \{\pi_1, \beta_1, \ldots, \pi_M, \beta_M\}$.

The overall log-likelihood[12] across all individuals can then be written as

$$LL(\theta) = \sum_{i=1}^{N} w_i \log p_i(\theta), \tag{23}$$

where $w_i \in \{1, 2\}$ depending on the number of movies the participant chose on the selection screen.

[12] Because participants who specified interest in more than one movie were randomly assigned to a single movie from their selection list, such participants are underrepresented in the collected sample. In other words, the sample for movie A consists of all participants who chose movie A only and 50% of those participants who chose both movies on the selection screen.

The likelihood for such participants is adjusted by weighting each individual likelihood by the inverse of their sampling probability to get the true likelihood. The weighted likelihood is given as $WLL(\theta) = \sum_{i=1}^{N} w_i \log p_i(\theta)$, where $w_i \in \{1, 2\}$ depending on the number of movies the participant chose on the selection screen.

Because the information matrix equality does not hold for this estimator, I use the sandwich form $N^{-1}\mathbf{A}^{-1}\mathbf{B}\mathbf{A}^{-1}$ to compute the asymptotic variance of the estimates, where $A(\theta_0) = p\lim(1/N) \cdot \sum_{i=1}^{N} w_i(\partial^2 \log p_i(\theta)/\partial\theta\partial\theta')|_{\theta_0}$ and $B(\theta_0) = p\lim(1/N)\sum_{i=1}^{N}(w_i)^2 \cdot (\partial \log p_i(\theta)/\partial\theta)(\partial \log p_i(\theta)/\partial\theta')|_{\theta_0}$ (Manski and Lerman 1977).

Figure 6 **(Color online) Demand Estimates: Decay Parameter**

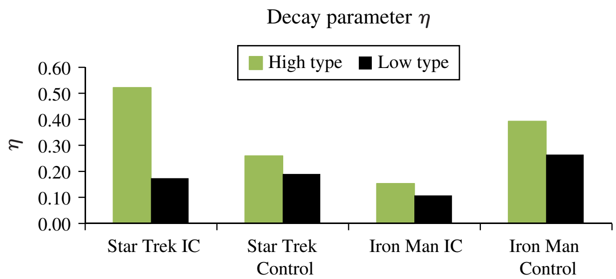
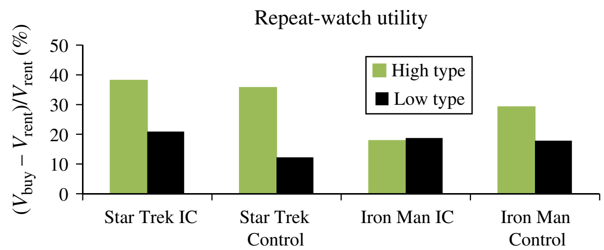


Figure 8 **(Color online) Demand Estimates: Repeat-Watch Utility**



Note. V_{buy} and V_{rent} are computed using the demand estimates at $P_b = P_r =$ \$10.99 to illustrate the effect of the repeat-watch parameter.

5. Results

Table 3 presents the results of the demand estimation for both movies across both conditions (incentive-compatible and control). Type-1 consumers are less price sensitive than Type-2 consumers. Going further, Type-1 consumers are referred to as high-type consumers and Type-2 as low-type consumers. Online Appendix E provides descriptive statistics on the profiles of these two types. The overall purchase elasticities range from −3.37 to −4.09 across different movies while rental elasticities are relatively smaller in magnitude ranging from −1.83 to −1.96. By consumer type, purchase elasticities range from −2.70 to −3.75 for Type-1 consumers and −4.78 to −8.52 for Type-2 consumers. Rental elasticities for Type-1 consumers range from −1.78 to −3.04 and −1.69 to −2.02 for Type-2 consumers.

Figures 6–8 explain the decay in first-time-watch valuation over time, η, the new-release period premium, $\kappa(1)$, and repeat-watch utility, γ.

Watching the movie for the first-time in its new-release period versus later. Figure 6 plots the decay parameter η across both movies and conditions. The closer η is to 0, the less the first-time valuation depreciates with time. In other words, consumers with lower η are more likely to enjoy their first-time consumption of the movie the same whether it is consumed in the current period or in the future.

Figure 7 plots the drop in willingness to pay, $(\kappa(t) - \kappa(t-1))/\alpha$, for the first-time watch of the movie over time. The figures show that the valuation drops much more quickly for (the high-type consumers of) Star Trek (IC) than for Iron Man (IC). Across all movies and conditions, high-type consumers are willing to pay \$1.50–\$2.75 extra to watch the movie as soon as it is released rather than wait another month. Both $\kappa(t)$ and η will affect how much consumers are willing to postpone their first-time consumption to later periods, and consequently the firm's pricing power.

Repeat-watch. Figure 8 plots the difference in purchase and rent value functions driven by a consumer's repeat-watch utility. The repeat-watch parameter, γ, is analogous to the durability of the content. The difference in this durability between different types of consumers will affect the extent to which the firm can use the purchase and rental markets to price discriminate between them. Here, we see that the two types of consumers for Star Trek (IC) differ more substantially in their repeat-watch utility compared to the two types of consumers for Iron Man (IC).

Figure 7 **(Color online) Demand Estimates: Drop in the WTP for the First-Time Watch Over Time**

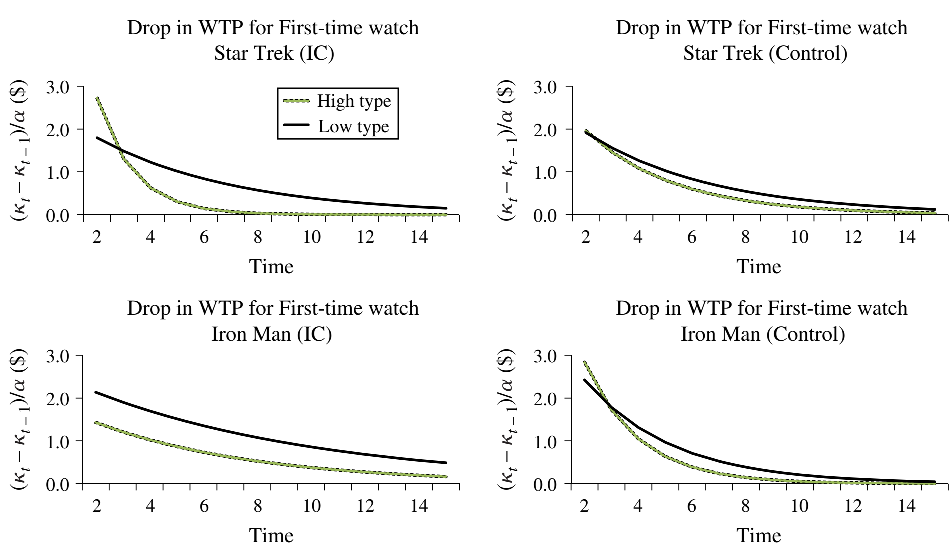


Table 4 Validation: Hit Rates

	Real Task 1				Real Task 2			
	Star Trek		Iron Man		Star Trek		Iron Man	
	IC	Control	IC	Control	IC	Control	IC	Control
N	41	29	46	43	37	30	50	28
Number correct	22	10	26	21	33	27	45	23
Percentage (%)	54	34	57	49	89	90	90	82

5.1. Validation

The survey asked respondents to respond to a "Real Task" as well (Figures 4 and 5). To validate responses to the conjoint task in this survey, I use the demand estimates to compute each individual's predicted choice at these prices and compare these to their actual choice in the Real Task. Table 4 reports for each survey and each task, the number of times the predicted choice matched the actual choice specified in the Real Task. A prediction is coded as Buy if the individual's predicted share for that option is higher than both the Rent and Postpone shares. As can be seen, the incentive-compatible condition does better than the control condition for all movies, except for Star Trek Real Task 2, where both the incentive-compatible and the control conditions perform almost equally.

Table 5 reports the answers to the two additional consistency-check questions, split by type of consumer. I find that the answers to these questions match the demand estimates. According to the demand estimates, the Type-1 consumers have a higher repeat-watch utility. As can be seen, these consumers are more likely to respond Yes to question 1 and are also more likely to watch the movie more than once. Additional validation checks, including aggregate predicted versus actual shares by segment, the estimated number of watches, and responses to consistency-check questions are provided in Online Appendix F.

6. Pricing Strategy With and Without Commitment

6.1. No Commitment

I first evaluate the pricing strategy of the firm without the ability to commit. In §6.2, I compare this strategy to a scenario where commitment is possible.

Having recovered the underlying parameters that govern consumers' preferences, I solve a dynamic equilibrium between the consumers and the firm. Papers that have numerically solved for a dynamic equilibrium include Dubé et al. (2010) and Goettler and Gordon (2011). Online Appendix G presents the algorithm for computing the optimal prices. This algorithm adapts the one developed by Nair (2007) to incorporate rental markets as well. In addition, I specify the consumer value functions as constraints that need to be satisfied in equilibrium (instead of iteratively solving for these functions) at every guess of the firm's pricing policy. This approach of constrained optimization has been demonstrated in Su and Judd (2012) and Dubé et al. (2012). The algorithm is solved numerically using the TOMLAB interface between MATLAB and the SNOPT solver, a system for constrained optimization.

Figures 9 and 10 plot the purchase and rental share evolution over time for the movies Star Trek and Iron Man, respectively. As can be seen, the fairly large difference in repeat-consumption preferences for Star Trek (seen in Figure 8) results in the firm being able to indirectly price discriminate the two types using the purchase and rental markets, i.e., the High Type participates in the purchase market and the Low Type in the rental market. On the other hand, for Iron Man, the large new-release-period preference (κ_1 is high for both types) causes both types of consumers to switch to the rental market. Moreover, the low separation in repeat-consumption preferences further hinders the firm's ability to successfully indirectly price discriminate.

Table 5 Type-1 Consumers Report Higher Likelihood of Watching Again

	Star Trek IC		Star Trek Control		Iron Man IC		Iron Man Control	
	Type-1	Type-2	Type-1	Type-2	Type-1	Type-2	Type-1	Type-2
Do you think you will watch this movie more than once?								
Yes (%)	80	60	87	31	85	53	81	53
No (%)	20	40	13	69	15	47	19	48
How many times do you think you will watch this movie?								
Not more than once (%)	20	32	13	55	11	41	13	48
2–5 times (%)	52	47	67	28	68	41	65	38
More than 5 times (%)	20	4	13	3	13	4	13	10
I'll know only after I have seen it at least once (%)	8	17	7	14	9	14	10	5

Figure 9 (Color online) Equilibrium Purchase and Rental Share Over Time—Star Trek

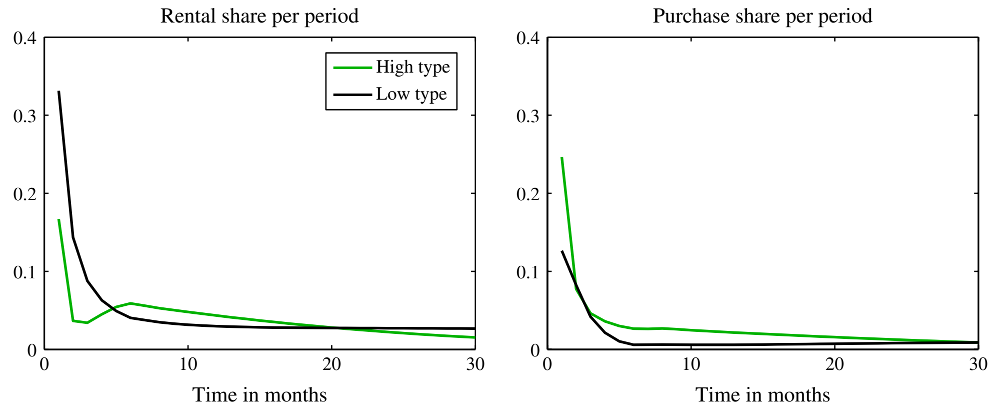


Figure 10 (Color online) Equilibrium Purchase and Rental Share Over Time—Iron Man

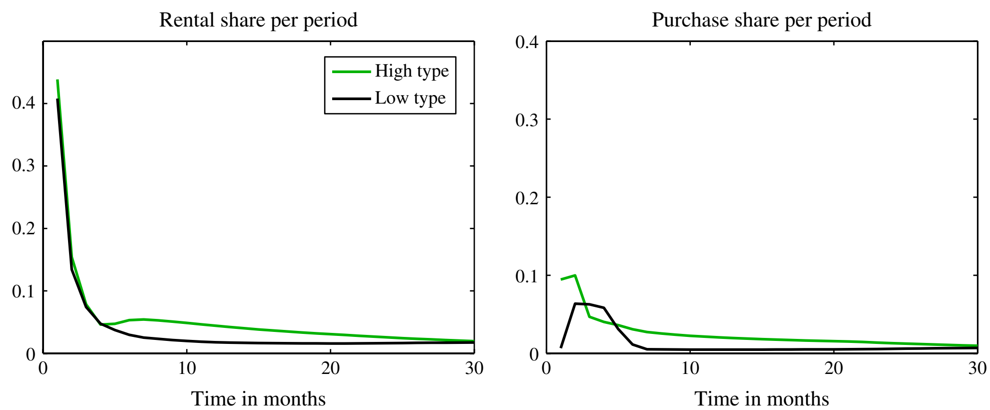


Figure 11 plots the equilibrium prices the firm charges over time.

6.2. Commitment

This section evaluates the scenario wherein a studio is able to commit to holding prices fixed over time. The studio's pricing problem in this case is to choose the time-invariant purchase and rental price that maximizes its net profit

$$[P_b, P_r] = \arg\max_{P_b, P_r} \sum_{t=1}^{T} \delta^t \sum_{m=1}^{M} q^m (Buy^m(S, t) P_b + Rent^m(S, t) P_r). \quad (24)$$

Under commitment, I find that both Star Trek and Iron Man should be offered only for purchase. Rental prices in equilibrium are almost equal to the purchase prices, resulting in negligible rental market shares (see Figure 11). At these prices, both types of consumers of Star Trek and only the high-type consumers of Iron Man, participate in the purchase market (see Figure 12). Coincidentally, both movies are currently available only for purchase in iTunes and Amazon, with Iron Man slated for a rental release on April 2015, nearly 1.5 years after it was made available for purchase (Figure 15).

Figure 11 plots the prices under the commitment and no-commitment scenarios for Star Trek and Iron Man, respectively. The studio is able to charge higher prices when it is able to commit because consumers know that prices will not fall in the future and no longer have incentives to engage in intertemporal substitution. As a result, most purchases occur in the first few periods (Figure 12). Consistent with the durable goods theory, this scenario earns the studio the highest profits (Figure 13). Although fewer consumers participate in the market in the commitment scenario, profits are 45% and 41% higher than in the no-commitment policy for Star Trek and Iron Man, respectively.

While I find that, under the demand estimates recovered, the firm should offer content only for purchase, keeping both markets open would serve as a price discrimination mechanism if consumers differed more substantially in their valuation of durability, that is, if the low-type consumers had a higher κ and a lower γ, making them candidates for a one-time rental transaction. To illustrate this point, I plot in Figure 14 the difference between purchase and rental prices for different values of γ_1, holding other parameters fixed for the movie Star Trek. As can be

Figure 11 (Color online) Equilibrium Prices for Star Trek and Iron Man Over Time Under the Commitment and No-Commitment Policies

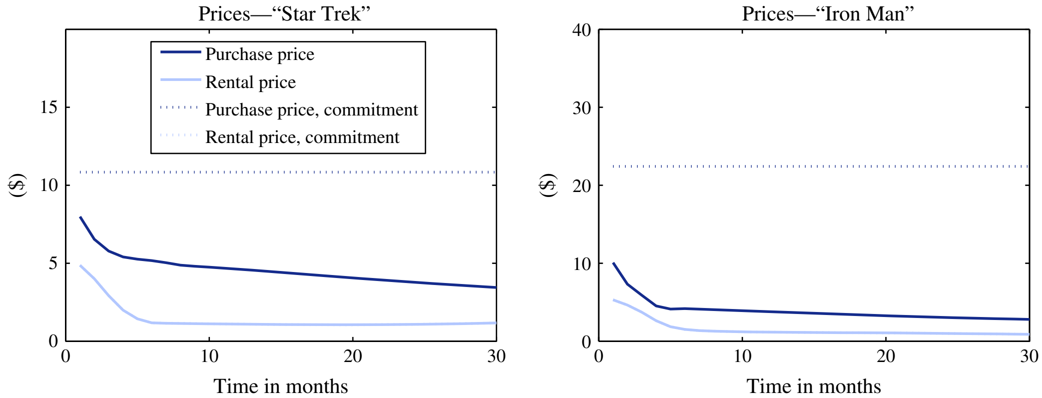
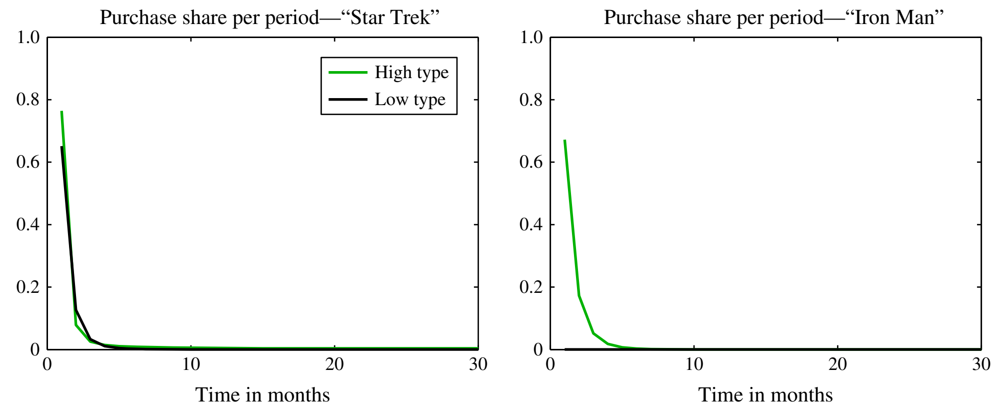


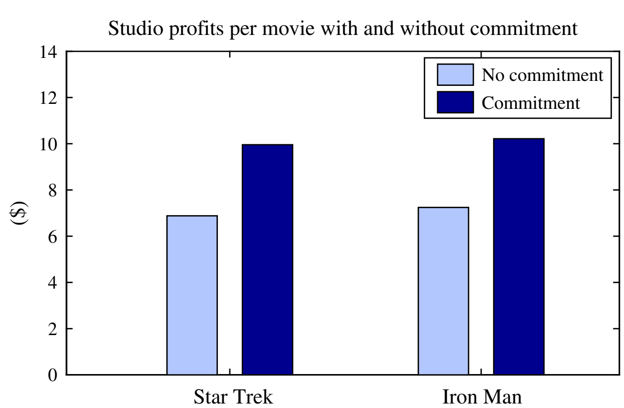
Figure 12 (Color online) Commitment Purchase Shares Over Time



seen, when γ_1 passes -0.5, the firm begins using both purchase and rental markets to engage in price discrimination.

Thus, the results indicate that when the firm is able to credibly commit, and when most consumers want to consume the content more than once, content should be made available only for purchase. In practice, some classics and children's movies that likely satisfy these criteria are indeed made available only for purchase (The Sound of Music, To Kill a Mockingbird, and Frozen are examples of movies available only for purchase on iTunes). Also, a few years ago, movies such as Finding Nemo, Bambi, and Cars were available only for purchase but are currently available for purchase and rent. This can either mean that firms have not yet reached the product and pricing equilibrium in the digital space and are exploring various

Figure 13 (Color online) Studio Profits Are Higher When It Has the Ability to Commit to a Price Path



Note. Profits are per consumer.

Figure 14 Difference in Purchase and Rental Prices as a Function of γ_1

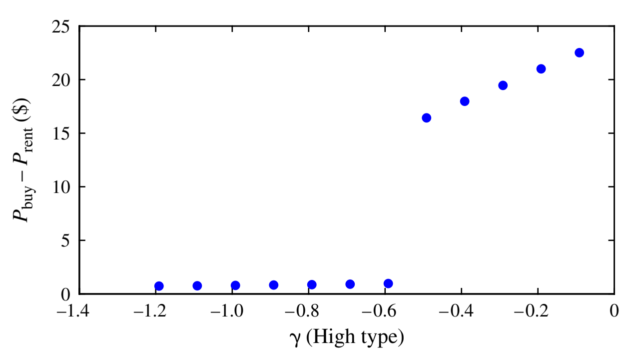
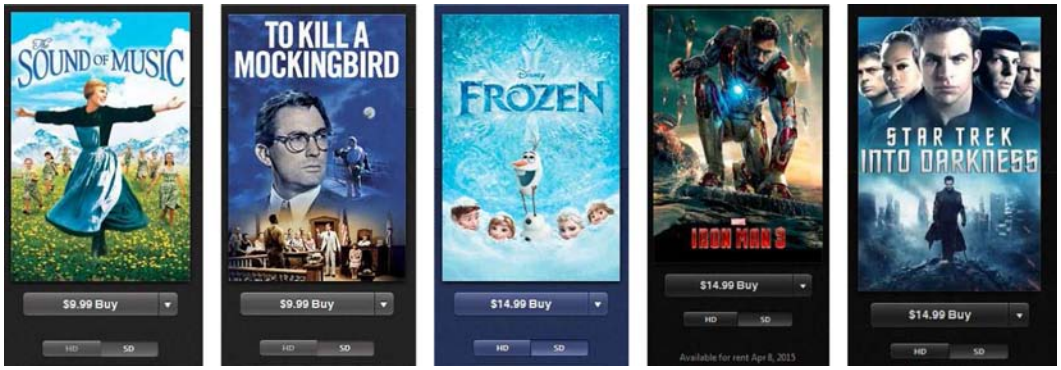


Figure 15 (Color online) Movies Available Only for Purchase



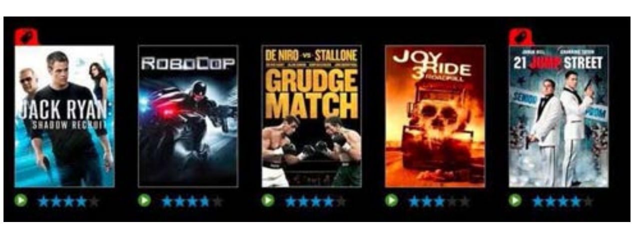
offerings, or that Apple's commitment is weakening over time as studios push for pricing flexibility. There is some evidence of the latter as seen by the presence of deals on Vudu, iTunes, and Amazon (Figure 16). This provides some indication that the digital world is moving toward a world where commitment may no longer be feasible as consumers begin to see and expect reduced prices soon after a movie's release. In that case, my simulations indicate that the provider will offer content for purchase and rent.

One caveat is that a more flexible heterogeneity specification can uncover a more extreme distribution of preferences, in which case sorting using purchase and rental markets, when the firm can credibly commit, can be optimal. I find this to be the case for one movie (Star Trek) across all movies in both surveys where identification of all parameters using a 3-type distribution was achieved. This suggests allowing for a more flexible heterogeneity specification. Nevertheless, in a forward-looking demand/supply-side setting accommodating this is challenging. I suggest this as an avenue for future research. Last, I have not considered the platform's problem that could involve optimizing prices and product configuration under the constraint of offering the same price and configuration across all movies.

7. Counterfactual Policy Evaluations

In this section, I evaluate the optimal strategy and profitability of a monopolist under two different scenarios. First, I compute the equilibrium pricing policy and profitability in the scenario where consumers' preferences are not time dependent; that is, $\eta = 0$. I perform this computation to illustrate how the firm sorts out high- and low-valuation consumers using time as a discriminatory mechanism. Second, I evaluate the loss in profitability if the studio were to delay rental availability by one month, a practice followed in the industry until 2010.

Figure 16 (Color online) Titles with Red-Coupon Tags Are "On-Sale" on the Vudu Platform



7.1. Time-Independent Preferences

Time as a Discriminatory Mechanism. Figure 17 plots the purchase and rental shares if consumers valued watching the movie Iron Man the same in all periods, that is, $\eta = 0$. Clearly, we observe a lot of intertemporal substitution occurring in this case. As consumers no longer care about the newness of the movie, they are more likely to wait for cheaper prices. This willingness to wait causes the firm to further lower its new-release-period prices. In equilibrium, the firm engages in a price-discrimination strategy catering to the high-type consumers early on and the low-type consumers in later periods. Comparing this to Figure 10 where the incentive to watch the movie in its new-release period is strong, consumers here are more likely to postpone their first-time consumption to later periods. Despite the ability of the firm to skim the market, it is unable to extract higher profits due to consumers' willingness to postpone their first-time consumption. Profits in this case are lower by 21%.

Purchase and Rent as Discriminatory Mechanisms. For Star Trek, the increment from buying relative to renting is larger for the high types compared with Iron Man, where the increment is similar for both high and low types (Figure 8). As a result, in equilibrium for Star Trek, the purchase market caters more to the high-valuation consumers. On the other hand, for Iron Man, both types of consumers respond similarly to purchase and rental markets in equilibrium, with the low-type consumers responding at lower price points, because they are more price sensitive

Figure 17 Iron Man Shares if Consumers Value New-Release Period the Same as Other Periods

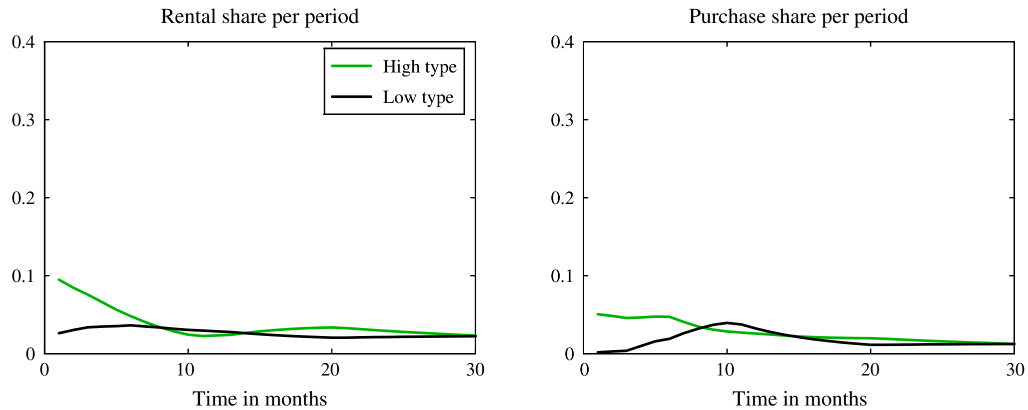
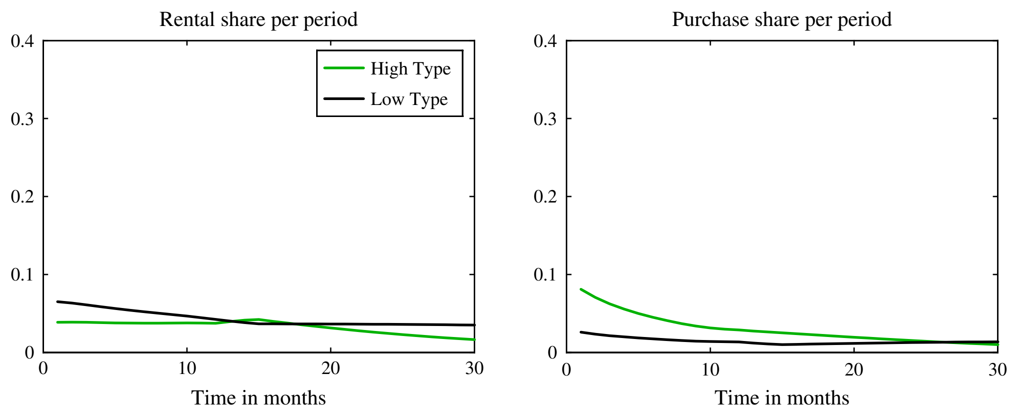


Figure 18 Star Trek Shares if Consumers Value New-Release Period the Same as Other Periods

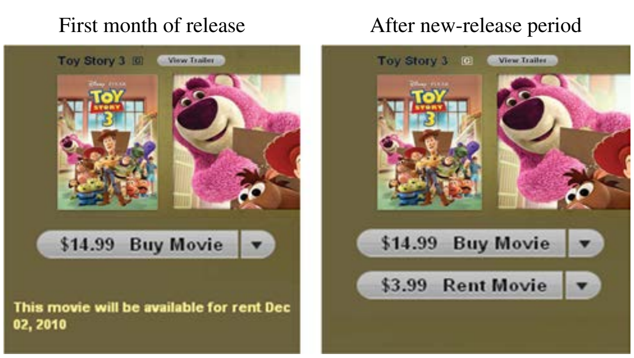


and more likely to engage in intertemporal substitution. The firm's ability to price discriminate using the purchase and rental markets is seen clearly in Figures 18 and 9.

7.2. Delaying Rental Availability

From 2008 to 2010, digital downloads of a newly released movie were available for purchase one month before the rental option (see Figure 19). The

Figure 19 (Color online) Delayed Rental: Toy Story 3, Which Was Released for Online Home Video on November 2, 2010, Was Made Available for Online Rental One Month Later on December 2, 2010



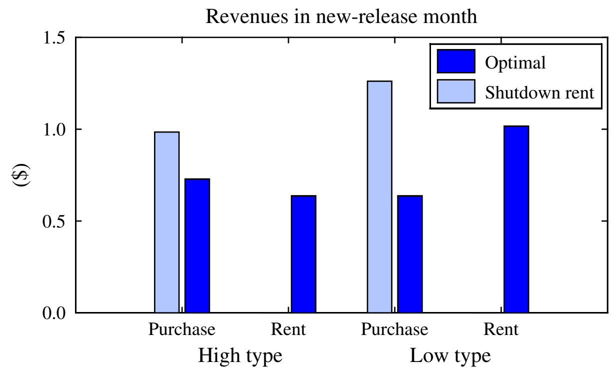
purchase option was priced at $14.99 and the rental option at $3.99. Studios likely created this window to price discriminate users willing to pay a premium to watch a movie in its new-release period. Studios adopted this strategy directly from the hard-copy world, where studios, to avoid competition from renters such as Redbox and Netflix, would sign contracts requiring them to delay rent offerings of DVDs by 28 days after a movie's release. Whether this strategy is optimal in the digital world where studios directly control rental revenue is unclear.

To evaluate this policy, I shut the rental market down for the movie Star Trek in the new-release period and compare the resulting strategy to the optimal strategy evaluated in §6. The firm's profit in the new-release period in this case consists of revenues from the purchase market alone

$$\pi(S, t=1) = \sum_{m=1}^{M} q^m (Buy^m(S, t=1) P_b(S, t=1)). \quad (25)$$

The new-release purchase price is lower ($7.61) compared to the case in which both markets are open ($7.99) because the firm tries to capture as many low-valuation consumers as possible. Figure 20 shows the

Figure 20 (Color online) Counterfactual Policy—Delaying Rental Availability (Star Trek)



Note. Revenues are per consumer.

impact of delaying rent on profits in the new-release period. As can be seen, the firm makes up for the lost rental revenues from the high-type consumers through the purchase market, but cannot completely gain the lost revenues from the low-type consumers.[13] Moreover, due to the drop in their first-time-watch utility, the low-valuation consumers will no longer be willing to pay high prices in later periods. Overall firm profitability decreases by 6.3%.

8. Conclusion

This paper empirically analyzed the interaction of purchase and rental markets in a durable goods setting to determine the profit-maximizing pricing strategy of a monopolist with the ability to serve both markets. Whereas online content shares many characteristics typical to durable goods, they have the additional feature of facing diminishing returns to consumption; that is, a consumer's valuation can drop after her first consumption. Adding this feature is not only relevant to analyzing digital content, but as this paper finds, also results in equilibrium the durable goods literature does not predict: Purchase and rental markets can be used to differentiate between consumers with different rates of diminishing returns to consumption.

This paper also finds that consumers with strong preferences for new-release-period consumption strengthen the firm's market power because consumers do not have incentives to postpone consumption. This same phenomenon negatively affects profitability when the firm delays rent: Consumers who would otherwise have paid a high price to rent early-on lose interest as the content becomes "old-news". Commitment has a considerable impact on profits, increasing firm profitability by as much as 45%. To some extent, Apple's current push for simplicity and maintenance of a simple pricing policy gives firms this commitment mechanism. However, as studios explore other avenues of distributing their content, they may face incentives to cut prices after the high-valuation consumers have purchased or rented the movie, thus losing the ability to commit.

The intertemporal preferences relevant to a firm's strategy were recovered using an incentive-compatible conjoint study designed specifically to recover consumers' preferences, using current-period choices alone. Studios can easily implement this method to gauge consumer preferences before a title is released for home video consumption. This information can provide additional data beyond box office performance and help uncover consumers' repeat-consumption and time-related preferences. These preferences are recovered by asking respondents to make simple and realistic trade-offs, i.e., choices they would typically make when deciding to watch a movie, and can then be used by the studio to decide the best product and pricing strategy for its movie.

Finally, I have considered a monopolist's pricing strategy, ignoring the effect of competition. This paper assumes that most products have consumers who will definitely consume the content, if not now then at some time in the future. However, to the extent that other alternatives are available, consumers may be further inclined to postpone their consumption. This postponement will negatively impact the monopolist's pricing power, and the equilibrium will be closer to that described in the Coase conjecture. Also, apart from the pay-per-use channel, which was the focus of this paper, subscription services such as Netflix and Amazon Prime offer (a limited number of) movies through their streaming services. These subscription services typically provide older catalog titles, mainly because providing premium content at all-you-can-eat subscription prices is infeasible. I have not considered subscription pricing in my analysis, leaving this for future work, which will require knowledge of the distribution of preferences across all types of movies to determine appropriate subscription bundles and prices.

Supplemental Material

Supplemental material to this paper is available at http://dx.doi.org/10.1287/mksc.2014.0896.

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[13] Mukherjee and Kadiyali (2011) model purchase and rental cross-channel substitution using aggregate data in a static setting. They find that delaying rental release reduces revenues because consumers prefer opting out to switching to the purchase channel.

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