IS OTT VIDEO A SUBSTITUTE FOR TV? POLICY INSIGHTS FROM CORD-CUTTING

Jacob B. Malone, Aviv Nevo, Zachary Nolan, and Jonathan W. Williams*

Abstract—The video entertainment industry is experiencing increases in over-the-top (OTT) video usage and cord-cutting behavior. Using unique panel data from 2012–2016, we document the behavior of the 2.4% of households who "cut the cord" annually. After dropping TV, these households increase internet usage by 22%, reduce payments to multiple-system operators (MSOs) by 50%, and 16% acquire new OTT video subscriptions. These results indicate meaningful substitution between OTT video and TV and suggest that competition authorities should consider broadening market definitions. MSOs appear to have little incentive to degrade OTT video, despite OTT video's contribution to declining TV revenues.

I. Introduction

ONE of the most important recent developments in the video entertainment industry is the emergence of over-the-top (OTT) video. Companies like Netflix and Hulu are household names, and tech giants have entered this space via Amazon Prime, Apple TV+, and YouTube (owned by Google). Additionally, offerings are expanding to include live broadcasts such as sporting events. To access this rich online content, consumers must connect to the internet through an internet service provider. Most internet service providers, such as cable companies (e.g., Comcast) or telcos (e.g., AT&T) are multiple-system operators (MSOs), offering both internet and TV service.[1]

In this paper, we provide insight into whether OTT video is a meaningful substitute to the MSO's TV service by empirically studying the behavior of households who drop TV service, that is, "cut the cord." Specifically, we provide empirical facts from a unique household-level panel containing detailed information on internet usage, TV viewership, and subscriptions. We document the characteristics of households who cut the cord, their behavior after they cut the cord, the implications of cord-cutting for MSO revenue and costs, and its impact on the revenues of OTT video providers. These facts add to policy discussions that to this point have been mostly theoretical.

Whether OTT video is a substitute for TV is relevant for competition policy in video markets. For example, if OTT video is a substitute for TV service, it should be considered when defining markets in merger and antitrust conduct investigations. Knowing whether OTT video is a substitute for the MSO's TV service is also important when evaluating the MSO's incentives to embrace the rise of OTT video. On one hand, the popularity of OTT video increases the value of internet access, which is now the primary service MSOs provide. This suggests the MSO should do what it can to promote these services provided it can capture a share of the surplus and the additional network costs required to accommodate it are not too great. On the other hand, if OTT video is a substitute for the MSO's TV service, improvements to OTT video will pull consumers away from the MSO's TV service, consistent with the trend of cord-cutting. The loss of profits from the TV service, which includes lost sales for a product with a positive margin, as well as potential loss of TV advertising, suggests the MSO might try to limit the expansion of OTT video. Concerns over this latter effect have led to calls for Net Neutrality, that is, internet service providers must treat all types of internet traffic equally and not block, or slow down, specific services.[2]

Our analysis uses a household-level panel obtained from a North American MSO. The data include two separate panels, one from 2012 and another from 2015–2016. The 2012 sample includes household-level subscription and payment information from billing records, viewership of the MSO's TV service, and the volume (bytes) of internet traffic. We also have detailed demographic information (e.g., income bracket, age, etc.) from credit-report records for each of the 28,884 households. The 2015–2016 sample, which comprises the same set of households, contains billing records and the volume of internet usage by application or protocol (e.g., Netflix). Using these data, we provide descriptive statistics such as the relationship between household demographics and volume of internet usage.

During the course of our sample, 2,710 households cut the cord, yielding an annualized rate of approximately 2.4%.[3] We find that households who cut the cord tend to be smaller, younger, lower-income, and heavier internet users. Households who prefer content for which there is a lack of close

Received for publication April 8, 2021. Revision accepted for publication August 20, 2021. Editor: Benjamin R. Handel.

*Malone: CableLabs; Nevo: University of Pennsylvania; Nolan: University of Delaware; Williams: University of North Carolina at Chapel Hill.

We thank Greg Crawford, Shane Greenstein, Tommaso Valletti, and Ali Yurukoglu for comments, and the National Science Foundation (Grant SES-1324717) and the NET Institute for support of our research. We are grateful for the generosity of the North American MSO that provided the data. All remaining errors are our own. Nevo is currently on leave serving as the Director of the Bureau of Economics at the Federal Trade Commission. The views expressed in this paper are his own and do not necessarily reflect the views of the Commission or any individual Commissioner.

A supplemental appendix is available online at https://doi.org/10.1162/rest_a_01132.

[1]Hereafter, we use "MSO's TV service" to refer to the managed video products sold by MSOs, for example Comcast's XFINITY Digital Cable TV.

[2]The Net Neutrality debate has been an active and lively debate for over a decade and is likely to continue, as evident by the call for appropriate Net Neutrality rulemaking in the Executive Order issued by President Biden (https://www.wsj.com/articles/biden-revives-net-neutrality-targets-big-broadband-providers-11625858529).

For discussions of Net Neutrality see Wu (2003), which introduced the term, as well as Lee and Wu (2009) and Greenstein et al. (2016).

[3]This estimate is consistent with industry-wide trends in Moffett and Nathanson (2016).

The Review of Economics and Statistics, November 2023, 105(6): 1615–1623

https://doi.org/10.1162/rest_a_01132

substitutes in OTT video subscriptions (e.g., sports and premium channels) are less likely to cut the cord. Conversely, households who spend their time viewing general interest and broadcast channels, which are readily available in OTT video bundles, are more likely to cut the cord.

After cutting the cord, we find households increase overall internet traffic by 22%. This increase in usage is driven by OTT video, which accounts for over 60% of traffic in our sample and increases by 24% when a household cuts the cord. Sling TV, a streaming service comprising bundles of linear TV channels and arguably the closest substitute to the MSO's TV service, sees a tenfold increase in usage. We also observe increases in active use of Netflix, Hulu, Sling TV, and other streaming services. At least 16% of cord-cutters take up additional OTT video subscriptions after dropping the MSO's TV service. These findings indicate that OTT video is, to some degree, a substitute for TV service, suggesting regulatory authorities should carefully consider the role of OTT when defining markets for media merger cases.

Cancelled TV subscriptions reduce the MSO's revenue by \$69 per household-month, approximately half of the average cord-cutting household's monthly bill.[4] Additionally, the MSO also faces the costs of upgrading their network to accommodate increased internet usage. At the same time, OTT video operators see an increase in revenues of \$4.11 per household-month, which accounts for only 6% of lost MSO revenue.

Our findings demonstrate that there is meaningful substitution between TV service and OTT video and that the loss of revenue for the MSO from cord-cutting is not trivial. We therefore provide empirical support to the theoretical concern that MSOs may have the incentive to impede access to OTT video and try to steer consumers back to its TV service. However, several factors suggest concerns over MSO incentives to degrade the quality of OTT video might be exaggerated. First, payments to OTT video providers by cord-cutters account for a small fraction of their former TV service payments, suggesting impeding OTT video may not efficiently recapture video surplus. Second, the MSO could try to combat cord-cutting by simply raising the price of its internet service, which is neutral with respect to content.

We do not determine the optimal MSO response to OTT video in this paper; however, we find here and elsewhere (Nevo et al., 2016 and Malone et al., 2020) that usage and willingness to pay are heterogeneous across consumers. Therefore, permitting the MSO to price discriminate between users who are likely to cut the cord and more heavily use the network can help reduce the incentive to take other actions to prevent cord-cutting by capturing surplus associated with OTT video. This is consistent with the fact that despite the 2018 repeal of content neutrality restrictions by the FCC, nonneutral conduct has not manifested among the major MSOs. As such, our analysis provides suggestive evidence that concerns over this particular aspect of Net Neutrality might be overstated. We do not speak to other aspects of the debate, such as the division of surplus between MSOs and content providers, content entry, network management, investment in quality such as speed, or investment trade-offs associated with alternative Net Neutrality policies.

In a related but complementary paper, McManus et al. (2022) offer a theoretical model to further study MSO incentives to price discriminate. They use a different data set, with variation in prices created by the introduction of usage-based pricing, to estimate consumers' price responsiveness along several dimensions and quantify some of the incentives discussed in this paper. Both papers study MSO incentives but differ in methods and key variation in the data (here the time series of cord-cutting and in McManus et al. (2022) the introduction of usage-based pricing).

Related to the point that the MSO might want to degrade its internet service by impeding OTT video access, Mussa and Rosen (1978) theoretically show how firms may seek to degrade product quality to impact consumers' choices, while Crawford and Shum (2007) empirically study bundling of channels in TV packages to demonstrate this effect. More broadly, there are a number of theoretical and empirical studies of discriminatory nonlinear pricing and its impact on consumer choices in telecommunications: Economides and Hermalin (2015); Lambrecht et al. (2007); Miravete (2003); Grubb (2015); and Grubb and Osborne (2015). Our work also relates to the recent literature focusing on the distribution of live TV and the relationships between telecommunications and media firms. For example, see Crawford and Yurukoglu (2012) and Crawford et al. (2017).

Our results complement an extensive, but largely theoretical, literature on Net Neutrality: Economides and Hermalin (2012); Armstrong (2006); Bourreau et al. (2015); Choi et al. (2015); Choi and Kim (2010); Economides and Tag (2012); Gans (2015); Reggiani and Valletti (2016); and Sidak (2006). One recent empirical contribution on the neutrality of platforms, but not MSOs specifically, is Tudon (2022), which studies the implications of neutrality on Amazon's Twitch platform. Regulatory discussions for other "gatekeeper" platforms are ongoing, and although many additional contexts exhibit similar tensions between vertical platform affiliates competing with substitutes on the platform, data in those settings are generally unavailable.

Our study also contributes to the literature on demand for broadband services: Prince and Greenstein (2017); Goetz (2019); Goolsbee and Klenow (2006); Dutz et al. (2009); Rosston et al. (2013); Greenstein and McDevitt (2011); Goolsbee and Klenow (2006); Edell and Varaiya (2002); and Hitte and Tambe (2007). Malone et al. (2014, 2020) and Nevo et al. (2016) also analyze high-frequency data on usage of telecommunications services, but the data set used in this paper is unique in several ways. First, it includes information on both TV and internet subscriptions and usage. Second, it includes two distinct panels that span a period of rapid

[4]The MSO saves per-subscriber fees it pays to TV content providers, but since margins on the TV service (inclusive of advertising revenues) are positive, the cancelled subscriptions reduce the MSO's profits.

TABLE 1.—BROADBAND PLANS AND USAGE

	All Households		Cord-Cutters		Non–Cord Cutters	
	2012	2015–2016	2012	2015–2016	2012	2015–2016
Plan Selection						
Speed (Mbps)	22.50	49.32	23.41	51.76	22.41	49.07
Below Median Tier	0.25	0.25	0.24	0.27	0.25	0.25
Median Tier	0.65	0.61	0.66	0.57	0.65	0.62
Above Median Tier	0.10	0.14	0.10	0.16	0.10	0.13
Internet Usage						
Mean	1.70	3.93	2.27	5.65	1.64	3.76
Standard Deviation	2.66	4.76	3.32	6.39	2.58	4.53
25th Percentile	0.29	0.96	0.47	2.04	0.28	0.85
Median	0.85	2.56	1.28	4.13	0.82	2.40
75th Percentile	2.08	5.37	2.73	7.52	2.01	5.14
95th Percentile	5.98	12.21	7.52	15.30	5.84	11.79
99th Percentile	11.86	19.98	16.83	23.61	11.32	19.28
Number of Households	28,884		2,710		26,174	

This table summarizes broadband plan choice and internet usage for households in the 2012 and 2015–2016 samples. Observations are at the household level, with usage aggregated to the average daily level for each household. Below (above) median speed tier refers to broadband plans with download speeds lower (higher) than the plan selected by the median household in the sample.

change for the industry, allowing for comparison of trends over a longer time horizon. Third, it contains demographics for each included household.

The remainder of the paper is organized as follows. Section II describes our data sources and provides descriptive statistics from the two panels. Section III analyzes the characteristics and behavioral changes of households who cut the cord. Section IV discusses redistributive effects for market participants and the implications of our results for MSO incentives. Section V concludes and discusses topics for future research.

II. Data and Descriptive Analysis

Our data set contains 28,884 households served by a North American MSO,[5] which we observe during two periods: 2012 and 2015–2016.

We define the sample as households observed throughout the whole period that had TV service in 2012. The 2015–2016 data, which are our primary source for the analysis, contain nine months of detailed information on the composition of internet traffic, including the identities of specific applications and websites (e.g., Netflix) accessed by each household. The 2012 data contain seven months of somewhat less-detailed household-level information on internet and TV engagement, and household demographic characteristics. In both periods, we observe the MSO services chosen by each household. Therefore, using the account identifier we observe service plan and usage choices over almost five years. See the appendix for a more detailed description of the data sources.

A. *Plan Choice and Usage Statistics*

In table 1 we present descriptive statistics of plan choice and usage for households in the sample. In both periods, the MSO offered multiple internet service tiers that varied by speed. In 2012, the most popular internet tier, which offered the median speed, was chosen by 65% of households; 25% of households chose tiers with slower speeds, and 10% chose tiers with faster speeds. In the 2015–2016 sample, more households (14% of the sample) switched to the faster speed tiers, even though all tiers improved in speed relative to 2012 (as can be seen in the average speed presented in the first row).

By construction, in 2012 all households in the sample subscribed to a plan that gave them access to a TV service which included both re-transmitted broadcast channels (e.g., NBC, CBS, etc.) and network channels (e.g., ESPN, USA, etc.).[6]

By the end of the 2015–2016 period, 2,710 households, just under 10%, "cut the cord," namely, dropped their TV service while retaining only internet service.[7] Of those who kept both TV and internet service, a higher percentage subscribed to the above median internet speed tier (13% compared to 10%). This was even more true for those households who dropped TV service: 16% subscribed to the above median tier. Households who eventually cut the cord ended up with speeds that were on average about 20% higher, despite having similar speeds in 2012.

Internet usage increased significantly from 2012 to 2015–2016. In 2012, the median household used about 0.85 gigabytes (GB) per day, while the mean household used 1.70 GB per month. In 2015–2016, both numbers increased significantly: the median household used 2.56 GB per day, while the mean household used 3.93 GB per day. The households who eventually cut the cord started at a higher level in 2012,

[5] In this market, like many other markets in the United States, the MSO is the primary option for high-speed broadband access.

[6] Ideally we could track household subscription and usage decisions across multiple MSOs, but we do not have access to such data. By restricting our attention to households that at some time during the panel took up TV service in a single MSO, we may underestimate the true share of households without TV service.

[7] We define a household as a "cord-cutter" if we see them with TV service at the start of the sample, but without one at the end of the sample. Our sample is balanced and therefore does not include consumers who moved out of town or dropped the MSO's services altogether during the sample period.

TABLE 2.—INTERNET USAGE DESCRIPTIVE REGRESSIONS

	Log Total GB		Log Streaming GB	
	(1)	(2)	(3)	(4)
Household Size	0.009	0.010*	0.017**	0.018**
	(0.006)	(0.005)	(0.009)	(0.008)
Average Adult Age	−0.294***	−0.260***	−0.432***	−0.391***
	(0.008)	(0.008)	(0.012)	(0.012)
Number of Children	0.276***	0.273***	0.446***	0.443***
	(0.011)	(0.011)	(0.017)	(0.016)
Tenure at Address	−0.138***	−0.122***	−0.210***	−0.192***
	(0.009)	(0.008)	(0.013)	(0.013)
Income	0.057***	−0.008	0.017	−0.057***
	(0.013)	(0.012)	(0.019)	(0.019)
TV Subscriber		−0.548***		−0.714***
		(0.030)		(0.046)
Phone Subscriber		−0.075***		−0.072***
		(0.016)		(0.026)
Below Median Internet Tier		−0.677***		−0.809***
		(0.019)		(0.029)
Above Median Internet Tier		0.427***		0.437***
		(0.023)		(0.036)
Constant	1.994***	2.535***	1.354***	2.050***
	(0.042)	(0.047)	(0.064)	(0.073)
Observations	28,884	28,884	28,762	28,762

OLS regression coefficients with standard errors in parentheses. Column headings indicate the dependent variable. Average adult age and tenure at address are measured in tens of years. Income is measured in hundreds of thousands of dollars. One hundred and twenty-two households never use streaming, and are omitted from regressions (3) and (4). $^{*}p < 0.10$, $^{**}p < 0.05$, and $^{***}p < 0.01$.

and also saw a slightly larger percentage increase in usage between the two periods.

Common features of both periods are very heterogeneous and heavily skewed distribution of internet usage. For example, in 2012 the 95th percentile of usage was 5.98 GB daily and the 99th percentile was 11.86 GB. In 2015–2016, the 95th percentile household used 12.21 GB daily and the 99th percentile household used 19.98 GB.

The key addition to the 2015–2016 sample, relative to the 2012 sample, is information on the composition of internet usage. Streaming and OTT video account for 54% of all internet usage, and another 33% of traffic comes from web browsing. While web browsing makes up the majority of internet usage for households in the lower tail of the total usage distribution (60% for the 10th percentile household versus 15% for the 90th percentile household), online video usage is highly correlated with the total usage level (20% for the 10th percentile household versus 55% for the 90th percentile household). We illustrate these composition changes graphically in figure A1 of the online appendix.

B. *Household Heterogeneity*

The demographic information for our sample is representative of a typical U.S. market. The median household has 3 members, adults with an average age of 47, an income of $62,500, and has lived at its current address for 10 years. We find all sample statistics fall within one standard deviation of the average demographic values across U.S. metropolitan statistical areas (reported in the 2012 American Community Survey).

In table 2 we report the results of regressions relating internet usage levels to household characteristics. In particular, we regress the log of total usage and log streaming usage, measured in gigabytes, on plan choices and demographic information. We find that larger households and those with more children tend to engage more with the internet, while older or longer tenure households use the internet less overall. These differences are significant both in terms of total traffic and specifically for streaming traffic, although in both cases these variables explain a relatively small fraction of the overall variation. Internet usage decisions also vary meaningfully with internet-tier and TV plan subscriptions. Households with a TV subscription have less overall and streaming usage and those on more expensive internet tiers have greater overall and streaming usage. The effect of demographic characteristics on internet usage and streaming does change slightly once we include plan selection, which should not be surprising since plan selection varies with household demographics. We present more details on the relationship between plan selection and demographics in table A2 of the online appendix.

III. Empirical Analysis

We now document (i) household-usage patterns that are predictive of cord-cutting and (ii) how a household's usage behavior changes after cutting the cord.

A. *Household Attributes That Predict Cord-Cutting*

To provide insight on the attributes of who is likely to cut the cord, we create an indicator equal to one if the household is a "cord-cutter" (i.e., a household that drops the MSO's TV service by the end of the 2015–2016 period). We then run a series of probit regressions of the cord-cutting indicator on household characteristics, including demographics, plan selection, and usage decisions. Average marginal effects from these regressions are reported in table 3. While specifications (1) and (2) employ the full sample, specifications (3) and (4) focus only on cord-cutting that occurs during the 2015–2016 period in order to leverage the internet usage decomposition that we only observe during that period. We observe 2,710 cord cuts over the course of the sample, of which 605 occur during the 2015–2016 nine-month period.

From specifications (1) and (2) in table 3, we see certain demographic characteristics are important predictors: younger, smaller, and less affluent households are more likely to cut the cord. These demographic results are intuitive for several reasons. First, preferences for television are known to vary with age. Nielsen, for example, reports that older adults watch much more traditional TV than younger individuals. Second, larger households may have more diverse content preferences, making it harder to find substitutes to TV. In addition, larger households likely watch more TV than smaller households, making substitution to online video more bandwidth intensive and thus more costly as a substitute to the MSO's TV service. Third, since cord-cutting leads to a significant reduction in monthly payments, we would expect these

TABLE 3.—PREDICTORS OF CORD-CUTTING

	(1)	(2)	(3)	(4)
Household Size	−0.005***	−0.005***	−0.000	−0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Average Adult Age	−0.018***	−0.017***	−0.003***	−0.002**
	(0.002)	(0.002)	(0.001)	(0.001)
Tenure at Address	−0.017***	−0.016***	−0.004***	−0.004***
	(0.002)	(0.002)	(0.001)	(0.001)
Income	−0.171***	−0.167***	−0.035**	−0.039***
	(0.027)	(0.027)	(0.015)	(0.015)
Phone Subscriber		−0.009***		
		(0.003)		
Premium Channels Subscriber		−0.017***		
		(0.004)		
Sports Package Subscriber		−0.010***		
		(0.003)		
Daily Internet Use		0.052***		0.008***
		(0.005)		(0.002)
Active Sling TV				0.042***
				(0.007)
Active Hulu				0.006***
				(0.002)
Active Netflix				0.006***
				(0.002)
Time Period	2012–2016	2012–2016	2015–2016	2015–2016
Observations	28,884	28,884	26,779	26,779

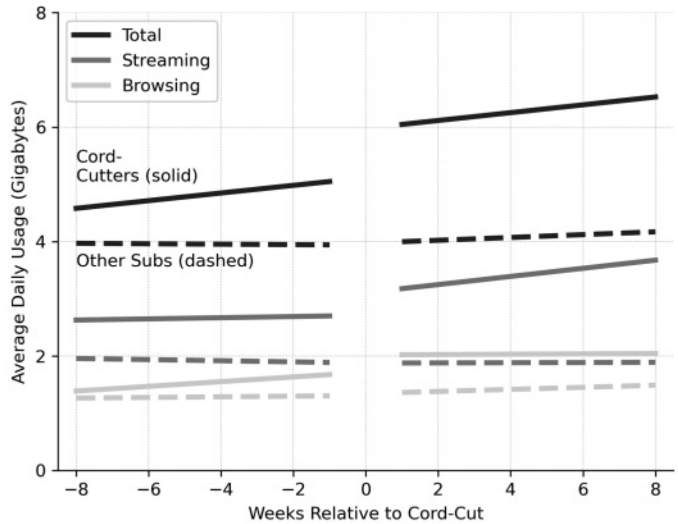
Probit regression average marginal effects with standard errors in parentheses. The dependent variable in the first two columns is an indicator for cord-cutting between the end of the 2012 sample and the end of the 2015–2016 sample. The dependent variable in the second two columns is an indicator for cord-cutting during the 2015–2016 sample. Households who cut the cord prior to the third month of the 2015–2016 sample are excluded. Active Sling TV, Active Hulu, and Active Netflix are indicators of positive use of each service during the first two months of the 2015–2016 sample. Daily Internet Use is in tens of gigabytes. Average adult age and tenure at address are measured in tens of years. Income is measured in hundreds of thousands of dollars. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

savings to be more attractive to lower-income households, all else equal.

The variables that have the most predictive power are related to internet usage. For example, an increase in 2012 usage from the median level to the 95th percentile increases the predicted probability of cord-cutting by 3.4 percentage points, about 35% of the observed rate. TV subscription choices also have a strong impact. Intuitively, households who prefer content that is not attainable through online video might be less likely to drop the MSO's TV service in favor of an OTT video substitute. Indeed, households who subscribed to the Sports and Premium channel packages, which during our sample contained content with few online substitutes, were much less likely to drop the MSO's TV service.

Specifications (3) and (4) in table 3 focus on cord-cutting instances that occur during the 2015–2016 sample period in order to incorporate additional predictors from the 2015–2016 sample. This allows us to check the robustness of the 2012 results and include information on which applications each household engages with online. We limit our sample to those households who had not yet cut the cord by the start of the 2015–2016 sample period. After this reduction in the sample, we are left with 605 cord cuts out of the remaining 26,779 households. To study the effect of OTT video engagement on cord-cutting, we create indicators for active use of the three largest OTT video applications in our data based on the first two months of the 2015–2016 sample and then ask which of the remaining bundled households drop the MSO's TV service during the sample period.

FIGURE 1.—AVERAGE DAILY USAGE BEFORE AND AFTER CORD-CUTTING



This figure presents OLS lines of fit for average daily usage of Total, Streaming, and Browsing traffic for the eight weeks before and after cord-cutting. The solid lines are the estimates of cord-cutter usage and the dashed lines are for all other subscribers.

We find that engaging with Sling TV in the first two months of the 2015–2016 sample increases the probability of cord-cutting by 4.2 percentage points, approximately 185% of the base rate in the sample. Engaging with Hulu and Netflix increase the probability of a cord-cut by 26% and 29%, respectively. The magnitude of the Sling TV effect is intuitive, as it was the primary OTT video application to offer a live TV experience similar to the MSO's TV service during the sample period. The results on demographics and internet use are similar to those from the full sample.[8]

B. *Usage and Streaming Behavior After the Cord Is Cut*

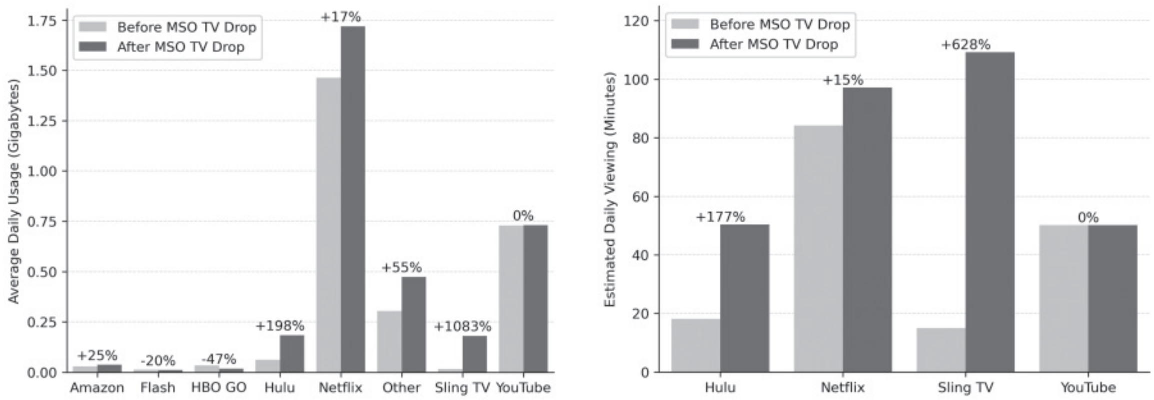
In this section, we study the change in internet behaviors when households cut the cord. We focus on the 2015–2016 panel because it allows us to observe internet activity by category and by application, both before and after cord-cutting occurs. We show that behavioral changes around the time of cord-cutting reflect direct substitution of viewing habits from TV to OTT video alternatives.

In figure 1, we report changes in average total usage, streaming usage, and web browsing usage in the weeks surrounding the cord-cut date. Our sample allows us to identify the exact date each household drops the MSO's TV service, which we use as a reference point for these behavioral changes.

The other households are included to emphasize that the changes we observe are attributable to the subscription

[8]When comparing the results across samples, it is important to note that the sample period used in the 2015–2016 regressions is approximately one-fifth the length of the period in the first two specifications. As such, when comparing the magnitude of coefficients between specifications (1) and (2) and specifications (3) and (4), multiply the coefficients in the latter column by 5 to adjust for period length.

FIGURE 2.—OTT VIDEO USAGE BEFORE AND AFTER CORD-CUTTING



(a) GBs (b) Estimated Minutes

This figure depicts the change in daily usage of OTT video applications in the eight weeks before and after households drop the MSO's TV service. Panel a shows the average change in gigabytes used of each application among all households that cut the cord. Panel b shows the estimated change in daily minutes engaged with the most-used applications among households that actively use them. Minutes are calculated by comparing the byte counts observed in the data with average bit rates published by the application. A household is considered an active user if it ever engages with the application in either the eight weeks before or after dropping the MSO's TV service.

change and not a result of aggregate usage growth over time.[9] The first takeaway from figure 1 is that cord-cutters have greater total usage than other subscribers, and greater streaming usage specifically, even before cutting the cord. In general, the difference between the two groups grows after the MSO's TV service is dropped. Specifically, we observe a 22% increase (4.9 GB/day to 6 GB/day) in average daily usage between the eight weeks prior and eight weeks following a cord cut. There is also an increase in daily streaming usage from 2.9 GB/day to 3.6 GB/day, a 24% increase, consistent with cord-cutters using OTT video to substitute for the MSO's TV service.

Just as the total usage and streaming usage levels immediately increase with cord-cutting, we also observe shifts in usage across other categories of traffic. Comparing average usage for the eight weeks before and after households drop the MSO's TV service, 63% of the increase in total daily usage is due to streaming usage and another 27% is from web browsing. Overall, 90% of the increase is explained by these two categories alone.[10]

Figure 2 reports the change in usage of specific OTT video applications among households who drop the MSO's TV service. In figure 2a, we report the average change in daily gigabytes used of each application. We observe the largest increases in OTT video usage in Netflix, Hulu, and Sling TV. Netflix usage increases by 0.25 GB/day, a 17% increase that explains nearly half of the total increase in OTT video usage. Hulu and Sling TV together account for another 0.3 GB increase in usage, and both applications are used substantially more after households drop the MSO's TV service, with increases of 198% and 1,083%, respectively. The case of Sling TV is particularly interesting because of its linear video format, which sets it apart from the other OTT video applications we observe.

In figure 2b, we use information published by the four most-used OTT video applications to convert bytes of traffic into time spent and assess changes in viewing duration for each application among active users.[11] Netflix is the most-watched application by its users both before and after households drop the MSO's TV service, with average viewing increasing 15% to just over an hour and a half per day after its subscribers cut the cord. Viewing of Sling TV increases 628%, over an hour per day, after households drop the MSO's TV service, while Hulu viewing increases by nearly 30 minutes per day, and YouTube usage remains constant. Sling TV's increase stands out again with a daily increase of over 90 minutes per day among households who are active users of the application. In fact, Sling TV is the only OTT video service aside from Netflix that we estimate over an hour of daily viewing. The similarity in content to the MSO's TV service and the substantial increase in time allocation together suggest that after cutting the cord, households are directly substituting viewing from the MSO's TV service to the OTT video platform.

Besides an increase in usage and time spent on the services, we find that 16% of cord-cutters increase the number of OTT video services they actively use. This increase comes from increases in the three largest services: 1.66% of the cord-cutter sample begins actively watching Hulu, 7.35% begins actively watching Netflix, and 6.30% begins actively watching Sling TV.

[9]We construct the time series of daily usage for other households by calculating average usage by households who do not cut the cord on each day in the sample, centering the date range according to each cord-cut reference date, and then averaging across cord-cutters.

[10]These estimates might be conservative if we think that households start ramping up their usage prior to cutting the cord.

[11]We determine which households are "active" users by tracking positive usage of each application, since we do not have data on actual subscriptions. This method of identifying active users of the services cannot take into account the prevalence of password sharing.

IV. Policy Insights

A. *Insights for Competition Policy*

Historically, U.S. competition agencies have not included OTT video services as part of the relevant market when investigating competition in video markets, either on the viewer or advertising side. Our results demonstrate that consumers substitute to OTT video services when cutting the cord. Although further work is needed to quantify the extent of this substitution, our results suggest this definition warrants closer examination.[12] We note that including OTT video services might mean that in some cases, say a merger between two TV stations, the market is more competitive than previously thought. On the other hand, as we show below, substitution between TV service and OTT video service can potentially raise concerns of anticompetitive conduct by firms with market power.

More recently, MSOs have merged with producers of media content, which introduces further challenges for competition policy. In the past, mergers like Comcast–NBC Universal and AT&T–Time Warner could reasonably be viewed as vertical mergers with the MSO acquiring an input into their video-distribution service. Concerns like the foreclosure of the input to competing video distributors would still exist, but so would proconsumer aspects like the elimination of double marginalization. The innovation of OTT video introduces additional trade-offs for MSOs that complicate evaluation of these mergers. For example, the recent introduction of OTT video offerings like HBO Max and Peacock allow an MSO to capture a share of the surplus from cord-cutters, but also introduces an incentive for the MSO to prioritize its own OTT video over competing sources (e.g., "zero rating" of certain content against usage allowances). How regulatory agencies integrate new streaming services into the analysis of media mergers is an important open question relevant to several ongoing cases like Discovery-Warner and Amazon-MGM. These concerns have led to strong merger preconditions over prioritization and increased pressure on the FCC to pursue complementary regulatory policy like Net Neutrality.[13]

B. *Insights for Net Neutrality*

Cord-cutting has implications for revenue and therefore MSO incentives. We find that average monthly revenue to the MSO from cord-cutters falls by 50%, from $138 to $69, after TV service is dropped. This is a significant loss for MSOs. A cord-cutting rate of 2.4% per year shrinks operator revenue at a rate exceeding 1% per year. In addition to a lower mean, the distribution of revenue per household following a cord-cut also has less variance, due to households paying for fewer services with fewer add-on options.[14] Some households also change internet tiers at the time they drop the MSO's TV service, meaning the overall revenue change consists of both a decline in TV revenue and a change in revenue due to contemporaneous internet tier transitions. Approximately 12% of households also make a change to their internet tier at the same time that they drop the MSO's TV service. Overall, the number of households on below-median speed tiers remains the same, while upgrades from the median speed tier to higher-speed tiers results in a 27% increase in the take-up of premium speed tiers among cord-cutters. In figure A6 of the online appendix we depict the distribution of internet tier selection among cord-cutters as well as a transition matrix. The impact of these upgrades does little to offset the loss in TV revenues.

The increase in OTT video services revenue is much smaller. Using the increase in subscriptions reported in the previous section and the monthly cost of these subscriptions,[15] we estimate the per-household increase in monthly OTT video spending after cutting the cord to be $4.11.[16] Comparing our estimates, OTT video providers capture approximately 6% of the lost MSO TV revenue due to cord-cutting.[17]

These numbers confirm the theoretical predictions discussed in the Introduction: the increase in popularity of OTT video is indeed both a dilemma and an opportunity for MSOs. We find that after cutting the cord consumers increase usage of and subscriptions to OTT video services. Therefore, as the quality of OTT video increases, consumers are more likely to cut the cord and subsequently increase internet usage. This reduces the MSO's revenue from cord-cutters by 50% and reduces profits since the MSO loses the positive margin on TV services and advertising revenues. The MSO's costs are also higher because of higher internet usage. The reductions in revenues are nontrivial and therefore suggest concerns regarding the MSO's incentive to impede access to OTT video have some empirical support.

On the other hand, there are several factors that suggest concerns over the MSO's incentives to extract rent from OTT video providers, one of the motivations for Net Neutrality,

[12] These markets continue to evolve, and our estimates may be somewhat dated given how fast the market has changed in recent years. However, our intuition is that, if anything, substitution has increased over time as OTT video offerings increase.

[13] AT&T recently began counting HBO Max usage against wireless data limits, nationwide, after passage of California's Net Neutrality standards. https://www.cnbc.com/2021/03/17/att-will-count-hbo-max-toward-data-caps-blames-net-neutrality-law.html

[14] We provide a visualization of the effect of a cord cut on monthly operator revenue in figure A5 of the online appendix.

[15] We use the prices of a standard subscription to each service: Hulu Plus is $7.99, Netflix is $9.99, and Sling TV with two add-ons is $30.

[16] We may be underestimating this number. First, we do not observe subscriptions directly, but rely on observing active usage of a service to infer whether each household is a subscriber. Some households may pay for more OTT subscriptions than we observe them use during the sample period. Second, as shown in figures A2 and A7 of the online appendix, we find evidence that households experiment with online video alternatives to the MSO's TV service in advance of cutting the cord. As such we maybe undercounting new subscription changes that occurred before households drop the MSO's TV service.

[17] Households could conceivably purchase TV bundles from other operators, but we believe these instances would be rare due to the loss of the bundling discount associated with purchasing TV and broadband subscriptions from the same MSO.

might be exaggerated. If interaction in the video market was a "zero-sum game," namely, a loss to the MSO is a gain to the OTT video providers, then these concerns might be better founded. However, our evidence shows that this is far from being true. Cord-cutting reduces the revenues of MSOs, but the gain to OTT video providers is small, only 6% of the decline in MSO revenue. It does not seem that impeding OTT video service is an efficient way to recover some of the lost surplus.[18] Furthermore, the MSO could try to combat cord-cutting by simply raising the price of its internet service, which is neutral with respect to content.

Instead of impeding access the MSO might find it optimal to improve the quality of its internet offerings by encouraging high quality OTT video services. Our results show the heaviest users of internet service also disproportionately use OTT video and therefore an improvement of internet service would likely increase their willingness to pay for it. There are many strategies that MSOs may use to slow cord-cutting and benefit from improved OTT video, especially if valuations are heterogeneous as our results here and elsewhere suggest (Nevo et al., 2016; Malone et al., 2020). For example, McManus et al. (2022) show that flexible usage-based pricing strategies can be effective at splitting the surplus generated by OTT video innovations in a way that leads MSOs to embrace their presence. This is consistent with industry trends. During this time period, MSOs were worried, as our numbers suggest they should be, about the cord-cutting trend that arose due to the rapid introduction and innovations associated with OTT video. However, the few MSOs that acted took strategies focused on trying to benefit from the improved OTT offerings.

V. Future Directions

We provide evidence that consumers view TV service and OTT video services as substitutes. More empirical work, especially using more recent data, is needed to quantify the magnitude of the substitution and provide insight into (optimal) strategies that MSOs may use to deal with the improvement in OTT video services. For example, MSOs might respond through usage-based pricing, more aggressively discounting bundles and personalized à la carte offerings, or by focusing exclusively on data services. Compounding these issues, there is an increasingly complicated web of relationships between media companies and MSOs, established by vertical integration (e.g., AT&T–Time Warner or Comcast–NBC) and partnerships that integrate only selected OTT video services into hardware platforms distributed by the MSO (e.g., Comcast's Flex streaming box). To study these topics and offer insight into the distribution of surplus in the industry, which determines long-run investments in networks and media content, more economic modeling is necessary.

[18]One could imagine a world where the MSO would try to extract rent from the OTT video providers by auctioning exclusivity to one OTT video service, who would then significantly increase prices. This seems somewhat unlikely to be optimal since many households seem to be multihoming.

REFERENCES

Armstrong, Mark, "Competition in Two-Sided Markets," *RAND Journal of Economics* 37:3 (2006), 668–691. 10.1111/j.1756-2171.2006.tb00037.x

Bourreau, Marc, Frago Kourandi, and Tommaso Valletti, "Net Neutrality with Competing Internet Platforms," *Journal of Industrial Economics* 63:1 (2015), 30–73. 10.1111/joie.12068

Choi, Jay Pil, and Byung-Cheol Kim, "Net Neutrality and Investment Incentives," *RAND Journal of Economics* 41:3 (2010), 446–471. 10.1111/j.1756-2171.2010.00107.x

Choi, Jay Pil, Doh-Shin Jeon, and Byung-Cheol Kim, "Network Neutrality, Business Models, and Internet Interconnection," *American Economic Journal: Microeconomics* 7:3 (2015), 104–141. 10.1257/mic.20130162

Crawford, Gregory, and Matthew Shum, "Monopoly Quality Degradation and Regulation in Cable Television," *Journal of Law and Economics* 50:1 (2007), 181–219. 10.1086/508310

Crawford, Gregory, and Ali Yurukoglu, "The Welfare Effects of Bundling in Multichannel Television Markets," *American Economic Review* 102:2 (2012), 643–685. 10.1257/aer.102.2.643

Crawford, Gregory, Robin Lee, Michael Whinston, and Ali Yurukoglu, "The Welfare Effects of Vertical Integration in Multichannel Television Markets," *Econometrica* 86 (2017), 891–954. 10.3982/ECTA14031

Dutz, Mark, Jonathan Orszag, and Robert Willig, "The Substantial Consumer Benefits of Broadband Connectivity for US Households," Internet Intervention Alliance working paper (2009).

Economides, Nicholas, and Benjamin Hermalin, "The Economics of Network Neutrality," *The RAND Journal of Economics* 43:4 (2012), 602–629. 10.1111/1756-2171.12001

——— "The Strategic Use of Download Limits by a Monopoly Platform," *The RAND Journal of Economics* 46:2 (2015), 297–327. 10.1111/1756-2171.12087

Economides, Nicholas, and Joacim Tag, "Network Neutrality on the Internet: A Two-Sided Market Analysis," *Information Economics and Policy* 24:2 (2012), 91–104. 10.1016/j.infoecopol.2012.01.001

Edell, Richard, and Pravin Varaiya, "Providing Internet Access: What We Learn from INDEX," in *Broadband: Should We Regulate High-Speed Internet Access?* (Washington, DC: Brookings Institution, 2002).

Gans, Joshua, "Weak Versus Strong Net Neutrality," *Journal of Regulatory Economics* 47:2 (2015), 183–200. 10.1007/s11149-014-9266-7

Goetz, Daniel, "Dynamic Bargaining and Size Effects in the Broadband Industry," working paper (2019).

Goolsbee, Austan, and Peter Klenow, "Valuing Products by the Time Spent Using Them: An Application to the Internet," *American Economic Review P&P* 96:2 (2006), 108–113.

Greenstein, Shane, and Ryan McDevitt, "The Broadband Bonus: Estimating Broadband Internet's Economic Value," *Telecommunications Policy* 35:7 (2011), 617–632. 10.1016/j.telpol.2011.05.001

Greenstein, Shane, Martin Peitz, and Tommaso Valletti, "Net Neutrality: A Fast Lane to Understanding the Tradeoffs," *Journal of Economic Perspectives* 30:2 (2016), 127–150. 10.1257/jep.30.2.127

Grubb, Michael, "Consumer Inattention and Bill-Shock Regulation," *Review of Economic Studies* 82:1 (2015), 219–257. 10.1093/restud/rdu024

Grubb, Michael, and Matthew Osborne, "Cellular Service Demand: Biased Beliefs, Learning, and Bill Shock," *American Economic Review* 105:1 (2015), 234–271. 10.1257/aer.20120283

Hitte, Loran, and Prasanna Tambe, "Broadband Adoption and Content Consumption," *Information Economics and Policy* 74:6 (2007), 1637–1673.

Lambrecht, Anja, Katja Seim, and Bernd Skiera, "Does Uncertainty Matter? Consumer Behavior under Three-Part Tariffs," *Marketing Science* 26:5 (2007), 698–710. 10.1287/mksc.1070.0283

Lee, Robin, and Tim Wu, "Subsidizing Creativity through Network Design: Zero-Pricing and Net Neutrality," *Journal of Economics Perspectives* 23:3 (2009), 61–76. 10.1257/jep.23.3.61

Malone, Jacob, John Turner, and Jonathan Williams, "Do Three-Part Tariffs Improve Efficiency in Residential Broadband Networks?" *Telecommunications Policy* 38:11 (December 2014), 1035–1045. 10.1016/j.telpol.2014.06.004

Malone, Jacob, Aviv Nevo, and Jonathan Williams, "The Tragedy of the Last Mile: Congestion Externalities in Broadband Networks," NET Institute working paper (2020).

McManus, Brian, Aviv Nevo, Zachary Nolan, and Jonathan W. Williams, "The Steering Incentives of Gatekeepers in the Telecommunications Industry," National Bureau of Economic Research, Working Paper Series 30399 (2022). http://www.nber.org/papers/w30399.

Miravete, Eugenio, "Choosing the Wrong Calling Plan? Ignorance and Learning," *American Economic Review* 93:1 (2003), 297–310. 10.1257/000282803321455304

Moffett, Craig, and Michael Nathanson, "Q3 2016 Cord-Cutting Monitor: Dancing on the Edge of a Cliff?" MoffettNathanson Research technical report (2016).

Mussa, Michael, and Sherwin Rosen, "Monopoly and Product Quality," *Journal of Economic Theory* 18:2 (1978), 301–317. 10.1016/0022-0531(78)90085-6

Nevo, Aviv, John Turner, and Jonathan Williams, "Usage-Based Pricing and Demand for Residential Broadband," *Econometrica* 84:2 (2016), 411–443. 10.3982/ECTA11927

Prince, Jeffrey, and Shane Greenstein, "Measuring Consumer Preferences for Video Content Provision via Cord-Cutting Behavior," *Journal of Economics & Management Strategy* 26:2 (2017), 293–317.

Reggiani, Carlo, and Tommaso Valletti, "Net Neutrality and Innovation at the Core and at the Edge," *International Journal of Industrial Organization* 45:1 (2016), 16–27. 10.1016/j.ijindorg.2015.12.005

Rosston, Gregory, Scott Savage, and Bradley Wimmer, "Effect of Network Unbundling on Retail Price: Evidence from the Telecommunications Act of 1996," *Journal of Law and Economics* 56:2 (May 2013), 487–519. 10.1086/667995

Sidak, Gregory, "A Consumer-Welfare Approach to Network Neutrality Regulation of the Internet," *Journal of Competition Law & Economics* 2:3 (2006), 349–474.

Tudón, José, "Prioritization vs. Congestion on Platforms: Evidence from Amazon's Twitch.tv," *The RAND Journal of Economics* 53:2 (2022), 328–355. 10.1111/1756-2171.12409

Wu, Tim, "Network Neutrality, Broadband Discrimination," *Journal of Telecommunications and High Technology Law* 1:2 (2003), 141–178.