

# Binge Yourself Out: The Effect of Binge Watching on the Subscription of Video on Demand

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We analyze outcomes of two randomized field experiments to study the effect of binge watching on the subscription of Video-on-Demand (SVoD). In both cases we offer access to SVoD service to a random set of households and use another random set of households as control group. In both cases, we find that the households induced to binge watch TV shows are less likely to pay for SVoD after the gift period. In our second experiment, we also show that treated households subscribe the service less despite enjoying more their experience with the VoD system. Our results suggest that binge watchers deplete the content of interest to them very fast, which reduces their short-term willingness to pay for SVoD. We also show that carefully crafted recommendation reminders aimed at widening the preferences of consumers for content lessen the concerns of binge watchers with content refresh and thus may help content providers manage supply costs that may otherwise become prohibitive with frequent updates to SVoD catalogs.

*Key words:* Binge Watching, Subscription-based Video-on-Demand, Recommendation Reminders, Randomized Experiment

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## 1. Introduction

Binge watching refers to watching video, usually TV shows, for a long period of time in one sitting. In 2013, Harris Interactive conducted a survey on the behalf of Netflix on 3,078 US adults of which 1,496 reported streaming TV shows at least once per week. 73% of the latter defined binge watching as watching 2 or more episodes of the same TV show in a row (Spangler 2013). 76% of them reported that watching multiple episodes of a great TV show back to back is a refuge from their busy lives and 79% reported that binge watching makes the TV shows more enjoyable. More recently in 2016, Deloitte surveyed 2,131 US consumers of which 73% reported binge watching an average of 6 episodes, or 5 hours, per sitting. 90% of millennials reported having binge watched before and 38% of them do so on a weekly basis (Deloitte 2016). Some degree of binge watching existed since the 1990s with the DVD format but it was only recently that binge watching became a notable cultural and social phenomenon (Matrix 2014, Richmond 2014), with many industry reports citing binge watching as a regular practice among US consumers (Statista 2016).

The shift towards binge watching has been enabled by the development of video streaming technologies that are now prevalent both online (Matrix 2014) and on TV (Abreu et al. 2016, Belo et al. 2016). These technologies allow consumers to optimize their schedules and watch their preferred content whenever they want. At the same time, they also allow content providers to make several episodes of the same TV show available at once, thus allowing for binge watching, which was usually not possible in the world of linear TV in which episodes of the same TV show would, for the most part, only air on a weekly or a daily basis. The introduction of binge watching can have significant implications for the entertainment industry. Besides the already visible changes on the demand side, binge watching can also significantly affect the supply side of the market. In particular, binge watching is already affecting the creative process and the programming and distribution strategies of content providers, calling for changes to the business models used to monetize content. For example, some screen writers now write “highly serialized” stories that consumers can appreciate better when viewed in multi-episode sessions (Jurgensen 2012, Barton 2015). Some content distributors encourage binge watching using novel features such as automatically starting the next episode of a certain TV show when one episode ends. Some content distributors even release all episodes of the same TV show season at once (Schweidel and Moe 2016) inviting consumers to watch full seasons in only a few days.

The entertainment industry has been moving quickly to embrace business models that support binge watching despite the lack of studies looking at the effects that may arise from such shift. Content providers and distributors have been keen to implement strategies that promote binge behavior without knowing in detail the potential problems that they may trigger. For example, consuming more content per unit of time is likely to lead consumers to deplete the content of interest to them faster and thus increase the cost that firms have to incur to add new titles to their catalogs to keep consumers engaged. This paper aims at addressing this knowledge gap by studying the effect of binge watching on the subscription of Video-on-Demand (SVoD) services. We explore results from two randomized field experiments, run in partnership with TELCO. TELCO is a major telecommunications provider offering VoD services in addition to TV, Internet and telephony. In the first experiment, a number of households were offered access to a channel that broadcasted movies and TV shows 24/7. A random subset of them were held out for control purposes. Another random subset of them were offered access to this channel with Time-Shift TV (TSTV). The remainder of the households were offered access to this channel without TSTV. Using TSTV the former set of households could effectively binge watch by going back in time and consume several episodes of the same TV show in the same sitting. We find that offering access to this channel increased its consumption and that TSTV increased its consumption in binge mode. We also find that offering access to this channel without TSTV did not change the households’ likelihood of

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subscribing it after the experiment. However, offering access to it with TSTV reduced the latter by about 10%. Using our randomized assignment of treatments during this experiment as instruments for the time that households spent watching this channel in binge and non-binge mode allows us to show that the reduction in likelihood of subscribing this channel after the experiment is driven by the time that households spent binge watching it during the experiment.

In the second randomized experiment, we study the impact of TELCO-SVoD, which is a SVoD service similar to Netflix, Hulu and Amazon Prime. A number of households, selected at random, were offered access to this service for free for a period of 3 months. Another random set of households were used as control group and did not get this gift. Again, we find that households offered this gift subscribed the service less after the experiment and that this behavior was driven by the households that binge watched TELCO-SVoD content. The reduction in the probability of TELCO-SVoD subscription after the experiment was about 16%, thus in line with our findings in the first experiment. We also find that the households offered access to TELCO-SVoD enjoyed more their overall experience with the VoD system at TELCO. Our analysis shows that these households issued more likes per lease in this VoD system than control households and the increment in this statistic comes from titles included in TELCO-SVoD. Therefore, the households that obtained access to this SVoD library for free did not subscribe it less after the gift period because they did not like the content. We also show that having had access to free trials to test TELCO-SVoD in the past did not change the likelihood of subscribing the service after our experiment. Instead, our results suggest that these households subscribed TELCO-SVoD less because they depleted the content that was of interest to them faster. Essentially, TELCO-SVoD was an attractive product to consumers at the beginning of the experiment but became less so as time went by without TELCO adding new content to the catalog. This result has significant implications for firms in the entertainment industry. Indexing the rate at which providers add content to SVoD libraries to the rate at which consumers watch content is likely to address this concern but may become exaggeratedly expensive. For example, in recent times, Netflix has been adding originals to their SVoD catalog at an unprecedented pace, more than doubling its long term debt in 2017 to \$4.8 billion and increasing its long-term obligations, such as those with rolling licensing agreements, to \$15.7 billion (Ng 2017).

A significantly cheaper strategy that content distributors may use to keep binge watchers engaged with their SVoD service is to expose them to content that they would not otherwise consider. Consumers typically browse SVoD catalogs to form a consideration set and then choose content to watch from this smaller set (Chen and Yao 2016, Honka and Chintagunta 2016). Recommendation reminders may lead consumers to expand their consideration sets widening their preferences for content in ways that lead them to enjoy the existing catalogs more. This way, content providers may

be able to slow down the rate at which they may be required to add content to their existing SVoD libraries allowing them to manage costs more judiciously. However, not all types of recommendation reminders may effectively achieve this objective. During TELCO’s experiment with TELCO-SVoD, a subset of households selected at random received generic reminders telling them that they could use TELCO-SVoD to watch movies and TV shows. These reminders were aimed at attracting consumers to TELCO-SVoD without giving them any suggestion for specific content to watch. Another subset of households, also selected at random, received customized reminders telling them that they could use TELCO-SVoD to watch particular TV shows. The specific TV shows suggested to each household were determined using a state-of-the art recommender system. The remainder of the households did not receive any reminders. Reminders were sent out by text message every other week during the experiment. We find that customized reminders steered viewership towards content that households would not organically choose to watch and that the households that received these reminders did not reduce their likelihood of subscribing TELCO-SVoD after the experiment. The consumers that did not receive reminders or that received generic reminders still subscribed TELCO-SVoD less after the experiment compared to the corresponding control households. These results show that carefully crafted reminders may offset the reduction in the subscription of SVoD services that arise due to binge watching.

The fact that binge watching may lead consumers to subscribe SVoD less may seem puzzling at first, in particular given the significant investment of content providers and distributors to allow it. However, several reasons may explain this behavior. First, binge watching is becoming a mainstream mode of video consumption across all types of demographics and being in business without serving binge watchers may be disadvantageous. Second, consumers are usually willing to pay more for a SVoD service that allows for binge watching. In fact, TELCO run a survey to a random sample of consumers which shows that, on average, they are willing to pay \$1.9 to access their favorite TV show if all its episodes were release one by one on a weekly basis. However, they are, also on average, willing to pay an additional \$7.1 if they could watch all episodes of this TV show at once. These statistics show that there might be some opportunity to add content to SVoD libraries at a rate similar to what consumers watch it by sharing some of the additional costs with them.

TELCO run another survey to households included in the TELCO-SVoD experiment asking them whether they subscribed the service after the experiment and if not why. A disproportionated number of binge watchers indicated lack of content refresh and a high price as the main reasons for not subscribing. This self-reported assessment comes in line with the idea that content depletion is a problem to manage SVoD catalogs. The answers to this survey show that TELCO-SVoD lost value during the experiment and more so for binge watchers, who were no longer interested in paying \$9.5

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per month to continue the service after the experiment. Finally, consumers who received customized reminders did not indicate lack of content refresh as a concern as often as other consumers, which provides additional evidence that this type of reminders acted on TELCO’s consumers by expanding their consideration sets increasing the value they associated to the outstanding TELCO-SVoD catalog after the experiment. Our results provide a surprising perspective of the potential effect that binge watching may have on the entertainment industry, inviting managers to consider carefully the implications of allowing for binge watching for their supply schedules.

The remainder of this paper is organized as follows. The next section reviews the relevant literature. Section 3 studies the outcomes of our first randomized experiment and analyzes the effect of consumption and of binge watching on the likelihood of SVoD subscription. Section 4 studies the outcomes of our second randomized experiment and analyzes the effect of catalog exhaustion and of reminders on the latter. Finally, section 5 concludes.

## **2. Literature Review**

### **2.1. Binge Behavior**

Binge behavior has been defined as a heavy rate of consumption over a short period of time (Schweidel and Moe 2016). In the medicine literature, binge behavior has been associated to the idea of addiction. For example Kubey and Csikszentmihalyi (2002) study the addictive nature of watching TV and find that viewing begets more viewing because individuals want to maintain a passive and relaxed state of mind when they watch TV and try to avoid the stress that they experience when their TV viewing sessions end. Economists rationalize binge behavior in a utility maximization framework and suggest that when people binge they must be optimizing their consumption schedule for enjoyment purposes (Becker and Murphy 1988). A rich line of research in the marketing literature on binge shows that people adapt to repetitions of the same stimuli and that they are particularly bad at predicting hedonic adaptation (Loewenstein and Frederick 1997, Nelson and Meyvis 2008). For example, people adapt to regions that they enjoy (Schkade and Kahneman 1998), repeated consumption of their preferred ice cream (Kahneman and Snell 1990), repeated exposure to a song that they like (Galak et al. 2011) or repeatedly watching a TV show that they enjoy (Nelson et al. 2009). Frederick and Loewenstein (1999) discuss that with some exceptions the process of adaptation reduces the enjoyment associated to positive experiences over time, which hints at the fact that binge behavior may be a suboptimal strategy for consumers to maximize their medium to long term utility. This stream of research on adaptation and on the progression of affect suggests that individuals choose to consume too quickly goods that they enjoy because they fail to self control or hold incorrect beliefs (or misapply correct beliefs) about the benefits of longer inter-consumption intervals (Galak et al. 2013). In this paper we study the effect of binge watching

TV shows on the consumers' enjoyment and on their willingness to pay for a service that allows for binge watching. This question is now pertinent to the entertainment industry because new business models based on Subscription-based Video-on-Demand (SVoD) have flourished in recent years, such as Netflix, Hulu, Amazon Instant Video, which have been encouraging binge watching at an unprecedented rate (Wilbur 2008, Bronnenberg et al. 2010, Schweidel and Moe 2016).

However, the increased rate of video consumption with binge watching may trigger unforeseen consequences to the entertainment industry. For example, consumers are unlikely willing to pay for SVoD catalogs that do not refresh at a reasonable pace. Binge watchers deplete SVoD catalogs faster exacerbating this problem. Furthermore, consumers have limited attention spans (Johnson et al. 2012) and each consumer is usually only interested in a relatively small subset of the today's large SVoD catalogs (Godinho de Matos et al. 2017). However, to the best of our knowledge, Schweidel and Moe (2016) is the only paper to date that studies of the impact of binge watching, in this case on the consumption of advertising. The authors characterize the drivers of binge watching behavior and focus on its impact on the consumption of ads at Hulu.com. They use observational data to conclude that (1) viewing begets more viewing; (2) exposure to advertising discourages binge watching; and (3) binge watching is affected by situational factors, such as content previously consumed and the individual's inherent tendency to engage in binge watching; (4) binge watching has a negative impact on the response to advertising and this effect worsens with the length of the viewing session.

## **2.2. Recommendation Reminders**

The Over-The-Top (OTT) Video Market Tracker presented at the 2016 NAB Show by Parks Associates suggests that the ongoing perceived value of SVoD services is essentially determined by the content library. This would unlikely pose a problem to today's entertainment industry given that digitization and high-speed Internet allow for providing access to catalogs that are orders of magnitude larger than those offered by the traditional brick-and-mortar stores from a decade ago (Resnick and Varian 1997, Brynjolfsson et al. 2003, Anderson 2006). Yet, the same report shows that many households subscribe SVoD service from a provider because specific content is available there and terminate contract right after watching it. This behavior arises in a world where consumers know a-priori what they want to watch, fetch the content that interests them quickly, watch it and leave (Chernev 2003). Using these OTT platforms to browse for new content to watch becomes only secondary – a process sometimes characterized as boring and time consuming (Mullins 2016, Bolluyt 2017).

The literature in psychology had already anticipated the kind of behavior referred above when it showed that individuals have limited cognitive processes, short time attention spans and difficulties

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to process new information (Camerer et al. 2003, Thaler Richard and Sunstein Cass 2008). It is therefore likely that individuals subscribing SVoD services have imperfect knowledge of the depth of the content library available to them and are unaware of most of the content that they may be likely to enjoy. Therefore, highlighting such content to consumers may increase the value that they associate to SVoD. Digital recommender systems help consumers navigate these large sets of alternatives (Resnick and Varian 1997). At their core, these recommender systems change product saliency. They highlight some products to consumers at the expense of others that become relatively more hidden. (Häubl and Trifts 2000) discuss the challenges that consumers face when evaluating large product assortments. They run a controlled experiment using a simulated online store and find that recommendations reduce the search effort of consumers to fetch product information. They also find that recommendations shorten consideration sets but increase the quality of the products placed in these sets, improving the quality of purchase decisions. Other papers confirm these findings. For example, using an analytical model and several simulations, Fleder and Hosanagar (2009) show that recommender systems help individuals find new products but can also bias choice towards popular content, thus generating rich-get-richer phenomena that reduce diversity.

In parallel, the academic literature has also established that nudges and reminders help consumers overcome inattention by highlighting information about products that consumers incorporate in their decision making processes (Häubl and Murray 2006, Johnson et al. 2012). For example, (Karlan et al. 2016) developed and tested a model of limited attention in intertemporal choice in the context of savings decisions. In three field experiments they show that reminders increased savings for clients who recently opened savings account and that messages mentioning saving goals and financial incentives were particularly effective. In another field experiment, (Calzolari and Nardotto 2016) show that simple weekly reminders induce users to substantially increase gym attendance. They also show that, in their setting, users responded to reminders immediately and recurrently. Furthermore, reminders are cheap, can easily scale up and are not usually coercive because individuals retain the freedom to ignore them (Momsen and Stoerk 2014). Reminders have been shown to be effective in many different contexts such as managing energy consumption (Allcott and Mullainathan 2010), adhering to healthcare treatments (Raifman et al. 2014) and even improving credit ratings (Bracha and Meier 2014). Therefore, it may be that combining content recommendations with reminders, that is, issuing recommendations to consumers on a regular basis, may help consumers discover new content in the SVoD catalog of a platform that does not update the catalog very frequently thus limiting the problems that may consequently arise. Our paper studies how carefully crafted recommendation reminders may affect the subscription rate of SVoD in a real world setting.

### 3. The Effect of Consumption and of Binge Watching on SVoD Subscription

#### 3.1. Experimental Design

Our industry partner, hereinafter called TELCO, is a large multinational telecommunications provider. TELCO focus on selling Pay-TV services in the country we analyze, serving more than 1.5 million households. In addition to TV, Internet and telephony TELCO offers Video-on-Demand (VoD), both transactional (TVoD) (pay per item viewed) and subscription-based (SVoD) (monthly fee with unlimited viewership).

The basic TV service offered by TELCO includes 100 TV channels and access to a TVoD library with more than 2,000 movies and TV shows. TELCO also offers additional a-la carte services, which can be purchased separately, such as the TV Show Channel, herein after represented by TVSC, which broadcasts popular movies and TV shows 24/7.

A random sample of 30,000 triple play households was used in an experiment involving the TVSC in the summer of 2015. These households did not subscribe the TVSC in the month before this experiment. One third of these households, hereinafter called *Control*, selected at random, were held out from any intervention. The other two thirds, hereinafter called *Gift*, were offered access to the TV Show Channel during a period of 6 consecutive weeks. This group of households was further split into two subgroups of equal size. The households in the *Gift LinearTV* group were offered access to the TVSC without TSTV, that is, the content aired in this channel could only be watched live. The households in the *Gift TSTV* group were offered access to this channel with TSTV, that is, the content aired in this channel could be consumed both live and using TSTV.

Households in the *Gift TSTV* group could effectively, and productively, binge watch the content aired in this channel because going back in time allowed them to watch several episodes of the same TV show in the same sitting. Households in the *Gift LinearTV* group could only watch more than one episode of the same TV show in the same sitting if they were broadcasted sequentially in live mode. The activation of the TVSC, with and without TSTV, did not require any action from the households in the experiment. Households received an email and a text message notifying them about the temporary offer, which was readily available to use. During this experiment, the TVSC broadcasted 52 distinct TV shows and 58 seasons with 454 distinct episodes). The content aired included popular titles such as House of Cards, Fargo and Suits. Therefore, the TVSC can be taken as a SVoD service with a good but small catalog.

#### 3.2. Descriptive Statistics

Table 1 shows that the consumption of the TVSC across households that binge watched it during the experiment was very different from those that watched this channel but did not binge watch it. Roughly 40% of the *Gift* households  $((5,963+2,106) / 20,000)$  watched the TVSC during the

experiment. Roughly 26% of them binge watched it at least once during the experiment. We follow the definition used in the 2013 Netflix survey and define binge as watching 2 or more episodes of the same TV show in the same sitting row (Spangler 2013). On average, the number of TV show episodes watched by binge watchers was 4 times that watched by non-binge watchers. Binge watchers spent roughly 5 times more time watching the TVSC during the experiment. On average, 25.5% of the time that they spent watching the TVSC was spent binge watching it.

**Table 1 Consumption of the TVSC during the experiment across gifted households for households that binge watch the TVSC and for households that do not.**

	Variable	Mean	St.Dev.	Median	Q05	Q95
No Binge (5,963 households)	Number of Episodes	3.375	3.174	2.000	1.000	9.900
	Number of Seasons	3.124	2.675	2.000	1.000	8.000
	Number of TV Shows	3.101	2.637	2.000	1.000	8.000
	Watch Time (hours)	1.395	1.490	0.908	0.164	4.231
	Fraction of Binge Time	0.000	0.000	0.000	0.000	0.000
Binge (2,106 households)	Number of Episodes	12.973	12.984	9.000	2.000	39.000
	Number of Seasons	8.428	6.719	7.000	1.000	22.000
	Number of TV Shows	8.114	6.352	7.000	1.000	21.000
	Watch Time (hours)	6.403	7.418	3.998	0.943	19.886
	Fraction of Binge Time	0.433	0.255	0.377	0.110	1.000

Table 2 shows additional statistics about how households consumed the TVSC during the experiment per treatment condition. A session in this table is defined as a period of VoD streaming separated by one hour or more of inactivity (Schweidel and Moe 2016). Households gifted access to the TVSC exhibit much more sessions with 3 or more episodes. On average, the number of sessions this long increased 10% (0.144/0.131) for the households in the *Gift TSTV* group compared to households in the *Gift LinearTV* group. The number of *Binge 2* sessions, that is, sessions in which households watched 2 or more episodes of the same also TV show) increased 10% (0.209/0.189) from the former to the latter group of households. The number of *Binge 3* sessions, that is, sessions in which households watched 3 or more episodes of the same TV show, increased 37% (0.220/0.161). The significant jump in this statistic from *Binge* sessions to *Binge 3* sessions arises because the TVSC broadcasted live two episodes of the same TV show back to back relatively often during our experiment, thus inducing some level of light (only 2 episodes) binge watching across households in the *Gift LinearTV* group. Finally, and on average, a significant difference between households in the *Gift TSTV* group and households in the *Gift LinearTV* group is the time that they spent binge watching the TVSC. Households in the latter group spent 31% (0.142/0.108) more time binge watching this channel during the experiment than households in the former group.

**Table 2 Consumption of the TVSC during the experiment across all experimental groups (Control, LinearTV and TSTV).**

Group	Episodes #	Households #	Sessions				Watch Time (hours)		
			#	%	%B2+	%B3+	All	Other	Binge
Gift Control	1	829	1,265	0.786	0	0	0.094	0.084	0.010
	2	198	229	0.142	0.214	0			
	3+	98	115	0.071	0.339	0.148			
Gift LinearTV	1	2,801	7,024	0.656	0	0	0.695	0.587	0.108
	2	1,426	2,285	0.213	0.189	0			
	3+	944	1,402	0.131	0.389	0.161			
Gift TSTV	1	3,025	7,200	0.649	0	0	0.746	0.604	0.142
	2	1,467	2,301	0.207	0.209	0			
	3+	1,065	1,594	0.144	0.462	0.220			

%Bx+ indicates the percentage of sessions in which households watch x or more episodes of the same TV show.

Finally, table 3 shows the average of several covariates during the month before the experiment for households in the *Control* group. We show data for how long the household subscribed TV and Internet from TELCO, its monthly bill, whether she pays the monthly bill using direct deposit, the amount of traffic exchanged with the Internet (both download and upload) and whether the household received free TVSC offers in the past. The F-statistic and the associated P-value are for the analysis of variance comparing the average of these covariates across all experimental groups in our experiment (*Control*, *Gift LinearTV* and *Gift TSTV*). These columns show that our randomized schedule to place households in experimental conditions achieved good balance in the covariates that we observe before the experiment took place.

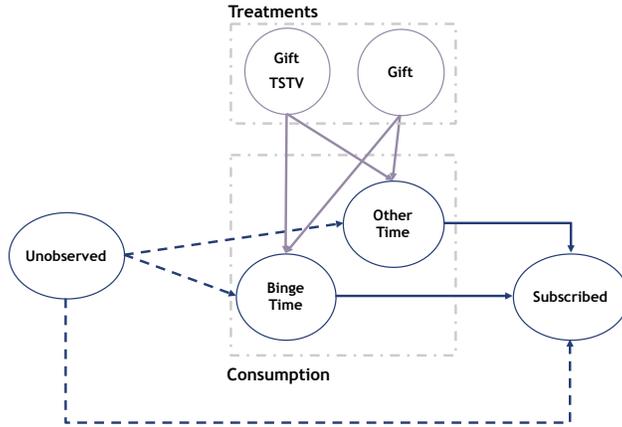
**Table 3 Analysis of variance for pre-treatment covariates comparing households across all groups (Control, LinearTV and TSTV).**

Covariate	Mean Control Group	F-stat	P-value
TV Tenure (month)	77.350	0.210	0.811
Internet Tenure (month)	52.200	0.250	0.779
Bill (USD/month)	66.790	0.279	0.757
Direct Deposit	0.345	1.541	0.214
Download Traffic (Gb/month)	44.246	1.895	0.150
Upload Traffic (Gb/month)	11.040	0.379	0.684
Past TVSC Gift	0.321	0.885	0.413

### 3.3. Empirical Strategy

The Direct Acyclic Graph (DAG) in Figure 1 illustrates the setup of our experiment. Offering access to the TVSC (*Gift*) is likely to affect the time that households spend watching this channel both in

binge (*Binge.Time*) and in non-binge mode (*Other.Time*). Likewise when access to this channel is offered with Time-Shift TV (*Gift.TSTV*). The time that households spend watching the TVSC, both in binge and non-binge mode, is likely to affect whether they subscribe this channel after the experiment (*Subscribe*). Finally, unobservables (*Unobserved*) affect both the consumption of this channel and the latter rendering the time that households spend watching it, both in binge and in non-binge mode, endogenous in our setting. Table 4 describes all covariates used in this section of our paper.



**Figure 1** Direct Acyclic Graph describing the setup of our TVSC experiment.

**Table 4** Covariates used in our analysis of the TVSC experiment.

Variable Name	Variable Description
Subscribed (0/1)	Household subscribed to TVSC up to 3 months after the experiment
Gift (0/1)	Household offered TVSC with or without TSTV
Gift TSTV (0/1)	Household offered TVSC with TSTV
Past Gift (0/1)	Household offered TVSC in the past
Watch Time Other (hours)	Time household spends watching TVSC in non-binge mode
Watch Time Binge (hours)	Time household spends watching TVSC in binge mode
Watch Time All (hours)	Time household spends watching TVSC

We can identify the effect of offering access to the TVSC with and without TSTV on the likelihood of subscription using:

$$Subscribed_i = \alpha_0 + \alpha_1 Gift_i + \alpha_2 Gift\_TSTV_i + \epsilon_i \quad (1)$$

This specification measures the effect of the Intention to Treat (ITT) households with access to the TVSC, with and without TSTV, which averages the behavior of several types of households. We can also measure the effect of watching the TVSC across the households offered access to it

on the likelihood of subscription after the experiment, that is, the Local Average Treatment Effect (LATE), using:

$$Watch\_Time\_Other_i = \psi_0 + \psi_1 Gift_i + \psi_2 Gift\_TSTV_i + \epsilon_i \quad (2)$$

$$Watch\_Time\_Binge_i = \beta_0 + \beta_1 Gift_i + \beta_2 Gift\_TSTV_i + \nu_i \quad (3)$$

$$Subscribed_i = \gamma_0 + \gamma_1 \hat{Watch\_Time\_Other}_i + \gamma_2 \hat{Watch\_Time\_Binge}_i + \eta_i \quad (4)$$

where equations 2 and 3 measure how offering access to the TVSC with and without TSTV changes the time that households spend watching it during our experiment, and thus provide first-stage estimates. Note that in our setting, identification of the effect of both binge and non-binge watching on the posterior likelihood of subscription comes from the fact that we have two independent instrumental variables for our two endogenous variables.

Finally, we acknowledge that offering access to the TVSC may affect the posterior likelihood of subscription in ways that are unrelated to the consumption of this channel. This would be represented in the DAG of Figure 1 by an additional arrow from *Gift* and/or *Gift.TSTV* to *Subscribe* (direct or through other mechanisms). We provide two robustness checks to address this concern. First, we test whether having had access for free to the TVSC before our experiment affected the likelihood of subscription after the experiment. A statistically significant result in this specification could indicate that offering access to this channel for free may lead some consumers to wait for future gifts thus reducing their short-term likelihood of subscription. We test this hypothesis using:

$$\begin{aligned} Subscribed_i = & \alpha_0 + \alpha_1 Gift_i + \alpha_2 Gift\_TSTV_i \\ & + \alpha_3 Past\_Gift_i + \alpha_4 Gift \times Past\_Gift_i + \alpha_5 Gift\_TSTV \times Past\_Gift_i + \epsilon_i \end{aligned} \quad (5)$$

Second, we measure the effect of having access to the TVSC and of binge watching it during our experiment on the posterior likelihood of subscription only across the households that had access to this channel, which is therefore likely to wash away the effects that the gift may have triggered that are unrelated to how households used it (given that all households in this subsample had the gift). For this purpose, we use:

$$Subscribed_i = \zeta_0 + \zeta_1 Gift\_TSTV_i + \epsilon_i \quad (6)$$

$$Watch\_Time\_Binge_i = \delta_0 + \delta_1 Gift\_TSTV_i + \nu_i \quad (7)$$

$$Subscribed_i = \lambda_0 + \lambda_1 \hat{Watch\_Time\_Binge}_i + \eta_i \quad (8)$$

where equation 6 provides an ITT estimate and equation 7 provides the first stage for the LATE estimate in equation 8.

### 3.4. Results and Discussion

Table 5 shows that offering access to the TVSC without TSTV did not change the likelihood of subscription after the experiment. However, offering access to it with TSTV reduced this likelihood. The results in Columns (1) and (2) indicate that, on average, for households receiving the gift with TSTV, the probability of subscribing TVSC after the experiment declined by 0.008 percentage points from the baseline purchase probability of 0.082 of the control group. This amounts to a 10% drop in the probability of subscription. Columns (3) and (4) in this table show that offering access to the TVSC without TSTV increased its consumption in binge and non-binge mode. The former increased roughly 9 times and the latter increased roughly 6 times. Offering access to this channel with TSTV increased its consumption in binge mode roughly 12 times without any statistically significant change on the time that households spent watching it in non-binge mode compared to the control group. Households without the gift binge-watched this channel 12% of the time that they spent watching it. This statistic increases to 15.5% and 19% for the households offered access to this channel without and with TSTV, respectively. Finally, columns (5) and (6) in this table show that the more households watched the TVSC in non-binge mode the more likely they were to subscribe it after the experiment. However, the more they binge-watched the TVSC during the experiment the less likely they were from doing so.

**Table 5** Effect of offering access to the TVSC with and without TSTV after the experiment

	Subscribed		Watch Time		Subscribed	
	ITT LPM (1)	ITT Probit (2)	Other 1STG OLS (3)	Binge 1STG OLS (4)	LATE 2SLS (5)	LATE IV Probit (6)
(Intercept)	0.082*** (0.003)	-1.394*** (0.018)	0.084*** (0.004)	0.011*** (0.002)	0.080*** (0.003)	-1.406*** (0.024)
Gift	0.001 (0.004)	0.008 (0.026)	0.503*** (0.015)	0.097*** (0.005)		
Gift TSTV	-0.008** (0.004)	-0.057** (0.026)	0.017 (0.020)	0.034*** (0.008)		
Watch Time Other (hours)					0.055* (0.032)	0.377* (0.213)
Watch Time Binge (hours)					-0.275* (0.141)	-1.875** (0.930)
Num. obs.	30000	30000	30000	30000	30000	30000
RMSE	0.271		1.184	0.461	0.293	
AIC		16667.791				
Log Likelihood		-8330.896				

\*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ ; Heteroskedasticity-consistent standard errors in ()

Table 6 compares only households in the *Gift* group. As discussed before, comparing only across these households helps to de-confound potential effects that offering the gift could have triggered that could show up in our estimates when comparing against households in the *Control* group. Columns (1) and (2) show that households in the *Gift TSTV* group subscribed the TVSC less than households in the *Gift LinearTV* group after the experiment. The results in Column (2) indicate a reduction of 0.84% in this likelihood from a baseline subscription rate of 8.3%, thus a 10% decline. Columns (3) and (4) show that TSTV contributed only to increase the consumption of the TVSC in binge mode. Households in the *Gift TSTV* group spent 31.5% more time binge-watching the TVSC than households in the *Gift LinearTV* group.

Columns (5) and (6) show that the lower likelihood of TVSC subscription after the experiment across households in the former group came from the additional time that they spent binge watching this channel during the experiment. The negative coefficient in column (6) of table 6 associated to the time spent binge watching the TVSC during the experiment arises from the light binge watchers without TSTV (e.g. those that took advantage of the fact that sometimes a couple of episodes of the same TV show aired back to back and binge watched the TVSC less than 2.5 hours during our experiment) that would otherwise binge watch much more with TSTV. The results in this column show that the consumers that binge watched the TVSC for more than 6 hours during the experiment (which corresponds to approximately 8 episodes of the same TV show) were very unlikely to subscribe the TVSC after the experiment (their likelihood of subscription reduced to 0.1% from a baseline of 12.7%). In sum, our results show that binge watching reduces the likelihood of SVoD subscription.

**Table 6** Effect of binge watching in the TV Show Channel on the likelihood posterior subscription among households with TVSC gift

	Subscribed		Watch Time		Subscribed	
	ITT LPM (1)	ITT Probit (2)	Other 1STG OLS (3)	Binge 1STG OLS (4)	LATE 2SLS (5)	LATE IV Probit (6)
(Intercept)	0.083*** (0.003)	-1.386*** (0.018)	0.587*** (0.014)	0.108*** (0.005)	0.109*** (0.016)	-1.205*** (0.107)
Gift TSTV	-0.008** (0.004)	-0.057** (0.026)	0.017 (0.020)	0.034*** (0.008)		
Watch Time Binge (hours)					-0.246** (0.125)	-1.681** (0.855)
Num. obs.	20000	20000	20000	20000	20000	20000
RMSE	0.269		1.424	0.554	0.302	
AIC		11012.594				
Log Likelihood		-5504.297				

\*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ ; Heteroskedasticity-consistent standard errors in ()

Finally, table 16 in Appendix .1 shows that having had access to free trials of the TVSC before our experiment did not change the likelihood of TVSC subscription after the experiment and therefore we do not find evidence that these trials reduce the consumers’ willingness to pay for the TVSC.

## 4. The Role of Catalog Exhaustion and of Reminders on SVoD Subscription

### 4.1. Experimental Design

Our second experiment focuses on TELCO-SVoD, which is a SVoD service that could be purchased for \$9.5/month. TELCO-SVoD competes with online content streaming services such as Netflix, Hulu and Amazon Prime. When our study took place, TELCO-SVoD offered access to approximately 1,300 movies and 75 TV shows covering a total of 133 seasons. The average IMDb rating for the content available on TELCO-SVoD was 7.5/10 and, on average, the release date of the first season of the TV shows available was 2012. According to unogs.com, the size of the catalog provided by TELCO-SVoD was comparable to Netflix’s in several European countries, Russia, India and South Africa in 2015. We note that TELCO did not add content to TELCO-SVoD catalog during the experiment described below.

TELCO selected a random sample of 30,000 households that did not subscribe TELCO-SVoD in the month before this experiment. A subset of 15,000 of them, selected at random, hereinafter called *Treated*, were offered access to TELCO-SVoD for free for a period of 3 consecutive months (October – December 2016). The remaining 15,000 households, hereinafter called *Control*, did not receive such an offer. Some households, both *Treated* and *Control*, were selected to receive recommendation reminders. A subset of 5,000 *Treated* households and a subset of 5,000 *Control* households, in both cases selected at random, were sent no reminders. A subset of 5,000 *Treated* households and a subset of 5,000 *Control* households, in both cases selected at random, were sent generic recommendation reminders. These reminders were sent every other week during the experiment by text message and included the following text: *”With TELCO-SVoD you have unlimited access to thousands of movies, complete TV-shows and content for kids that you can watch on TV or using our app in any mobile device”*. Finally, the reminder of the *Treated* households (5,000) and of the *Control* households (5,000) were sent customized recommendation reminders. These reminders were also sent every other week during the experiment by text message and included the following text: *”You can watch all episodes of TV Show X using TELCO-SVoD, you can watch on TV or using our app in any mobile device”*. *X* in this message represents the title of the TV show recommended by TELCO. Our study did not attempt to optimize these recommendation reminders, which could be potentially achieved by adjusting their frequency, the text in the message or the recommendation algorithm used to compute *X*. These reminders were sent to household to

try to affect the frequency at which they consumed content from TELCO-SVoD, either in binge or non-binge mode. Appendix .2 provides additional details about the recommendation engine used by TELCO during this experiment to issue recommendations.

We consider only 12 weeks of data out of the 14 weeks that the experiment lasted. We exclude from the analysis the first experimental week because it took time to activate TELCO-SVoD and not all *Treated* households had access to it during this week (a maximum number of households could be activated per day to reduce the strain in the network). We also exclude from the analysis the last experimental week because it coincided with Christmas and between December 23rd and December 25th TELCO launched a major mass marketing campaign priming households to try TELCO-SVoD during the Christmas break.

Finally, a brief survey was sent to *Treated* households two weeks after the experiment. The survey asked if the household subscribed TELCO-SVoD after the gift period. If not, a follow up question asked the household to choose reasons why she did not among the following options: high price, lack of time, lack of interest, lack of content refresh or other (under which a field for running text was available).

#### 4.2. Descriptive Statistics

Table 7 shows statistics for the consumption of TELCO-SVoD for treated and control households that watched TELCO-SVoD at least once during the experiment. Offering access to TELCO-SVoD more than 4-folded the number of households watching it (2,990/706). Treated households exhibit significantly more sessions, more TV shows, episodes and movies watched. They also spent 87% more time watching TELCO-SVoD content.

**Table 7 Consumption of TELCO-SVoD during the experiment across control and treated households that watched TELCO-SVoD content.**

	Variable	Mean	St.Dev.	Median	Q05	Q95
Control (706 households)	TELCO-SVoD Vieweing Sessions	5.445	8.265	2.000	1.000	21.000
	TELCO-SVoD TV Shows	0.435	1.405	0.000	0.000	2.750
	TELCO-SVoD TV Show Episodes	1.851	8.662	0.000	0.000	8.000
	TELCO-SVoD Movies	3.479	8.477	1.000	0.000	17.000
	TELCO-SVoD Total Titles	8.667	16.571	2.000	1.000	34.750
	TELCO-SVoD Watch Time (hours)	7.024	14.651	1.485	0.003	27.977
Treated (2,990 households)	TELCO-SVoD Vieweing Sessions	8.923	13.464	4.000	1.000	35.550
	TELCO-SVoD TV Shows	0.780	1.611	0.000	0.000	3.000
	TELCO-SVoD TV Show Episodes	5.318	18.538	0.000	0.000	30.000
	TELCO-SVoD Movies	8.365	15.234	3.000	0.000	35.000
	TELCO-SVoD Total Titles	17.751	29.934	6.000	1.000	72.750
	TELCO-SVoD Watch Time (hours)	13.179	24.525	4.208	0.016	55.426

Table 8 shows additional statistics about how households consume TELCO-SVoD content during the experiment for *Control* and *Treated* households. A session in this table is again defined as a period of TELCO-SVoD streaming separated by one hour or more of inactivity (Schweidel and Moe 2016). We observe a total of 30,525 TELCO-SVoD sessions in our data, 87.5% of which by treated households. Viewing sessions for treated and control households are generated by 2,990 and 706 unique households, respectively. Among treated households, 46.6% of TELCO-SVoD sessions include a single title (a TV show episode or a movie), 21.9% include two titles and 11.9% include three titles. These statistics are 57.3%, 20.4% 9.5%, respectively, for control households showing that treated households tend to exhibit longer sessions. We observe 6,184 *Binge 2* sessions (sessions that include 2 or more episodes of the same TV show) and 3,600 *Binge 3* sessions (sessions that include 3 or more episodes of the same TV show) across treated households. They correspond to 23.2% and 13.5% of all sessions from treated households, respectively. These statistics are 12.2% and 7.2% for control households showing that treated households tend to binge watch TELCO-SVoD relatively more. Treated households that watched TELCO-SVoD content, that is, that started a TELCO-SVoD stream during the experiment, watched an average of 0.780 different TELCO-SVoD TV shows and an average of 5.318 different TV show episodes. The households that watched more TV shows (top 5%) watched 3 different TV shows. These statistics show that households tend to watch several episodes of a few TV shows. Finally, treated households spend much more time than their control counterparts watching TELCO-SVoD content. In particular, the amount of time they spend binge watching increases 15 times (0.878/0.059).

Table 9 shows the average of several covariates during the month before the experiment for households in the *Control* group. We report similar covariates to the case of the TVSC experiment. The F-statistic and the associate P-value are for the analysis of variance comparing the average of these covariates across all experimental groups in our experiment, namely *Control No Reminders*, *Control Generic Reminders*, *Control Customized Reminders*, *Treated No Reminders*, *Treated Generic Reminders* and *Treated Customized Reminders*. These columns show that our randomized schedule to place households in experimental conditions achieved good balance in the covariates that we observe before the experiment took place. The table show mean for all households in the *Control No Reminders* group.

### 4.3. Empirical Strategy

The Direct Acyclic Graph (DAG) in Figure 3 illustrates the setup of our experiment. Offering access to TELCO-SVoD (*Gift*) is likely to affect the time that households spend watching it both in binge (*Binge\_Time*) and in non-binge mode (*Other\_Time*). Targeting households with reminders, both generic (*Generic\_Reminders*) and customized (*Customized\_Reminders*), may affect the time

**Table 8 Consumption of TELCO-SVoD during the experiment across experimental groups (Control and Treated).**

Group	Episodes	Households	Sessions				Watch Time (hours)		
			#	%	#B2+	#B3+	All	Other	Binge
Control	1	633	2,204	57.336	0	0	0.279	0.221	0.059
	2	313	785	20.421	153	0			
	3	187	364	9.469	114	95			
	4	101	180	4.683	78	71			
	5	81	116	3.018	46	40			
	6	42	69	1.795	28	23			
	7	30	34	0.884	16	16			
	8	24	26	0.676	8	8			
	9	15	17	0.442	8	7			
	10+	27	49	1.275	18	17			
Treated	1	2,669	12,436	46.610	0	0	3.073	2.160	0.878
	2	1,686	5,837	21.877	2,179	0			
	3	1,180	3,172	11.889	1,438	1,259			
	4	864	1,804	6.761	871	764			
	5	599	1,079	4.044	523	488			
	6	450	727	2.725	380	346			
	7	326	452	1.694	227	213			
	8	229	321	1.203	157	145			
	9	174	219	0.821	110	105			
	10+	328	634	2.376	299	280			

#Bx+ indicates the number of sessions in which households watch x or more episodes of the same TV show.

**Table 9 Analysis of variance for pre-treatment covariates comparing households across all groups (Control No Reminders, Control Generic Reminders, Control Customized Reminders, Treated No Reminders, Treated Generic Reminders, Treated Customized Reminders).**

Covariate	Mean of Control No Reminders	F-stat	P-value
TV Tenure (month)	79.569	0.656	0.657
Internet Tenure (month)	51.078	0.663	0.652
Bill (USD/month)	66.781	1.749	0.120
Direct Deposit	0.349	1.016	0.406
Download (Gb/month)	37.621	0.375	0.866
Upload (Gb/month)	6.581	0.626	0.680
Past TELCO-SVoD Gift	0.145	1.745	0.121

that households spend watching TELCO-SVoD content, both in binge (*Binge Time*) and in non-binge (*Other Time*) mode. The time that households spend watching TELCO-SVoD, both in binge and non-binge mode, is likely to affect whether they subscribe this service after the experiment (*Subscribe*). Finally, unobservables (*Unobserved*) affect both the consumption of TELCO-SVoD and the latter rendering the time that households spend watching it, both in binge and in non-

binge mode, endogenous in our setting. Table 10 describes all covariates used in this section of our paper.

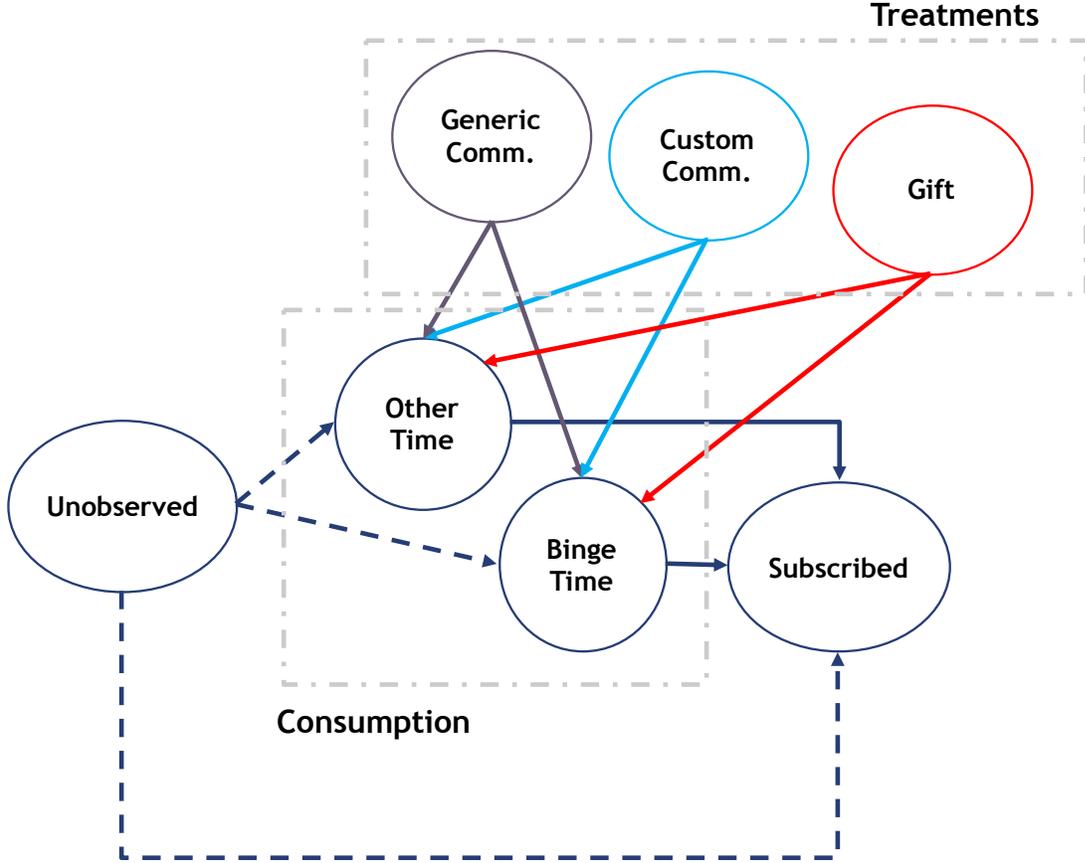


Figure 2 Direct Acyclic Graph describing the setup of our TELCO-SVoD experiment.

We can identify the effect of offering access to TELCO-SVoD on the likelihood of subscription after the experiment using:

$$Subscribed_i = \alpha_0 + \alpha_1 Gift_i + \epsilon_i \quad (9)$$

Similarly to the case of the TVSC, we can also test whether having had access for free to TELCO-SVoD before our experiment affected the likelihood of subscription using:

$$Subscribed_i = \delta_0 + \delta_1 Gift_i + \delta_3 Past\_Gift_i + \delta_4 Gift_i \times Past\_Gift_i + \epsilon_i \quad (10)$$

In the case of this experiment, we can also measure how offering access to TELCO-SVoD affects how much households enjoy TELCO's VoD system, proxied by the number of likes per lease issued, overall and for both TELCO-SVoD and non-TELCO-SVoD content:

**Table 10 Covariates used in the TELCO-SVoD experiment.**

Variable Name	Variable Description
Subscribed (0/1)	Household subscribes TELCO-SVoD up to three months after the experiment
Gift (0/1)	Household offered TELCO-SVoD
Past Gift (0/1)	Household offered TELCO-SVoD in the past
Likes/Lease All (number)	Total number of likes per lease issued by the household
Likes/Lease TELCO-SVoD (number)	Likes/lease issued by the household for TELCO-SVoD content
Likes/Lease Other VoD (number)	Likes/lease issued by the household for non-TELCO-SVoD content
Watched (0/1)	Household watched TELCO-SVoD content
Binged (0/1)	Household binge watched TELCO-SVoD content
Watch Time Other (hours)	Time household spends watching TELCO-SVoD in non-binge mode
Watch Time Binge (hours)	Time household spends watching TELCO-SVoD in binge mode
Watch Time All (hours)	Time household spends watching TELCO-SVoD
N Episodes (number)	Number of distinct TELCO-SVoD episodes that household watches
N TV Shows (number)	Number of distinct TELCO-SVoD shows that household watches
Generic Reminders (0/1)	Household received generic reminders
Customized Reminders (0/1)	Household received customized reminders

$$Likes/Lease\_All_i = \beta_0 + \beta_1 Gift_i + e_i \quad (11)$$

$$Likes/Lease\_TELCO - SVoD_i = \gamma_0 + \gamma_1 Gift_i + u_i \quad (12)$$

$$Likes/Lease\_Other\_VoD_i = \psi_0 + \psi_1 Gift_i + v_i \quad (13)$$

In this setting, we can also identify the effect watching TELCO-SVoD on the posterior likelihood of subscription using:

$$Watch\_Time\_All_i = \lambda_0 + \lambda_1 Gift_i + \epsilon_i \quad (14)$$

$$Subscribed_i = \gamma_0 + \gamma_1 Watch\_Time\_All_i + \eta_i \quad (15)$$

In this specification, Equation 14 provides the first stage estimates for equation 15. In another model, we split  $Watch\_Time\_All_i$  into  $Watch\_Time\_Other_i$  and  $Watch\_Time\_Binge_i$  to identify the effect of binge and non-binge watching TELCO-SVoD on the posterior likelihood of subscription:

$$Watch\_Time\_Other_i = \alpha_0 + \alpha_1 Gift_i + \alpha_2 Generic\_Reminders_i + \alpha_3 Customized\_Reminders_i$$

$$+ \alpha_4 Gift_i \times Generic\_Reminders + \alpha_5 Gift_i \times Customized\_Reminders + \epsilon_i \quad (16)$$

$$Watch\_Time\_Binge_i = \beta_0 + \beta_1 Gift_i + \beta_2 Generic\_Reminders_i + \beta_3 Customized\_Reminders_i$$

$$+ \beta_4 Gift_i \times Generic\_Reminders + \beta_5 Gift_i \times Customized\_Reminders + \nu_i \quad (17)$$

$$Subscribed_i = \gamma_0 + \gamma_1 \hat{Watch\_Time\_Other}_i + \gamma_2 \hat{Watch\_Time\_Binge}_i + \eta_i \quad (18)$$

Equations 16 and 17 provide the first stages for equation 18. In another model, we replace  $Watch\_Time\_Other_i$  by  $Watched_i$  and  $Watch\_Time\_Binge_i$  by  $Binged_i$ . The former represents whether household  $i$  watched TELCO-SVoD content during the experiment. The latter indicates whether household  $i$  binge watched TELCO-SVoD content during our experiment, that is, whether she started streams for two or more episodes of the same TV show in the same sitting at least once during our experiment. Note that in our setting, the identification of the effect of both binge and non-binge watching on the posterior likelihood of TELCO-SVoD subscription comes from the fact that we have three instrumental variables for our two endogenous variables. Note also that we interact  $Gift$  with both  $Generic\_Reminders$  and  $Customized\_Reminders$  because both treated and control households received reminders during our experiment.

Finally, we measure how reminders mediate the effect of offering access and watching TELCO-SVoD on the posterior likelihood of TELCO-SVoD subscription using:

$$\begin{aligned} Subscribed_i &= \alpha_0 + \alpha_1 Gift_i + \alpha_2 Generic\_Reminders_i + \alpha_3 Customized\_Reminders_i \\ &+ \alpha_4 Gift_i \times Generic\_Reminders + \alpha_5 Gift_i \times Customized\_Reminders + \epsilon_i \end{aligned} \quad (19)$$

$$\begin{aligned} Watch\_Time\_All_i &= \alpha_0 + \alpha_1 Gift_i + \alpha_2 Generic\_Reminders_i + \alpha_3 Customized\_Reminders_i \\ &+ \alpha_4 Gift_i \times Generic\_Reminders + \alpha_5 Gift_i \times Customized\_Reminders + \epsilon_i \end{aligned} \quad (20)$$

$$\begin{aligned} Subscribed_i &= \alpha_0 + \alpha_1 \hat{Watch\_Time\_All}_i \\ &+ \alpha_2 Generic\_Reminders_i + \alpha_3 Customized\_Reminders_i \\ &+ \alpha_4 \hat{Watch\_Time\_All}_i \times Generic\_Reminders \\ &+ \alpha_5 \hat{Watch\_Time\_All}_i \times Customized\_Reminders + \epsilon_i \end{aligned} \quad (21)$$

We also show results for equation 20 replacing  $Watch\_Time\_All_i$  by  $N\_Episodes_i$  and by  $N\_TV\_Shows_i$ , which indicate the number of distinct episodes and TV shows that household  $i$  watched from TELCO-SVoD during the experiment. This analysis allows us to understand how reminders affect the type of content consumed during our experiment.

#### 4.4. Results and Discussion

Table 11 shows that after the experiment *Treated* households subscribed TELCO-SVoD less than *Control* households. The result in column (2) indicates that the likelihood of subscribing this service after the experiment was 0.28% lower for the former households from a baseline of 1.7%, thus a reduction of 16%. Columns (3)-(5) in table show that *Treated* households enjoyed their overall experience with TELCO VoD system more than control households. Overall they issued 36% more likes/lease in this system. Columns (4) and (5) show that this increase is associated to TELCO-SVoD at the expense of other VoD content. In addition Table 17 Appendix .1 shows that having had free trials of TELCO-SVoD before this experiment did not change the likelihood of subscription after the experiment and thus, similarly to the case of the TVSC, we do not find evidence that these trials reduce the consumers' willingness to pay for this service.

**Table 11** Effect of the TELCO-SVoD gift on TELCO-SVoD subscription after the experiment and on consumer satisfaction with video on demand services, proxied by the number of likes per lease issued during the experiment

	<i>Dependent variable:</i>				
	Subscribed		Likes/Lease		
	<i>OLS</i>	<i>Probit</i>	All <i>OLS</i>	TELCO-SVoD <i>OLS</i>	Other <i>OLS</i>
	(1)	(2)	(3)	(4)	(5)
(Intercept)	0.017*** (0.001)	-2.129*** (0.025)	0.013*** (0.001)	0.001*** (0.0002)	0.012*** (0.001)
Gift	-0.003** (0.001)	-0.072* (0.037)	0.003** (0.001)	0.004*** (0.0004)	-0.004*** (0.001)
Observations	29,950	29,950	29,944	29,944	29,944
Log Likelihood		-2,358.852			
Akaike Inf. Crit.		4,721.703			
Residual Std. Error	0.122		0.111	0.035	0.097
F Statistic	3.843**		5.342**	117.952***	12.819***

*Note:*

\*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Heteroskedasticity-consistent standard errors in ()

Columns 3-4 dropped 6 households for whom there was missing like information

Table 12 shows that the gift increased the time spent watching TELCO-SVoD content by 10 times. The result in columns (2) and (3) shows that the more households watched TELCO-SVoD content the less they subscribed the service after the experiment. In particular, the result in column (3) indicates that the average increase in the time spent watching TELCO-SVoD content induced by the gift reduced the likelihood of TELCO-SVoD subscription after the experiment by 1.5% from a baseline of 1.7% across the control group.

**Table 12** Impact of the TELCO-SVoD on overall TELCO-SVoD usage during the experiment and impact of overall TELCO-SVoD usage on TELCO-SVoD subscription after the experiment

	Watch Time		Subscribed
	OLS 1STG (1)	2SLS LATE (2)	IV Probit LATE (3)
(Intercept)	0.279*** (0.035)	0.017*** (0.001)	-2.130*** (0.029)
Gift	2.758*** (0.123)		
Watch Time All (hours)		-0.001* (0.001)	-0.044*** (0.014)
Num. obs.	29950	29950	29950
RMSE	10.632	0.125	

\*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ ; Heteroskedasticity-consistent standard errors in ()

Table 13 separates the effect of binge watching TELCO-SVoD content during the experiment on the likelihood of subscribing the service after the experiment from the effect of non-binge watching it. Columns (1) and (2) show that offering access to TELCO-SVoD increased both the time that households spent binge and non-binge watching TELCO-SVoD. These columns also show that customized reminders increased the time they spent watching TELCO-SVoD in non-binge mode. Column (3) shows coefficients with the expected signs for the effect of binge watching and for the effect of non-binge watching TELCO-SVoD content during the experiment. However, these coefficients are not statistically significant. The distributions of *Watch Time Binge* and *Watch Time Other* are skewed, have several outliers, and the shocks introduced by remainders on TELCO-SVoD consumption during our experiment are underpowered to separate these effects, which are measured on aggregate in column (3) of table 12. We reduce the skewness of these distributions and limit the impact that outliers may have on our estimation procedure (without discarding data points) by replacing *Watch Time Binge* and *Watch Time Other* by *Binged* and *Watched*, respectively, and then estimate a multivariate Probit. Columns (4) and (5) in this table provide the first stage estimates and column (6) shows our second stage results. This column shows that watching TELCO-SVoD during the experiment increased the probability of subscribing TELCO-SVoD after the experiment. However, binge watching TELCO-SVoD during that period reduced the likelihood of subscribing the service after the experiment. In particular, the coefficient associated to *Binge* in the last column of this table shows that the likelihood of subscribing TELCO-SVoD after the experiment for the households induced by the gift to binge watch TELCO-SVoD content during our experiment reduced 1.5% from a baseline of 1.7%.

Table 13 Splitting the effect of TELCO-SVoD Watch Time in binge and non-binge usage behavior on TELCO-SVoD subscription after the experiment

	Watch Time Other		Watch Time Binge		Subscribed		Watched		Binged		Subscribed	
	OLS (1)	OLS (2)	IV Probit (3)	IV Probit (4)	IV Probit (5)	IV Probit (6)	IV Probit (7)	IV Probit (8)	IV Probit (9)	IV Probit (10)	IV Probit (11)	IV Probit (12)
(Intercept)	0.27** (0.11)	0.06 (0.09)	-2.16*** (0.06)	-1.82*** (0.03)	-2.60*** (0.06)	-2.17*** (0.04)						
Gift	1.65*** (0.15)	0.68*** (0.12)		0.91*** (0.04)	0.87*** (0.07)							
Generic Communication	-0.08 (0.15)	0.00 (0.12)		-0.04 (0.05)	-0.08 (0.09)							
Custom Communication	-0.07 (0.15)	-0.01 (0.12)		-0.04 (0.05)	-0.14 (0.10)							
Gift x Generic Communication	0.34 (0.21)	0.24 (0.17)		0.10* (0.06)	0.09 (0.10)							
Gift x Custom Communication	0.53** (0.21)	0.18 (0.17)		0.10* (0.06)	0.15 (0.10)							
Watch Time Other (hours)			0.27 (0.49)									
Watch Time Binge (hours)			-0.80 (1.16)									
Watched											0.33*** (0.09)	
Binge											-0.76*** (0.09)	
Num. obs.	29950	29950	29950	29950	29950	29950						
RMSE	7.57	6.01										
AIC												
Log Likelihood												26557.68 -13260.84

\*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$

Table 14 shows the effect of reminders on the likelihood of subscribing TELCO-SVoD after the experiment. Columns (1) and (2) show that generic reminders did not change this likelihood but customized reminders did. The latter increased this likelihood and offset the negative effect of the gift on it reported before.

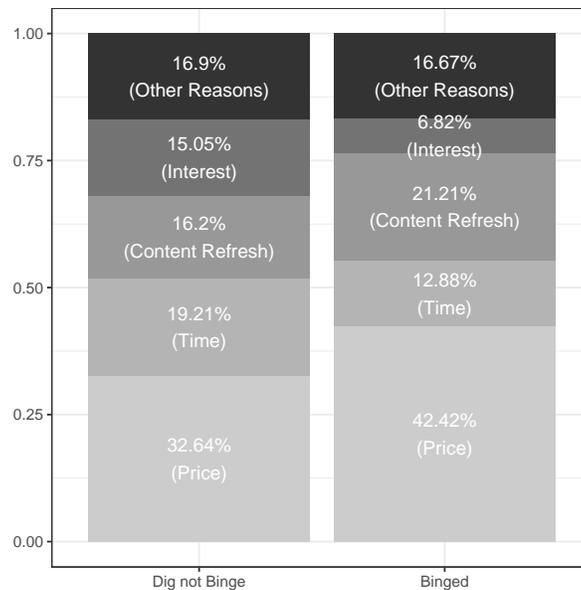
Columns (3) and (4) show that customized reminders did not slow down the consumption of TELCO-SVoD content during the experiment. On the contrary, these reminders increased the number of different TELCO-SVoD episodes that *Treated* households watched as well as the number of different TV shows. Appendix .2 provides additional analyses about the effect of reminders on TELCO-SVoD consumption showing that customized reminders steered consumption towards TELCO-SVoD content that households would unlikely organically consider. Columns (5) and (6) in this table show that the effect reminders on the likelihood of TELCO-SVoD subscription after the experiment comes from households that watched TELCO-SVoD during the experiment in all scenarios tested, customized communications canceled the negative effect of TELCO-SVoD Watch time on TELCO-SVoD subscription after the experiment.

Table 14 Effect of reminders on the household consumption during the experiment and on subscription behavior after the experiment

	Subscribed		N Lease		N TV Shows		Subscribed	
	OLS ITT	Probit ITT	OLS ITT	(3)	OLS ITT	(4)	2SLS LATE	IV Probit LATE
	(1)	(2)	(3)	(3)	(4)	(4)	(5)	(6)
(Intercept)	0.018*** (0.002)	-2.106*** (0.043)	0.489*** (0.073)	0.053*** (0.006)	0.018*** (0.002)	-2.090*** (0.051)		
Gift	-0.006** (0.002)	-0.163** (0.066)	4.201*** (0.349)	0.174*** (0.016)				
Generic Communication	-0.000 (0.003)	-0.000 (0.061)	-0.033 (0.106)	-0.011 (0.009)	-0.001 (0.003)	-0.017 (0.071)		
Custom Communication	-0.003 (0.003)	-0.074 (0.063)	-0.028 (0.126)	-0.021** (0.009)	-0.004 (0.003)	-0.099 (0.073)		
Gift x Generic Communication	0.003 (0.003)	0.089 (0.091)	0.659 (0.494)	0.018 (0.021)				
Gift x Custom Communication	0.007* (0.003)	0.180* (0.092)	0.850* (0.500)	0.065*** (0.023)				
Watch Time All (hours)								
Watch Time All (hours) x Generic Communication								
Watch Time All (hours) x Custom Communication								
Num. obs.	29950	29950	29950	29950	29950	29950	29950	29950
RMSE	0.122		17.578	0.782		0.125		
AIC		4725.031						
Log Likelihood		-2356.516						
Deviance		4713.031						

\*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ ; Heteroskedasticity-consistent standard errors in ()

The survey extended to all *Treated* households after the experiment allows us to collect additional information about why many households refrained from subscribing TELCO-SVoD after the experiment and about why customized reminders may have affected their decisions to do so. A total of 296 answers were collected from the 15,000 *Treated* households that were targeted with the survey. Figure 4 shows the relative importance of each answer, that is, how many households referred each answer among those that binge and that did not binge watched TELCO-SVoD during the experiment. High price and lack of content refresh are the only two answers that obtained a larger share among binge watchers. The share of households that indicate lack of time and lack of interest is actually larger among non-binge watchers. Appendix .3 shows that TELCO consumers are willing to pay more for a service that allows for binge-watching. Therefore, we find some evidence that lack of content refresh seems to be a major reason why binge watchers exhibit a lower likelihood of TELCO-SVoD subscription after the experiment.



**Figure 3** Reasons why Treated households did not subscribe TELCO-SVoD after the experiment (296 survey respondents). Each column indicates the percentage of households that selected each answer.

Finally, if customized reminders leveled off the likelihood of TELCO-SVoD subscription after the experiment because they expanded the consumers' consideration sets leading them to realize that there was still interesting content to watch, and thus pay for, in the TELCO-SVoD catalog, then one may expect that the consumers that received these reminders during the experiment may have been less concerned with the lack of content refresh in TELCO-SVoD's catalog. We use the answers collected from the post-experimental survey to analyze if this is the case. Table 15 shows

the results obtained from coding the different reasons for not subscribing TELCO-SVoD after the experiment as dummy variables and using logistic regressions to test whether receiving generic and customized reminders changed the likelihood of choosing each of them. These results provide strong evidence that customized reminders changed the consumers' perception about how much TELCO refreshed the TELCO-SVoD catalog during the experiment. In line with our previous results, we find that generic reminders did not have any effect on the reasons that consumers reported to not subscribe TELCO-SVoD after the experiment but customized reminders reduced by 15-17% the likelihood of reporting lack of content refresh as a driver for not doing so.

Table 15 Effect of reminders on the reasons to not subscribe TELCO-SVoD after the experiment.

		<i>Dependent variable:</i>							
		Price	Interest	Time	Content Refresh	Price	Interest	Time	Content Refresh
		<i>logistic</i>	<i>logistic</i>	<i>logistic</i>	<i>logistic</i>	<i>logistic</i>	<i>logistic</i>	<i>logistic</i>	<i>logistic</i>
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Generic Reminders						0.476 (0.396)	0.074 (0.475)	0.181 (0.435)	-0.092 (0.400)
Customized Reminders		-0.102 (0.241)	0.213 (0.273)	0.285 (0.248)	-0.739*** (0.263)	0.273 (0.392)	0.272 (0.469)	0.430 (0.430)	-0.812** (0.412)
Constant		0.557*** (0.163)	-1.253*** (0.189)	-0.836*** (0.171)	-0.504*** (0.162)	0.182 (0.350)	-1.312*** (0.426)	-0.981** (0.391)	-0.431 (0.356)
dy/dx									
Customized Reminders		-0.024 (0.057)	0.039 (0.050)	0.063 (0.055)	-0.153*** (0.052)	0.063 (0.089)	0.050 (0.086)	0.095 (0.095)	-0.167** (0.082)
Observations		296	296	296	296	296	296	296	296
Log Likelihood		-195.734	-162.769	-187.283	-178.558	-195.018	-162.757	-187.194	-178.531
Akaike Inf. Crit.		395.467	329.538	378.565	361.116	396.037	331.513	380.389	363.063

Note: \* p<0.1; \*\* p<0.05; \*\*\* p<0.01  
Heteroskedastic consistent standard errors in ()

## 5. Conclusions

Binge watching became a popular cultural and social phenomenon in recent times. It disrupts the traditional model of linear TV, which was based on tight broadcast schedules, by shifting control to consumers. Propelled by advanced content distribution networks over the Internet, Over The Top (OTT) platforms such as Netflix, Hulu and Amazon Prime allow consumers to watch what they want when they want. Content is available at all times from Subscription-based Video-on-Demand (SVoD) services, which now offers an unprecedented number of movies and TV shows. In many cases, content providers upload several episodes of the same TV show at once allowing for binge watching. In some cases, they even upload all the episodes of the same TV show season at once allowing consumers to view entire seasons over very short periods of time whereas before they could easily need several months to get to the season finales. Content providers and content distributors have raced very quickly to provide SVoD services allowing for binge watching. However, it is unclear whether content providers and content distributors fully anticipated all the potential consequences that such a shift could trigger. For example, with SVoD services that allow for binge watching consumers watch more content per unit of time, which is likely to lead them to deplete VoD catalogs faster reducing their interest, and consequently their willingness to pay, for the outstanding VoD catalog, at least in the short-run until new content is added to the SVoD library.

Our paper provides evidence of this mechanism at work. We partner with a major telecommunications provider – called TELCO – to study the impact of binge watching on the likelihood of SVoD subscription. We report results from two randomized control trials in both cases showing that binge watching reduces the latter. In our first experiment a number of households were offered access to a TV channel that broadcasted movies and TV shows 24/7. A random subset of these households were offered access to this channel with Time-Shift TV (TSTV) while the remainder of them could only watch this channel live. A third random set of households was used as a control group. Using TSTV the former set of households could effectively binge watch by going back in time and consuming several episodes of the same TV show in the same sitting. We find that the households that were offered access to this channel for free subscribe it less than the households that did not get the gift and that this result is driven by the fact that the former set of household used TSTV to binge watch this channel during the experiment.

Our second experiment studies the behavior households offered access to TELCO-SVoD, which is a SVoD service similar to Netflix, Hulu and Amazon Prime. A subset of households, selected at random, was offered access to TELCO-SVoD for free for a period of 3 months. The remaining households were not offered this gift as used as control group. TELCO did not update the content in the TELCO-SVoD library during this experiment. We find that the households that binge watched TELCO-SVoD were less likely to subscribe it after the experiment. However, they also enjoyed

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(proxied by likes per lease) more their overall experience with the VoD system at TELCO, ruling out the potential confounder that the content offered as part of TELCO-SVoD was unattractive.

The lower likelihood of SVoD subscription in the short-run across binge watchers may come as an undesired outcome for content providers and content distributors and may be troublesome now that binge watching is becoming a prevalent practice to consume video. Therefore, we also study whether recommendation reminders, aimed at expanding the preferences of consumers for existing content, could help address this concern. Enticing consumers to existing content in the outstanding SVoD catalog that they would not otherwise browse or watch could lead them to enjoy the SVoD service more maintaining them engaged for longer periods of time. This is likely to allow content providers to better manage the potentially prohibitive costs associated with a demanding schedule to create and distribute new content. During our experiment with TELCO-SVoD a subset of households used in the experiment, selected at random, received generic reminders. Another subset of households, also selected at random, received customized reminders. The former messages reminded consumers of TELCO-SVoD while the latter suggested particular TV shows that could be watched using TELCO-SVoD that households did not watch before. We find that the consumers that received customized reminders did not reduce their likelihood of subscribing TELCO-SVoD after the experiment. On the other hand, the consumers that did not receive these reminders were significantly less likely to subscribe the service after the experiment. Therefore, carefully crafted reminders may help to keep binge watchers engaged with SVoD services. A post-experimental survey to consumers treated with TELCO-SVoD confirmed lack of content refresh and a high price as the main reasons leading binge watchers to not subscribe the service after the experiment. However, consumers are willing to pay more for a SVoD service that allows for binge watching and the consumers that received customized reminders during our experiment reported lack of content refresh much more seldom as a concern, which provides additional evidence of the key role that this type of reminders may play to help manage the supply of VoD content.

Finally, we acknowledge that our study comes with some limitations. For example, TELCO was only able to collect answers from a few consumers that self-selected to answer the survey run after our second experiment and, therefore, our data do not represent the average households included in this experiment. Also, we measure the effect of recommendation reminders using a single recommender system, specific text messages and using a fixed schedule to issue them. Thus our results pertain to these conditions and may be different in other settings. Still, we show that customized reminders help to keep binge watchers engaged, which we believe provides a good signal for firms to invest in better recommendations technologies targeted at binge watchers. Finally, we acknowledge that a good experimental design to further test the effect of catalog depletion on SVoD subscription rates would be to randomize, at the household level, the rate at which the content

provider/distributor adds new content to the SVoD catalog. Unfortunately, this was not possible at TELCO, both for business and technical reasons, and therefore, we leave this idea for future research.

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## .1. The Effect of Past Free Trails on the Subscription of SVoD Services

Table 16 shows that the households that received free trails of the TVSC in the past, with or without TSTV, subscribed this channel after the experiment at the same rate as the households that did not get such offers. Columns (1) and (2) show results across all households used in the experiment, while columns (3) and (4) show results only across households that were gifted access to the TVSC. Table 17 shows similar results for the case of TELCO-SVoD, that is, the households that received free trails of TELCO-SVoD in the past subscribed TELCO-SVoD after the experiment at the same rate as the households that did not get such offers.

**Table 16** Effect of past trials on the subscription of the TVSC service after the experiment

	<i>Dependent variable:</i>			
	Subscribed			
	<i>OLS</i>	<i>probit</i>	<i>OLS</i>	<i>probit</i>
	(1)	(2)	(3)	(4)
Gift	-0.0003 (0.005)	-0.002 (0.032)		
Gift TSTV	-0.006 (0.005)	-0.041 (0.032)	-0.006 (0.005)	-0.041 (0.032)
Past TVSC Trial	0.013** (0.006)	0.085** (0.038)	0.018*** (0.006)	0.112*** (0.038)
Gift x Past TVSC Trial	0.004 (0.009)	0.027 (0.054)		
Gift TSTV x Past TVSC Trial	-0.008 (0.008)	-0.047 (0.054)	-0.008 (0.008)	-0.047 (0.054)
Constant	0.077*** (0.003)	-1.423*** (0.022)	0.077*** (0.003)	-1.425*** (0.023)
Observations	30,000	30,000	20,000	20,000
R <sup>2</sup>	0.001		0.001	
Adjusted R <sup>2</sup>	0.001		0.001	
Log Likelihood		-8,322.705		-5,498.578
Akaike Inf. Crit.		16,657.410		11,005.160
Residual Std. Error	0.271		0.269	
F Statistic	4.519***		5.610***	

*Note:*

\*p<0.1; \*\*p<0.05; \*\*\*p<0.01  
Heteroskedasticity-consistent standard errors in ()

## .2. Additional Information about the TELCO-SVoD Recommender System

**.2.1. Induced TELCO-SVoD Consumption** Figure 5 provides additional information about how reminders shaped the behavior of consumers during our experiment. We generated customized recommendations for all households in the experiment, that is, we determined the titles of the TV shows that would have been recommended to the households that did not get reminders and that got generic reminders, had they been targeted with customized recommendations during the experiment. The set of recommendations that

**Table 17** Effect of past trials on the subscription of the TELCO-SVoD service after the experiment

	<i>Dependent variable:</i>	
	Subscribed	
	<i>OLS</i>	<i>probit</i>
	(1)	(2)
Gift	-0.003*	-0.069*
	(0.002)	(0.040)
Past TELCO-SVoD Trial	0.003	0.072
	(0.003)	(0.069)
Gift x Past TELCO-SVoD Trial	-0.001	-0.027
	(0.004)	(0.100)
Constant	0.016***	-2.140***
	(0.001)	(0.028)
Observations	29,950	29,950
R <sup>2</sup>	0.0002	
Adjusted R <sup>2</sup>	0.0001	
Log Likelihood		-2,358.137
Akaike Inf. Crit.		4,724.274
Residual Std. Error	0.122	
F Statistic	1.797	

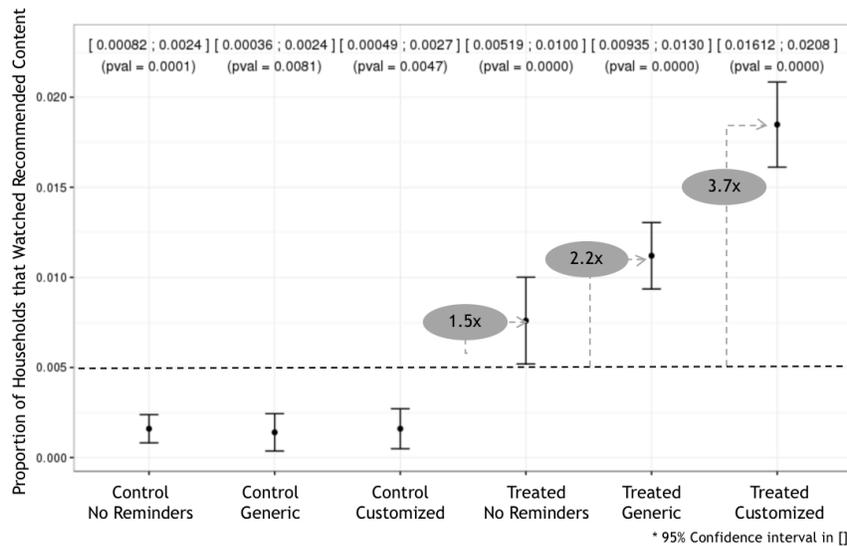
*Note:*

\* p&lt;0.1; \*\* p&lt;0.05; \*\*\* p&lt;0.01

Heteroskedasticity-consistent standard errors in ()

these households would have obtained joined with the set of recommendations received by the households that received customized reminders during the experiment includes 37 out of the 75 TV shows in TELCO-SVoD. The vertical axis in this figure represents the proportion of households in each experimental group that watched content from this subset during the experiment.

The horizontal dashed line represents the probability that a household picking up a title at random from TELCO-SVoD would choose a title in this set. As expected, the likelihood that control households choose titles from this set is very small given that they were not offered TELCO-SVoD. The estimate for *Treated* households without reminders is statistically above the horizontal dashed line, showing that without reminders households would tend to pick up titles from the ones that would be recommended to them, that is, TELCO's recommender system captures (part) of the households' preferences for TELCO-SVoD content. The estimate for *Treated* households with generic reminders is even higher than that for the previous households, showing that the effect is stronger when TELCO primed households to use TELCO-SVoD. When households are primed to watch TELCO-SVoD they tend to watch more content that would have been recommended to them. Finally, the estimate for *Treated* households with customized reminders shows that the households that were primed to watch content that they did not watch before watched a disproportionate amount of such content. Therefore, this figure provides some evidence that customized reminders steered consumption towards new content in the existing TELCO-SVoD catalog. This may have expanded their consideration sets and thus kept them interested in the outstanding SVoD catalog even after the gift period.



**Figure 4 Effect of recommendation reminders on the propensity of households to watch recommended TELCO-SVoD content.**

**.2.2. Implementation of the Recommender System** Customized recommendation reminders were developed using collaborative filtering. In this approach, users and products are described by a set of latent factors that are used to predict missing entries in the recommendation matrix. We used implicit feedback in the form of trailer views, purchases and likes because in TELCO’s case there are no explicit rankings for content. Latent factors were learned using Alternating Least Squares (ALS) from the spark.mllib 2.1.0 implementation. In our approach to using spark.mllib, instead of trying to model the matrix of ratings directly, our algorithm treats the data as representing the strength of user actions (e.g., the time that consumers spend watching a movie, whether they watched the trailer, the number of times they watched a movie, etc.). These data are then related to the level of confidence in observed user preferences. Finally, our model tries to find latent factors that can be used to predict the expected preference of a user for each item.

### **.3. The Consumers Willingness to Pay for Binge Watching**

An additional survey issued by TELCO allows us to learn about the consumers willingness to pay for a SVoD service that allows for binge watching. This survey was launched in the scope of other TELCO activities and

was aimed at learning more about the preferences of consumers for media content. A total of 1,843 valid answers were collected for the following question: *“Consider your favorite TV show. How much would you be willing to pay, up front, for a service that provides you all episodes of such TV show at once? How much would be willing to pay, up front, for a service that provides you all the episodes of your favorite TV show releasing one episode per week? In both cases you will only pay once for the service”*. On average, consumers reported that they are willing to pay \$1.9 to access their favorite TV show if all episodes were release one by one on a weekly basis. However, they are, on average, willing to pay an additional \$7.1 if they could watch all episodes of this same TV show at once. This large one-off premium that consumers may be willing to pay for the ability to binge watch their favorite TV show may be encouraging for content providers and content distributors because it shows that consumers may be willing to share the additional costs associated to producing content at a pace that allows for binge watching.