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How Video Rental Patterns Change as Consumers Move Online

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How will consumption patterns for popular and “long-tail” products change when consumers move from brick-and-mortar to Internet markets? We address this question using customer-level panel data obtained from a national video rental chain as it was closing many of its local stores. These data allow us to use the closure of a consumer’s local video store as an instrument, breaking the inherent endogeneity between channel choice and product choice. Our results suggest that when consumers move from brick-and-mortar to online channels, they are significantly more likely to rent “niche” titles relative to “blockbusters.” This suggests that a significant amount of niche product consumption online is due to the direct influence of the channel on consumer behavior, not just due to selection effects from the types of consumers who decide to use the Internet channel or the types of products that consumers decide to purchase online.

Key words: long tail; movie rentals; natural experiment; empirical estimation

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1. Introduction

A variety of papers and articles have documented large differences between the types of products purchased online and offline (e.g., Brynjolfsson et al. 2003, Anderson 2006, Brynjolfsson et al. 2011). However, these differences in purchase patterns across channels could be solely due to selection effects: heterogeneous consumers may sort into channels based on their tastes, or consumers who use both channels may choose the channel based on the types of products they want to purchase. Our objective in this paper is to investigate whether observed differences in consumption patterns between online and offline markets are solely due to selection or whether the nature of the channel has some impact on consumers’ choices.

Answering this question requires the use of customer-level panel data on online and offline purchases and an exogenous shock affecting consumers’ channel choices. In this paper we use just such a data set for DVD rentals. We base our empirical analysis on household-level panel data from a large video rental chain that closed many physical locations during our study period. The market for DVD rentals has traditionally exhibited “superstar” effects, where a few top-selling products take the majority of all revenues

(Rosen 1981); our focus is to empirically examine how the introduction of online commerce has changed the share of transactions taken by superstar versus niche DVDs.

We note that in our data the top 100 most popular DVDs make up 85% of in-store rentals for our focal company but account for only 35% of the company’s online rentals. However, we cannot use these simple statistics to conclude that online markets change consumer behavior because these statistics may be solely due to selection effects. Our approach to study whether online markets change consumer behavior is to examine how household-level rental patterns for popular and niche titles change when the exit of physical stores forces consumers to move from offline to online channels. Specifically, we use the exit of physical stores as an instrumental variable for the online versus offline channel choice. This instrument exploits transportation cost changes experienced by individuals located near the exiting stores. Our findings indicate that characteristics of the online channel cause superstar DVD titles to take a smaller share of the market as consumers shift from offline to online marketplaces.

From the standpoint of theory, online markets may (or may not) transform markets that have

traditionally exhibited “superstar” effects. Various supply-side or demand-side mechanisms can cause long-tail or superstar markets (Brynjolfsson et al. 2006, 2010). For example, the selection of products available from the Internet channel is often much wider than the selection available at physical stores. Online marketplaces can offer a larger selection of products than traditional physical stores can because the online channel has lower storage and inventory costs and there are no shelf space limitations. As a consequence, the concentration of overall sales across products may tend to decrease as transactions shift from offline to online channels.

Online channels could also change consumers’ product choices even when the sets of products offered online and offline are identical. In part, this might happen because the ways consumers search for products online and offline are fundamentally different. At physical stores, finding a popular product may be easier than finding a niche product, even when both are available. Popular products typically occupy more prominent shelf space in physical stores versus niche products that are relegated to less visible positions. In online marketplaces, search tools may be used to promote the discovery of niche titles tailored to individual customers’ preferences. However, personalization and recommendation engines and other search tools could also increase the concentration of product sales. For example, top 10 seller lists may tend to reinforce the popularity of already popular products. Similarly, recommendation systems may increase the concentration of product sales because they base their recommendations on actual sales and there are limited data for products that have low historical sales (Fleder and Hosanagar 2009, Oestreicher-Singer and Sundararajan 2012).

Our results contribute most directly to the empirical literature studying the effect of information technology on sales concentration patterns. Although the “long tail” was considered one of the best ideas of 2005 by industry observers (*BusinessWeek* 2005), it is important to note that there is no general agreement in the academic literature regarding how online commerce will affect the concentration of product sales. In this literature, Elberse and Oberholzer-Gee (2007) use aggregate data by title to study how online commerce affected the distribution of sales in the U.S. home video industry from 2000 to 2005. They find that although the number of product choices increases, by the end of their study period superstar products made up a larger proportion of sales than before.¹ Brynjolfsson et al. (2011) examine the concentration of product sales for a retailer of women’s

clothing selling through both Internet and catalog channels. Using cross-sectional data on sales, aggregated by item and channel, they find that the concentration of product sales is lower for the Internet channel than for the catalog channel.

Our paper is also related to the research examining grocery shopping using household-level data for households that shop interchangeably at online and offline stores from the same grocery chain (e.g., Chu et al. 2008). In this literature, our paper is most closely related to Pozzi (2012), who finds that brand exploration is more prevalent in physical stores than online. As consumption goods, however, groceries are substantially different from DVD rentals because groceries are typically consumed more repeatedly as compared to DVDs.²

The answers to questions surrounding how consumption patterns change when consumers move online are important for both the academic literature and for managerial practice. If the observed differences between online and offline markets are solely due to selection, without an effect on aggregate consumption, then there is no need for producers to change their behavior—and in our context in particular, motion picture studios should continue to focus on producing blockbuster titles. However, if using online markets changes consumer behavior, then producers may wish to reexamine their current strategies and shift their production toward more long-tail products.

2. Data and Setting

Our data come from a large video rental company that operates both brick-and-mortar stores and online DVD rental channels. For a monthly flat rate subscription, customers in our data can rent DVDs online, receive them in the mail, and then exchange these DVDs either through the mail or at a physical store.

The selection of DVD titles available for rental at these physical stores is a subset of the selection of titles available for rental online. Although a typical store has a rotating selection of approximately 2,000 titles, the online channel has more than 100,000 titles. The Internet channel has a much larger DVD selection than the selection available at physical stores because the online channel has lower storage and inventory

¹ Partly motivated by this result, Bar-Isaac et al. (2012) formulated a model in which a reduction in search costs generates both superstar and long-tail effects.

² Our results also contribute to a growing literature on the impact of popularity and recommendation information on online sales of niche and popular products (Tucker and Zhang 2011, Fleder and Hosanagar 2009, Oestreicher-Singer and Sundararajan 2012). In contrast to our study, these studies do not examine sales from physical stores or cross-channel choices. Our paper is also related to Waldfogel (2012), who documents a decrease in the degree of music sales concentration in a few artists, and to Goldfarb et al. (2012), who examine how social inhibitions in physical markets can affect market outcomes.

costs.³ Because of these storage capacity limitations, our focal company's physical stores stock more copies of new releases than of older titles. Inventory costs are also lower online than in physical stores because the company we study ships DVDs to its customers from a small number of centralized warehouses, compared with a substantially larger set of physical stores. Thus, because these shipping locations reach a much larger number of consumers than a physical store would, the law of large numbers indicates that the company can reduce inventory costs by more accurately predicting demand from the online channel.

Our data cover DVD rental activity from both the online and in-store channels for all subscribing customers and include more than 49 million rental transactions for the 30-week period from October 2, 2009, through April 29, 2010. Although consumers without a monthly subscription can rent DVDs from our company's physical stores, our data only include the information from consumers with a monthly subscription that allows the rental of an unlimited number of DVDs.⁴ Customers maintain an online queue of DVD titles they wish to watch, and when they return a DVD, the company sends the next DVD title from that queue to the subscriber's home.

Our data include the renting subscriber, DVD title, transaction date, and whether the DVD was delivered by mail or exchanged at a physical store. In addition, we have the zip code for each subscriber, the address for each physical location operated by this firm, and the closing date for the locations that were closed during our study period. For approximately 56% of the subscribers and for each week, we also have the distance between each of these customers' homes and their closest store.⁵

Table 1 presents the summary statistics for our data. The DVD rental market has experienced important changes during the last decade. Industry trends show that traditional physical stores have been displaced by online DVD rental services and, more recently, by video streaming services and by physical kiosks. We do not know exactly how the number of subscribers changed during our period of analysis because subscribers may not rent every week, and we do not

Table 1 Summary Statistics

Week	Number of transactions	Number of subscribers with positive rentals	Number of stores
Week 1	1,547,158	739,696	3,356
Week 2	1,511,517	721,494	3,356
Week 3	1,520,978	727,174	3,356
Week 4	1,580,138	743,421	3,354
Week 5	1,526,952	690,849	3,325
Week 6	2,212,001	798,357	3,324
Week 7	1,764,180	735,643	3,300
Week 8	1,590,305	721,258	3,072
Week 9	1,736,078	786,002	3,066
Week 10	1,607,267	735,969	3,066
Week 11	1,660,696	750,181	3,066
Week 12	1,725,464	764,054	3,065
Week 13	1,661,685	740,716	3,047
Week 14	1,744,056	770,986	3,047
Week 15	1,765,719	775,946	3,046
Week 16	1,693,175	748,035	3,046
Week 17	1,732,115	755,332	3,033
Week 18	1,733,123	758,485	3,033
Week 19	1,629,584	725,281	3,033
Week 20	1,620,146	726,576	3,032
Week 21	1,633,609	717,592	3,032
Week 22	1,637,397	721,227	2,860
Week 23	1,648,239	722,855	2,859
Week 24	1,625,214	713,490	2,858
Week 25	1,656,037	715,472	2,858
Week 26	1,617,684	702,461	2,844
Week 27	1,478,658	662,682	2,844
Week 28	1,441,504	650,747	2,844
Week 29	1,442,232	648,772	2,843
Week 30	1,432,050	645,485	2,843

have a list of subscribers indicating when they signed up for service or canceled their subscriptions. But the decrease in the number of subscribers renting DVDs by the end of our study period shown in Table 1 suggests that the number of subscribers decreased during this period. Our data come from a company that closed 15.2% of its physical stores during our period of analysis (see the last column of Table 1). Our focal company did not open new physical locations during the 30-week study period, and thus the number of physical store locations is entirely driven by store exit. The substantial change in the number of physical rental stores will play a central role in our identification strategy since we will use store exit as an instrumental variable for online versus offline channel selection by consumers.

Rentals via mail represent 68.3% of all rentals, and DVD exchanges at physical stores represent the remaining 31.7%. Averaging our information across subscriber-week observations with positive DVD rentals (subscribers may not rent every week and our data only record the rental instances), subscribers rented an average of 2.25 DVDs per week: 0.71 DVDs from the store and 1.54 DVDs by mail.

Importantly, a monthly subscription fee allows the rental of a certain number of DVDs at a time, but

³ Storage costs are even lower for video streaming services; however, video streaming was in its infant stages of development during our study period, and our focal company did not offer a video streaming service during our period of analysis.

⁴ These subscription plans include a restriction on how many DVDs a subscriber can have out at any given time.

⁵ We have distances to the closest store for all consumers who signed up for service after January 1, 2008. Although this is not a random sample of the subscribers, using these distances, we are able to provide a finer-grained examination of how transportation costs influence channel selection compared to using the zip codes for all the subscribers. These distances change weekly for each consumer as stores close.

subscribers do not pay a price each time they rent a DVD from either the online or offline channel. Thus, for subscribers, the DVD rental price is neither a driver of the online versus offline channel selection nor of the specific DVD title choice.

2.1. Popular and Niche Product Definitions

A stream of prior research, while focusing on examining the potential of information technologies to transform the distribution of sales across products and channels, has classified products as either niche or popular. Products are typically classified as niche when they are less likely to be stocked in physical stores or are only available after incurring a high search cost. In spite of this definition, because of data restrictions, prior studies classified products as niche or popular based primarily on product sales from the online channel and not on product sales from the offline channel. Our data have the advantage that they allow us to define the popularity of DVD titles during a week using information from both online and offline rental channels.

Classifying goods as either niche or popular based on online sales might be problematic if the distribution of sales across products online and offline are different. We know that firms choose which products to stock online and offline and furthermore know that product availability by channel may influence consumers’ channel choices. As an example of the possible problems that can occur when classifying products based solely on online sales, suppose that consumers buy a product online only when this product is not available at the physical store. If this situation is common for a given product, then this product could be classified as popular using online sales, even though many consumers are buying it online precisely because it is not available in physical stores and therefore could be considered a niche product. Additionally, some online retailers, because they face low competition from physical stores, may specialize in selling only niche products that are less likely to be

available at physical stores. For these retailers, classifying top-selling products as popular and the remaining products as niche may be incorrect.

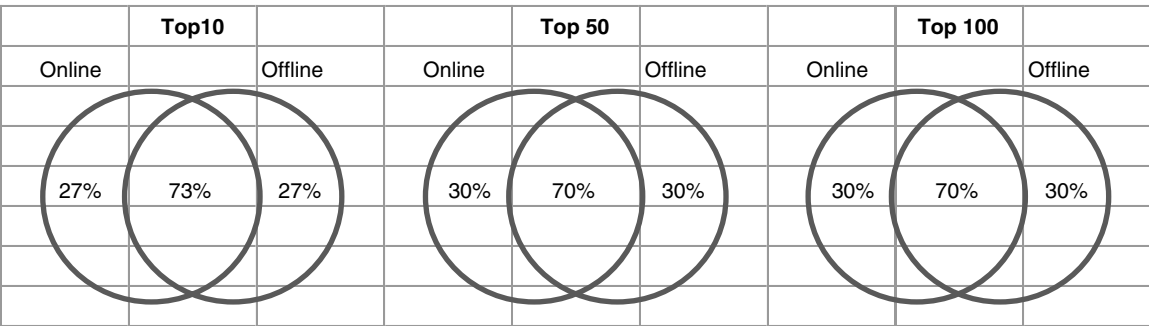
Using our data, we can only provide comparisons of transactions online and offline for a single product category (DVD rentals) and within a single firm. However, within this major firm, we can compare the extent to which the selection of DVDs rented online is different from the selection of DVDs rented offline. We do this by using online and offline data aggregated at the national level and by computing the total number of rentals for each DVD title and each channel during each week. We then rank DVDs by popularity, computing two separate weekly ranks of DVDs using either online or offline rental information.

Our definition also allows for the popularity of a DVD to vary from week to week: a DVD that is popular at the beginning of the study period can become niche by the end the study period since DVDs have short-lived popularity cycles. For example, 91 (228, 347) different DVD titles are among the top 10 (top 50, top 100) DVD titles for at least one week during our 30-week study period.

Figure 1 shows that the rankings of DVD rentals computed using online rentals are somewhat different from the rankings of DVD rentals computed using offline rentals. For example, comparing the top 10 DVD titles based on either online and offline rental information shows that a weekly average of 7.3 DVD titles are included in both rankings, but 2.7 DVD titles are included in only one ranking. Similarly, for the top 50 and top 100 DVDs, approximately 70% of the titles are included in both rankings and the remaining 30% of the DVD titles are included in only one ranking.

Differences between the online and offline rankings of DVD titles may be due to selection effects and may also be due to other cross-channel differences on the demand side or on the supply side. For example, these differences could be driven by preference heterogeneity between consumers who disproportionately choose the online versus the offline channel, different display and promotional activities across channels, or differences in the selection and inventory

Figure 1 Commonality Between Online and Offline Popular Titles



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of titles available from the offline and online channels. Using our data, it is difficult to disentangle the degree to which each factor may contribute to the differences between online and offline rankings. This is partly because we do not observe inventory or title assortments online and offline; moreover, title assortments may vary across our company's physical stores.⁶

In this section we have noted that the specific titles that are popular in the online channel are somewhat different from the titles that are popular in the offline channel. Using our data, we can generate popularity lists based on both online and offline rentals, and we will examine whether popular titles defined in this way change as consumers move online.

2.2. Superstars: Online vs. Offline DVD Rental Distributions

In Table 2 we see that superstar DVD titles take a substantially larger share of total rentals offline than they do online. For example, the top 100 DVD titles in our sample represent 84.6% of in-store rentals but only 35.1% of online rentals.

Although the statistics in Table 2 may be suggestive of how consumption patterns change when consumers move from offline to online markets, we must be cautious when interpreting Table 2. From these statistics alone, we cannot conclude that online commerce decreases the superstar nature of the DVD rental market since these differences in rental patterns across channels could be solely due to selection effects. For example, different rental concentrations may be due to heterogeneous tastes of the consumers who rent primarily online versus consumers who rent primarily offline. These differences could also be explained by selection effects due to consumers' impatience. If consumers are impatient regarding watching a newly released DVD and do not wish to wait for the DVD to arrive in the mail, then consumers who typically rent from both channels may select to rent from the physical store more often than from the online store when they wish to watch popular versus nonpopular DVDs.

Our objective in this paper is to examine whether consumption patterns change as consumers move online or whether the observed differences in online and offline consumption are primarily due to selection effects. Although in this paper we do not seek to identify why consumers change consumption patterns when they move online, beyond selection effects, the differences in the statistics in Table 2 may be an effect of the channel. We argued in the

⁶ Having acknowledged the limitations of our data for distinguishing between alternative explanations for the differences in the titles included in the rankings online versus offline, Table EA1 in the online appendix may provide some relevant information regarding the selection of titles available from each channel.

Table 2 Cumulative Share of Weekly Top-Ranked DVD Rentals by Channel

	Rented online and delivered by mail (%)	Rented from the physical store (%)
Top 10	11.0	47.7
Top 50	26.4	77.6
Top 100	35.1	84.6

introduction that the literature has identified a variety of long-tail effects arising from both demand and supply factors. Some demand and supply factors are more specific to our context. For example, the focal company's different display and promotional activities across channels may partly explain the statistics in Table 2. Popular products occupy a disproportionate amount of prominent shelf space in the company's physical stores as compared to the online channel. In addition, the queue system for video rentals may also partly explain the statistics in Table 2. Consumers who do not frequently update their online queue of DVDs may end up watching older and less popular titles when they move to the online channel.⁷

We now present our empirical approach for examining whether consumers change rental patterns as they move online or whether the differences in online versus offline consumption are primarily due to selection effects.

3. Econometric Model

As noted above, our objective is to study whether changes in which rental channel consumers use affect their selection of DVD rental titles and to establish whether online markets affect the consumption of superstar versus long-tail DVD titles. We showed in Table 2 that the distributions of DVD rentals online and offline are quite different. Superstar DVD titles in particular take a substantially larger share of all rentals made in physical stores than they do online. However, although these distributions are suggestive about what would be expected when consumers move from offline to online markets, we cannot use these statistics alone to conclude that the rental channel changes a household's selection of DVD rental

⁷ Although we do not observe inventory levels in our data, we monitored stock-outs for a matched set of newly released "popular" titles at three physical stores and through the company's online channel. Our brief examination showed that stock-outs of popular titles are not more common online than in physical stores, suggesting that our results are not due to online stock-outs of popular titles. Similarly, our focal company's policy was to shift physical inventory of popular titles from closing stores to the online channel (while selling off some long-tail inventory when a store closed). This shift, combined with the increased availability associated with a single centralized warehouse/queue versus multiple queues in physical stores, should have increased the relative availability of popular titles online as stores closed.

titles. Specifically, the different rental distributions online and offline in Table 2 could be explained solely by selection effects. Cross-section regressions would suffer from a similar problem because these regressions obtain empirical identification from comparing DVD rental selections across heterogeneous consumers.

Our empirical approach, then, is to control for unobserved heterogeneity using panel data, exploiting changes in DVD rental activity across time and across rental channel for each household. For each household i in each week t , we define the following variables: $Share\ Popular_{it}$ is the share of the number of superstar DVD title rentals (weekly top 10, top 50, and top 100) divided by the total number of rentals, and $Share\ Offline_{it}$ is the share of the number of rentals made offline divided by the total number of rentals made both online and offline.

We then use these variables to estimate the following fixed-effects model:

$$Share\ Popular_{it} = \alpha + \beta Share\ Offline_{it} + \gamma Total\ Rentals_{it} + \phi_i + \psi_t + \varphi_z \times t + u_{it}. \quad (1)$$

The variable $Total\ Rentals_{it}$ in Model (1) represents the total number of DVD rentals made by household i in week t . The coefficient β in Model (1) measures how weekly changes in the share of DVDs rented from the physical store relate to weekly changes in the share of popular DVD rentals. We control for the weekly total DVD rentals from both online and offline channels because our objective is to examine the effect of channel choice conditional on the total amount of rental consumption (the online appendix, available at http://www.utdallas.edu/~axz051000/MS_onlineappendix, presents results not controlling for weekly total DVD rentals). The model includes fixed effects for each household ϕ_i and for each week ψ_t and includes zip code-specific trends $\varphi_z \times t$.

By using a longitudinal model, we can “difference out” the time invariant unobserved characteristics of each household (e.g., household fixed effects capture income levels or household sizes that are unlikely to change substantially during a seven-month period). The week fixed effects capture aggregate changes over time, such as changes in DVD rental consumption that can be caused by school breaks or seasons. To account for preexisting trends at the level of the zip code, Model (1) also includes zip code-idiosyncratic trends. For example, these idiosyncratic trends may account for market-level changes, such as changes in Internet or cable television usage that might have affected rental consumption patterns during our study period. Identification in Model (1) arises from deviations from zip code-level trends in changes in the DVD rental selection and the rental channel within households from week to week.

Although our panel data approach allows us to control for the time invariant tastes of each household, and therefore accounts for the sorting of heterogeneous consumers into channels, ordinary least squares (OLS) estimates of Model (1) may still provide a misleading measurement of how the rental channel affects the selection of DVD rentals when a household’s desire for popular versus nonpopular DVDs changes over time. For example, consumers may choose to rent a popular DVD title from the physical store in weeks when they feel impatient about watching a popular newly released title and do not wish to wait for the DVD to arrive in the mail. The rental channel is a choice; individuals’ changes in their desires to watch popular versus nonpopular DVDs may influence their channel selection, creating an endogeneity problem. To identify how changes in the rental channel affect the overall selection of DVD rental titles, we need to observe changes in individuals’ shares of offline rentals that are not caused by weekly changes in the desire to watch popular versus nonpopular DVDs.

To break this endogeneity problem, we use the exit of physical stores as an instrumental variable. The rationale for using the exit of physical stores as an instrument is that the exit of a store, by changing the transportation cost of traveling to the store for the individuals that previously rented DVDs from the closing store, increases the relative cost of renting DVDs from the physical channel. In turn, the increase in the relative cost of renting DVDs from the physical channel may induce consumers to shift their rentals from the offline to the online channel. Our instrument is valid as long as it affects channel selection and can be excluded from Model (1). Specifically, the exit of a physical store is a valid instrument even when store closures are not random and are possibly related to a decrease in the local aggregate demand for DVD rentals, as long as store closures are unrelated to relative rental demands for popular versus nonpopular DVD titles.

We will use two alternative models to test whether households change the share of transactions made from physical stores when the stores in their geographical market exit. First, following Brynjolfsson et al. (2009), we assume that the transportation cost of traveling to the physical store increases when the number of physical stores in the zip code decreases. Brynjolfsson et al. (2009), however, treat zip codes as isolated markets. By computing distances in miles among the zip codes’ centroids using data from the U.S. Census Bureau, we can extend Brynjolfsson et al. (2009) to account for changes in the number of physical stores located in adjacent zip codes.

Specifically, we estimate the following first-stage model:

$$\begin{aligned} \text{Share Offline}_{it} &= \delta + \sum_{j=1}^6 \theta_j \text{Number of Stores in Zip Code}_{ijt} \\ &\quad + \rho \text{Total Rentals}_{it} + \vartheta_i + \tau_t + \zeta_z \times t + e_{it}, \quad (2) \end{aligned}$$

where j equal to 1 represents the zip code where household i resides, and j equal to 2 (3, 4, 5, and 6) represents zip codes with centroids located between 0 and 5 (5 and 10, 10 and 15, 15 and 20, and 20 and 30) miles away from the centroid of the zip code where household i resides. We also note that the number of stores in a zip code changes over time through store exit.

For a fraction of the consumers, we have the distance from the consumers' home to the closest store. Using these consumers, we estimate the following model:

$$\begin{aligned} \text{Share Offline}_{it} &= \omega + \epsilon \text{Distance to the Closest Store}_{it} \\ &\quad + \mu \text{Total Rentals}_{it} + \pi_i + \sigma_t \\ &\quad + \eta_z \times t + v_{it}, \quad (3) \end{aligned}$$

where $\text{Distance to the Closest Store}_{it}$ represents the geodesic distance between the location of household i and the closest physical store in week t . Note that the distances to the closest store change over time for households living near closing stores.

The focal company may naturally close its least successful stores, and the selection of which stores to close may be related to local demographic characteristics or to changes in the local-market environment. However, we believe that the exit of stores is unlikely to be affected by individuals' high frequency changes in their relative desires to rent popular versus nonpopular DVDs, in which case our instrument is orthogonal to the error. Moreover, the zip code-specific trends in our regression control for preexisting trends at the level of the zip code that might have induced stores' closures. These trends may include trends induced by demographics, Internet or cable connectedness, or the local-market environment. In sum, our instrument is valid if the high-frequency timing of store closure is unrelated to the relative desire to rent popular versus nonpopular titles. We also show, in Online Appendix EA2, that store closures are unrelated to the number of high-speed Internet providers in each zip code.⁸

⁸ The exit of physical stores may have potentially increased stock-outs of popular titles from surviving physical stores, leading to an increase in niche title consumption from physical stores. However, aggregate rentals of niche titles from physical stores do not show an upward time trend during the period of analysis.

It is important to note that our company faces competition from other DVD rental companies, and during our study period other companies rented DVDs exclusively by mail, from kiosks, and from physical stores.⁹ The entry of DVD rental kiosks (and even the mere existence of rental kiosks prior to our study period) and competition from other physical DVD rental stores might be thought to represent a challenge to our identification strategy because households living near closing stores may rent popular DVD titles from other companies while they continue to rent niche DVD titles from our focal company. If this happens, we would observe a change in the relative demand for popular versus niche titles associated with the exit of stores, when the unobserved consumption bundle of niche and superstar titles from both the focal company and the competitors might remain unchanged. This would invalidate the use of our instrument.

However, as noted above, our data only include information from consumers with a rent by mail subscription, and these subscribers do not pay a separate price each time they rent a DVD from either the online or offline channel. Although in theory the consumers in our data may simultaneously have subscriptions with our focal company and may be willing to pay extra to have a separate subscription with other competing companies, or to rent DVDs from competitive outlets, we are doubtful that this is a common practice. In this regard, we note that the market leader in rentals via kiosks, Redbox, considers that "people who use the kiosks tend to be casual viewers who don't want to be tied down to subscriptions or membership fees" (Green 2009). More importantly, in the appendix, we use historical data on Redbox locations to show that our conclusions in the main text are robust to restricting the analysis to locations without a local Redbox kiosk.

Of course, it is also true that households living near closing stores may decide to cancel their subscriptions from the focal company and begin renting from other companies (e.g., from Netflix), in which case their rentals will not be recorded in our data. For this reason, in the results below, we analyze the sensitivity of our results to attrition using a balanced panel of consumers.

4. Summary Statistics and Results

4.1. Summary Statistics

Table 3 presents summary statistics for our data, computed using household-week observations. Consumers in our data rent on average 2.25 DVDs per

⁹ The market could also be defined more broadly because consumers may consider DVD rentals as a substitute for cable television, DVD purchases, movie theaters, or other entertainment options such as playing games or using the Internet.

Table 3 Additional Summary Statistics

	Mean	Standard deviation	5%	95%
Total DVD rentals per week	2.255	1.391	1	5
Share of offline rentals	0.284	0.373	0	1
Share of rentals taken by top 10 titles	0.206	0.324	0	1
Share of rentals taken by top 50 titles	0.396	0.406	0	1
Share of rentals taken by top 100 titles	0.479	0.419	0	1
Stores per zip code ^a	0.525	0.612	0	2

Notes. These statistics are computed using 20,249,021 observations. As discussed in the text, some regressions do not use all the observations.

^aIn the data, zip codes have between zero and three stores.

week and they rent 28.4% of these DVDs from physical stores. On average, top 10 (top 50, top 100) DVD titles represent 20.6% (39.6%, 47.9%) of all transactions. The average number of stores per zip code is 0.52. We will use these statistics below in interpreting our regression results.

4.2. Ordinary Least Square Results

Table 4 presents the OLS estimation results for Model (1). The standard errors are clustered at the household level to allow for the possibility of serial correlation over time. The regressions include fixed effects for each week, more than 1.5 million fixed effects at the household level, and approximately 25,000 zip code-specific trends. The results show that households increase the fraction of rentals of popular DVDs when they rent more DVDs from the physical store. The coefficient estimates on the fraction of offline rentals are both statistically and economically significant.

The sizes of the coefficient estimates on the fraction of offline rentals indicate that a household that decreases the fraction of DVDs rented from the physical store from 28% to 0, as might be the case when

physical stores are eliminated as a choice for consumers (note that the mean of the share of offline rentals in Table 4 is 0.28), would decrease the fraction of top 10 (top 50, top 100) DVD rentals by 10.2 (13.9, 13.1) percentage points. These effects are substantial. For example, Table 3 shows that the top 10 DVD titles represent 20% of all rental transactions. Given this, the coefficient estimate on the share of offline rentals in column I of Table 4 indicates that top 10 DVD titles would take approximately 10% of all transactions if all physical stores go out of business, which represents a 50% decrease in the share of transactions taken by the top 10 DVD titles. Columns II and III of Table 4 indicate that when consumers move all their transactions to the online channel, the share of transactions taken by the top 50 and top 100 titles would decrease by 35% and 27%, respectively.¹⁰

The sign of the coefficient estimates on total DVD rentals per week is negative and economically small. The negative sign may be unsurprising because individuals may tend to rent top DVDs first and rent DVDs that are further down the popularity distribution during weeks when they increase the number of DVD rentals. Renting an additional DVD in a week reduces the fraction of top 10, top 50, or top 100 DVD rentals by between 0.6 and 1.2 percentage points.

4.3. Instrumental Variable Results

The regressions in Table 5 present our first-stage results examining how channel choice is affected by the exit of stores. The results in column I of Table 5 show that when one store exits from a zip code, consumers living in that zip code decrease their share of offline rentals by an average of 2.2 percentage points (or approximately 7.8% of the transactions made at physical stores). This result is expected because by increasing the transportation cost, the exit of a store from a zip code increases the relative cost of renting from the physical store for households that reside in that zip code.

Our first-stage results are consistent with the prior literature showing that the likelihood of purchasing products online decreases as the number of stores in the zip code increases (Brynjolfsson et al. 2009). However, Brynjolfsson et al. (2009) treat zip codes as isolated geographic markets, whereas we can also provide information regarding the size of the geographic market.

Column I of Table 5 shows how the impact of the exit of a store on channel choice dissipates for households living further away from the closing store. The

Table 4 Share of Popular Rentals—OLS Estimates

	I Top 10	II Top 50	III Top 100
Share of offline rentals (mean 0.28)	0.3650*** (0.0003)	0.4967*** (0.0004)	0.4682*** (0.0004)
Total DVD rentals (mean 2.25)	−0.0120*** (0.0001)	−0.0090*** (0.0001)	−0.0066*** (0.0001)
Constant	−0.0142*** (0.0004)	−0.0202*** (0.0004)	−0.0118*** (0.0005)
Observations	20,249,021	20,249,021	20,249,021
R-squared	0.3251	0.4248	0.4268

Notes. Includes fixed effects for both weeks (30) and individuals (1,529,028), and zip code-specific trends (24,648). Standard errors in parentheses are clustered by household. The mean of the dependent variable is 0.20 in column I, 0.39 in column II, and 0.47 in column III.

***Significant at 1%.

¹⁰ Although the coefficient is greater for the top 50 and top 100 titles than for the top 10 titles, the impact is smaller as a percentage change because the size of the dependent variable is also greater for the top 50 and top 100 titles compared to the top 10 titles.

Table 5 Share of Offline Rentals—First Stage

	I	II
Number of stores in the zip code where the household resides (mean 0.52)	0.02239*** (0.00078)	na na
Number of stores in zip codes between 0 and 5 miles away (mean 2.17)	0.00304*** (0.00031)	na na
Number of stores in zip codes between 5 and 10 miles away (mean 5.23)	−0.00004 (0.00019)	na na
Number of stores in zip codes between 10 and 15 miles away (mean 6.56)	0.00004 (0.00017)	na na
Number of stores in zip codes between 15 and 20 miles away (mean 6.89)	−0.00004 (0.00017)	na na
Number of stores in zip codes between 20 and 30 miles away (mean 12.80)	−0.0001 (0.00011)	na na
Distance to the closest store in miles (mean 3.6)	na na	−0.00898*** (0.00035)
Squared distance to the closest store in miles	na na	0.00012*** (0.00001)
Total DVD rentals (mean 2.25 in columns I and II)	0.02605*** (0.00008)	0.02518*** (0.00011)
Constant	−0.02364*** (0.00042)	−0.02841*** (0.00062)
Observations	20,249,021	9,141,694
F-test (global test for the excluded instruments in the second stage)	155.5	399.7
R-squared	0.2935	0.3199

Notes. Includes fixed effects for both weeks (30) and individuals (column I, 1,529,028; column II, 855,996) and zip code-specific trends (column I, 24,648; column II, 19,233). Standard errors in parentheses are clustered by household. The mean of the dependent variable is 0.28 in column I and 0.25 in column II.

***Significant at 1%.

results in column I of Table 5 indicate that the closure of a store within the zip code where a household resides has an impact on the household's channel choice that is seven times larger than the impact of the closure of a store in other zip codes with centroids located less than five miles away from the centroid of the zip code where the household resides. The results in column I of Table 5 also show how the exit of stores in zip codes located further away have no impact on households' channel choices.

We also use the geodesic distance from consumers' locations to the closest physical stores as an alternative instrument. We acknowledge that some consumers may use stores that are not the closest to their home address (e.g., stores nearby their working location or in the way when running errands), but we still believe that using the closest store to the home address is useful as an approximation for the transportation costs of using the offline channel. Comparing unconditional means, households living less than one mile away from a physical store make 29.4% of their rentals offline and households living more than 20 miles away from physical stores make 10.3% of their rentals offline. Column II of Table 5 shows the

estimates for Model (3) using the square of the distance to the closest store as an additional covariate to account for nonlinear transportation costs.¹¹ For example, the results in column II of Table 5 indicate that households residing near a closing physical store will decrease average rentals from physical stores by 8.8 percentage points (or approximately 35.2% of the transactions made from physical stores) when the new closest store for these households is 10 miles away. Moreover, the sizes of the coefficients indicate that households that reside near a closing physical store will decrease the transactions made from physical stores to approximately zero when the new closest store for these households is 30 miles away.

The results for the second stage of Model (1) in Table 6 still show that individuals increase the fraction of popular DVD rentals when they rent more DVDs from the physical store. The first three columns use column I in Table 5 for the first-stage regression and the last three columns use column II in Table 5 for the first-stage regression. In the first three regressions in Table 6, the sizes of the coefficient estimates on the fraction of offline rentals indicate that when a household decreases the fraction of DVDs rented from physical stores from 28% to 0, the fraction of top 10 (top 50, top 100) DVD rentals decreases by 10.7 (10.0, 7.3) percentage points. In the last three regressions in Table 6 the sizes of the coefficient estimates on the fraction of offline rentals indicate that when a household decreases the fraction of DVDs rented from the store from 25% to 0 (note that the mean of the share of offline rentals for the last three columns of Table 6 is 0.25), the fraction of top 10 (top 50, top 100) DVD rentals decreases by 10.4 (9.9, 8.9) percentage points.

Comparing the instrumental variables (IV) results in Table 6 with the OLS results in Table 4, we observe that the sizes of the coefficient estimates on the fraction of offline rentals are similar for top 10 titles and smaller, but still significant both economically and statistically for top 50 and top 100 titles.

As in Table 4, the coefficient estimates on total DVD rentals per week in Table 6 are negative and economically small.

4.4. Sensitivity of Results to Attrition

Table 1 suggests that our focal company lost subscribers during our study period. Additionally, the customer base exhibits a high churn rate likely fueled by free-of-charge trial period offers. Our panel of data is therefore unbalanced. An unbalanced panel does not generate biased estimates when the reason for

¹¹ We note that excluding the square of the distance from the first stage (or, alternatively, including higher-order polynomials) causes no substantial change in the second-stage results.

Table 6 Share of Popular Rentals—Instrumental Variables Estimates—Second Stage

	I Top 10	II Top 50	III Top 100	IV Top 10	V Top 50	VI Top 100
Share of offline rentals (mean 0.28 in columns I–III and 0.25 in columns IV–VI)	0.3856*** (0.0372)	0.3597*** (0.0457)	0.2638*** (0.0473)	0.4184*** (0.0391)	0.3969*** (0.0511)	0.3594*** (0.0524)
Total DVD Rentals (mean 2.25 in columns I–VI)	−0.0125*** (0.0010)	−0.0054*** (0.0012)	−0.0013 (0.0012)	−0.0129*** (0.0010)	−0.0068*** (0.0013)	−0.0044*** (0.0013)
Constant	−0.0137*** (0.0010)	−0.0234*** (0.0012)	−0.0166*** (0.0012)	−0.0092*** (0.0013)	−0.0177*** (0.0016)	−0.0086*** (0.0017)
Observations	20,249,021	20,249,021	20,249,021	9,141,694	9,141,694	9,141,694

Notes. Includes fixed effects for both weeks (30) and individuals (columns I–III, 1,529,028; columns IV–VI, 855,996) and zip code-specific trends (columns I–III, 24,648; columns IV–VI, 19,233). Standard errors in parentheses are clustered by household. The mean of the dependent variable is 0.20 in column I, 0.39 in column II, 0.47 in column III, 0.19 in column IV, 0.38 in column V, and 0.46 in column VI.

***Significant at 1%.

having missing observations is not correlated with the regression error term. For example, subscribers that rent DVDs in only one week during our study period do not bias the estimates since time demeaning for such observations yields all zeros. But to examine whether or not our previous empirical results are driven by changes in the customer base, in this section we rerun our regressions using a balanced panel of subscribers.

Table 7 presents OLS results analogous to those in Table 4, but only including the information from subscribers who rented at least one DVD in both the initial and final four weeks of our study period. There are 764,875 such subscribers, or approximately half of the total number of subscribers compared with Table 4. In Table 7 the coefficient estimates on both the fraction of offline rentals and the total DVD rentals per week variables are very similar to those in Table 4.

The similarity of the results in Tables 4 and 7 indicate that the effects of the online versus offline channel choice on superstar DVD rentals are not significantly different for subscribers who maintained subscriptions during the entire length of our study period versus subscribers who did not.

Table 7 Share of Popular Rentals—OLS Estimates—Balanced Panel

	I Top 10	II Top 50	III Top 100
Share of offline rentals (mean 0.30)	0.3713*** (0.0003)	0.5003*** (0.0004)	0.4701*** (0.0004)
Total DVD rentals (mean 2.33)	−0.0123*** (0.0001)	−0.0093*** (0.0001)	−0.0070*** (0.0001)
Constant	−0.0079*** (0.0004)	−0.0161*** (0.0005)	−0.0089*** (0.0005)
Observations	15,239,005	15,239,005	15,239,005
R-squared	0.3105	0.4094	0.4075

Notes. Includes fixed effects for both weeks (30) and individuals (764,875) and zip code-specific trends (21,396). Standard errors in parentheses are clustered by household. The mean of the dependent variable is 0.22 in column I, 0.41 in column II, and 0.49 in column III.

***Significant at 1%.

However, the value of a subscription may be greater as the distance to an offline store decreases because having a physical store nearby provides the additional value of exchanging DVDs at the store. Since attrition in our data is likely correlated with the exit of physical stores, attrition might bias our instrumental variable results. Tables 8 and 9 present first- and second-stage regressions analogous to those in Tables 5 and 6, but using the balanced subsample of our data.

Table 8 Share of Offline Rentals—First Stage—Balanced Panel

	I	II
Number of stores in the zip code where the household resides (mean 0.53)	0.02114*** (0.00085)	na na
Number of stores in zip codes between 0 and 5 miles away (mean 2.17)	0.00277*** (0.00034)	na na
Number of stores in zip codes between 5 and 10 miles away (mean 5.23)	−0.00009 (0.00020)	na na
Number of stores in zip codes between 10 and 15 miles away (mean 6.58)	0.00013 (0.00018)	na na
Number of stores in zip codes between 15 and 20 miles away (mean 6.93)	0.00002 (0.00018)	na na
Number of stores in zip codes between 20 and 30 miles away (mean 12.88)	−0.00011 (0.00012)	na na
Distance to the closest store in miles (mean 3.49)	na na	−0.00863*** (0.00043)
Squared distance to the closest store in miles	na na	0.00011*** (0.00001)
Total DVD rentals (mean 2.33 in column I and 2.34 in column II)	0.02518*** (0.00009)	0.02406*** (0.00014)
Contant	−0.00741*** (0.00046)	−0.00026 (0.00073)
Observations	15,239,005	5,667,199
F-test (global test for the excluded instruments in the second stage)	114.5	256.7
R-squared	0.2737	0.2888

Notes. Includes fixed effects for both weeks (30) and individuals (column I, 764,875; column II, 288,845) and zip code-specific trends (column I, 21,396; column II, 15,770). Standard errors in parentheses are clustered by household. The mean of the dependent variable is 0.30 in column I and 0.28 in column II.

***Significant at 1%.

Table 9 Share of Popular Rentals—Instrumental Variables Estimates—Second Stage—Balanced Panel

	I Top 10	II Top 50	III Top 100	IV Top 10	V Top 50	VI Top 100
Share of offline rentals (mean 0.30 in columns I–III and 0.28 in columns IV–VI)	0.4129*** (0.0443)	0.3147*** (0.0539)	0.2042*** (0.0556)	0.4125*** (0.0502)	0.3800*** (0.0650)	0.3546*** (0.0658)
Total DVD rentals (mean 2.33 in columns I–III and 2.34 in columns IV–VI)	−0.0133*** (0.0011)	−0.0047*** (0.0014)	−0.0003 (0.0014)	−0.0129*** (0.0012)	−0.0068*** (0.0016)	−0.0047*** (0.0016)
Constant	−0.0076*** (0.0005)	−0.0174*** (0.0007)	−0.0108*** (0.0007)	−0.0044*** (0.0007)	−0.0128*** (0.0008)	−0.0051*** (0.0009)
Observations	15,239,005	15,239,005	15,239,005	5,667,199	5,667,199	5,667,199

Notes. Includes fixed effects for both weeks (30) and individuals (columns I–III, 764,875; columns IV–VI, 288,845) and zip code-specific trends (columns I–III, 21,396; columns IV–VI, 15,770). Standard errors in parentheses are clustered by household. The mean of the dependent variable is 0.22 in column I, 0.41 in column II, 0.49 in column III, 0.21 in column IV, 0.40 in column V, and 0.48 in column VI.

***Significant at 1%.

The results for both the first- and second-stage regressions in Tables 8 and 9 using the balanced subsample are similar to those in Tables 5 and 6 using the entire sample. This similarity suggests that our previous results using the entire sample are not driven by changes in the profile of customers over time.

Regressions in the online appendix show various other sensitivity tests for our results, including results that exclude total DVD rentals as a covariate in Tables 4–6 (Online Appendix EA3, Tables EA3–EA5); results that only use subscribers for whom we have the distances from consumers' homes to the closest store in Table 4, column I of Table 5, and columns I–III of Table 6 (Online Appendix EA3, Tables EA6–EA8); and results examining rentals of "top 2,000" titles (those that are likely to be stocked in both physical and online channels) (Online Appendix EA4). Our main results are robust to each of these considerations.

5. Discussion

As the proportion of commerce conducted online increases, will producers and retailers need to reevaluate their investment and inventory choices? Answering this question is complicated by selection effects surrounding the types of consumers who purchase online and the types of products that consumers choose to purchase online. Although early research has observed a large proportion of sales online in niche products, it is unclear whether this observation is merely a reflection of the characteristics of the consumers who select the channel or the types of products that consumers select to purchase online versus offline or whether it might reflect a change in consumption patterns caused by the characteristics of the Internet channel.

Breaking the endogeneity between channel selection and channel behavior requires an exogenous shift in the cost of purchasing online and the ability to

observe customer-level purchase decisions by channel before and after the shift. Our data provide us with just such an opportunity. Our data document customer-level rental decisions before and after a customer's local video rental store closes, and our empirical analysis suggests that when consumers move online they are much less likely to rent blockbuster titles than they were previously.

While our objective in this paper has been to examine how channel selection affects consumption patterns, our results showing how the impact of store exit on channel choice varies depending on where consumers live relative to the closing store also complement and extend the prior literature on transportation costs and channel selection (e.g., Brynjolfsson et al. 2009, Forman et al. 2009). Specifically, our data are substantially more granular than those used in previous work studying this question.

Our main result, indicating that when consumers move to online channels they decrease their likelihood of renting popular titles, is of course not without limitations. Importantly, although we examine how consumption changes when consumers move online, we do not examine why this change in consumption patterns occurs and specifically what characteristics of the online channel (e.g., increased selection, recommendation systems, product display) may be driving this change.

We also note that if consumers were more likely to experience stock-outs in the online channel relative to the physical channel, or if the relative prevalence of stock-outs increased over time as stores closed, our results could be explained by supply-side mechanisms related to stock availability. However, our limited checks of stock levels in both channels described above suggest that popular titles do not have higher availability in physical channels than online. Similarly, as we noted above, our focal company's practice of moving inventory for popular titles

from physical stores to the online channel as stores closed, combined with the increased efficiency of a single online warehouse queue relative to multiple queues in physical stores and with the observed reduction in total subscribers as stores closed, should, if anything, increase the relative availability of popular titles online as stores close.¹²

Finally, we note that even focusing on a single market, our results could vary over time. For example, early adopters of rent by mail subscriptions might be more interested in niche DVD titles than late adopters are. In this regard, we believe that our analysis of a mature market provides a more useful examination of the market-level impact of online commerce on product concentration than an analysis of a nascent market would. Although our period of analysis is too short to examine how the results change over time, this examination is also a potential avenue for future research.

To summarize, our results show that there is a change in consumption patterns caused by the characteristics of the Internet channel. As a consequence, our finding that online channels may shift DVD consumption away from blockbuster titles and toward more niche titles may have implications for movie studios and movie producers. Specifically, movie studios have typically faced a market where a small number of hits made up the vast majority of industry profits. Our results suggest that this historical pattern of highly concentrated transactions in a handful of titles might have been driven by the characteristics of the offline channel and that studios may wish to shift their resources relatively toward more long-tail titles as consumers move online. There is obviously a need for more research to be in a position to predict the degree to which Internet markets change the incentives of movie producers and allow for the production of more niche titles; we believe this paper is a first step in that direction.

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Appendix. Sensitivity of Main Results to Redbox Kiosk Locations

In this appendix we use historical data on the location of Redbox kiosks as of April 28, 2010 (the end of our study period is April 29, 2010). We obtained these data from AggData LLC (<http://www.aggdata.com/>), a company that provides data to businesses and organizations. Tables A.1 and A.2 show that the conclusions in the main text are not affected when using only the information from individuals living in zip codes where Redbox was not present during our study period. During our study period, approximately one-fourth of the focal company's consumers lived in zip codes without a Redbox kiosk; these consumers made on average 26% of their transactions from physical stores (compared with 28% for all consumers) and rented a similar fraction of top 10, top 50, and top 100 DVD titles as other consumers do (comparing the mean of the dependent variables presented at the bottom of Table 6 in the main text and Table A.2). Table A.1 shows that Redbox had substantially more presence in zip codes where our focal company also had a physical presence (the mean of the variable *number of stores in the zip code where the household resides* is 0.52 in Table 5 in the main text, compared with 0.20 in Table A.1).

Table A.1 Share of Offline Rentals (No Redbox Presence)—First Stage

	I
Number of stores in the zip code where the household resides (mean 0.20)	0.02727*** (0.00244)
Number of stores in zip codes between 0 and 5 miles away (mean 2.15)	0.00494*** (0.00064)
Number of stores in zip codes between 5 and 10 miles away (mean 5.01)	−0.00103*** (0.00036)
Number of stores in zip codes between 10 and 15 miles away (mean 6.33)	−0.00027 (0.00034)
Number of stores in zip codes between 15 and 20 miles away (mean 6.57)	−0.00064* (0.00034)
Number of stores in zip codes between 20 and 30 miles away (mean 12.56)	−0.00030 (0.00022)
Total DVD rentals (mean 2.23)	0.02604*** (0.00016)
Constant	−0.02346*** (0.00082)
Observations	4,897,442
F-test (global test for the excluded instruments in the second stage)	30.6
R-squared	0.3026

Notes. Includes fixed effects for both weeks (30) and individuals (378,160), and zip code-specific trends (16,861). Standard errors in parentheses are clustered by household. The mean of the dependent variable is 0.26.

*Significant at 10%; ***significant at 1%.

¹² We also note that our results in the online appendix show that our long-tail effects are robust to excluding data for the top 5 or top 10 most popular titles that might be more likely to experience stock-outs (Online Appendix AE5).

Table A.2 Share of Popular Rentals (No Redbox Presence)—
Instrumental Variables Estimates—Second Stage

	I Top 10	II Top 50	III Top 100
Share of offline rentals (mean 0.26)	0.4471*** (0.0819)	0.3042*** (0.1021)	0.3202*** (0.1061)
Total DVD rentals (mean 2.23)	−0.0139*** (0.0021)	−0.0039 (0.0027)	−0.0026 (0.0028)
Constant	−0.0135*** (0.0021)	−0.0239*** (0.0026)	−0.0140*** (0.0027)
Observations	4,897,442	4,897,442	4,897,442

Notes. Includes fixed effects for both weeks (30) and individuals (378,160) and zip code-specific trends (16,861). Standard errors in parentheses are clustered by household. The mean of the dependent variable is 0.20 in column I, 0.39 in column II, and 0.47 in column III.

***Significant at 1%.

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