Video-Viewing Behavior in the Era of Connected Devices

Aniruddha BANERJEE
Centris Marketing Science, USA

James ALLEMAN
University of Colorado, USA

Paul RAPPOPORT
Temple University and SBRC, USA

Abstract: In the United States and elsewhere, traditional sources of television programming (or "pay TV") are facing rising competition from bypass or over-the-top ("OTT") alternatives in the form of streamed or downloaded access to video content. As a result, consumers of video content now fall into three segments: "cord loyalists" that continue to use pay TV exclusively, "non-pay TV" that includes consumers who have cut the video cord, i.e., dropped pay TV entirely in favor of OTT, and "cord couplers" that use both pay TV and OTT. Household demographics, use of connected OTT-capable devices, and availability of subscription-based and free streaming video services are hypothesized to influence how consumers choose to view video content. This paper reports on an empirical study of US households to answer two questions: (1) do households transition among the three OTT segments over time? and (2) what factors determine the household's decision to stay in, or move from, an OTT segment? Using a longitudinal survey panel of 7,655 unique households observed over three consecutive quarters in 2011 and relative risk ratios from multinomial choice models estimated using the data, the study confirms that connected devices (both their use and their variety) and certain key demographics (age, annual household income, and race/ethnicity) influence the household choice of OTT segment.

Key words: pay TV, OTT, cord loyalists, non-pay TV, cord couplers, transition among OTT segments, household demographics, connected devices, relative risk ratio.

In the United States and elsewhere, traditional sources of television programming (such as cable, satellite, or fiber-based telephone companies) face rising competition from bypass or "over-the-top" (OTT) alternatives that enable consumers to view TV programs in any place and at any time of their choosing. Most OTT bypass takes the

form of streaming or downloading (in both cases, video content is received over the Internet). Growing availability of high-speed broadband is frequently credited with increasing OTT access to video content; however, three other factors are, arguably, equally significant for OTT growth.

First, multi-functional or "connected" devices (such as computers, smartphones, tablets, game consoles, etc.) now enable streaming and downloading. These devices are all Internet-enabled and increasingly portable, and extend the video viewing experience well beyond live viewing and fixed locations. Most of them are alternative viewing screens as well, liberating the viewer from being tethered to a fixed TV set.

Second, demographics are important drivers of OTT behavior. As with voice cord-cutting, the biggest demographic drivers of video cord-cutting are younger consumers that live independently or in new households, as well as low-income consumers looking to avoid the high cost of subscribing to traditional packaged or multi-tiered television service. However, significant numbers of OTT users are actually co-consumers of both traditional television service and OTT. The demographic behind this is typically higher-income consumers who can afford multiple devices and multiple subscriptions. For them, the addition of OTT to traditional live television makes "TV anywhere and at any time" a reality.

Finally, sensing the rising importance of OTT, many paid or free streaming/downloading services, e.g., Netflix, Hulu, and YouTube, have emerged but others are gaining ground as well. All of them are important sources of movies, TV shows, news and weather, and sports, besides other programming (including original content). Realizing the threat these services pose, some traditional television service providers are now co-opting their competition by providing OTT access to their programs alongside their more traditional broadcasts, a strategy known as "TV Everywhere" (SPANGLER, 2012).

This paper reports findings from an investigation of some aspects of video-viewing behavior in the era of connected devices. In particular, we examine whether (and how) the three factors noted above influence household choices of traditional television or OTT for viewing video content.

■ Research plan

For this study, we used longitudinal survey data on household consumption of video content by various means. We began by identifying three mutually exclusive OTT segments, namely, "cord loyalists," "cord couplers," and "non-pay TV." For the three OTT segments, we separated households based on their use of traditional television sources and OTT (streaming or downloading activity) within the past month. Households that used subscription-based television or "pay TV" sources but had no OTT activity during that month were assigned to cord loyalists. Households that used both pay TV and OTT were assigned to cord couplers. Finally, households that relied solely on OTT-based viewing (either because they had replaced pay TV with OTT activity or had opted for OTT over pay TV at the time of household formation) were assigned to non-pay TV.

Next, we investigated two research questions regarding video-viewing behavior in the era of connected devices. First, do households transition among the three OTT segments over time, i.e., choose different ways to receive video content, and, if so, to what extent? Do households adding OTT to their viewing options also keep their pay TV service or drop it? Also, do households move back from OTT use to pure pay TV use?

Second, what determines the decision to stay in, or move from, an OTT segment? In other words, what features of the video consumption environment drive households into different OTT segments or, by the same token, cause those households to move among those segments? The environment in question is made up of household demographics, connected device ownership and usage, and the diffusion of OTT services for streaming and downloading. We investigated the stay/move choice in terms of these characteristics.

■ Data

US household data on both traditional television and OTT use were collected using a nationwide Centris survey, conducted from April 2011 to December 2011. We grouped the monthly data by calendar quarters, i.e., for 2Q11, 3Q11, and 4Q11, and then constructed a longitudinal panel from the data. Assignment to this panel was conditioned on a household having responded to the survey in at least two (not necessarily consecutive)

quarters. Table 1 summarizes household participation in this unbalanced longitudinal panel.

Table 1 - Participation pattern of unique households in US longitudinal panel on OTT Use, 2Q11-4Q11

Participation	*Unique households*	*Percent*	*Cumulative percent*
2Q11, 3Q11, 4Q11	4,241	55.4	55.4
2Q11, 3Q11	1,033	13.5	68.9
2Q11, 4Q11	933	12.2	81.1
3Q11, 4Q11	1,448	18.9	100.0
All	**7,655**	**100.0**	

Collectively, the 7,655 unique households produced 19,551 observations over the three quarters. The observations were almost uniformly distributed across the three quarters (6,207 in 2Q11, 6,722 in 3Q11, and 6,622 in 4Q11). [1]

We collected wide-ranging information for these households. The first set of data pertained to household ownership and use of devices that deliver video content and, in some instances, also double as viewing screens. The devices included the TV set, computer (desktop, laptop, or netbook), smartphone, tablet, game console, and connected media device (such as Apple TV or Roku). All except the last device are multifunctional, and the first four also serve as viewing screens.

The second set of data pertained to household viewing of streamed or downloaded video, using subscription or pay-per-use services (whether free or paid). Paid subscription services were separated into Netflix and all others (Hulu Plus, Blockbuster, iTunes, and Amazon), while free subscription services included Hulu and websites from which free streamed video is available.

The final set of data pertained to household demographics. Information was collected on the respondent's age, gender, and race/ethnicity, as well as on household size, annual household income, and presence of children in the age ranges 0-6, 7-11, and 12-17.

[1] The manner of construction of the longitudinal panel sets limits on the number of usable observations that can be obtained over a period of three or four quarters. Even with large surveys, household drop-out from consecutive months or quarters can be high enough to leave relatively few that appear repeatedly in the sample over time.

Although, for the most part, demographic information for households remained the same throughout the period of observation, information on device use and use of OTT services was expected to change over time and generally did. In particular, each household's OTT classification (whether cord coupler, cord loyalist, or non-pay TV) was tracked through all the quarters in which it appeared in the panel.

Except for household size (a count variable), we converted all other demographic variables into categorical variables as follows:

- age in four categories: 18-34, 35-39, 40-54, 55 and over [2];
- gender: male, female;
- annual household income: $0-$20,000, $20,000-$35,000, $35,000-$50,000, $50,000-$100,000, and $100,000 and over;
- race/ethnicity: White, African-American, Asian-American, Hispanic, and other;
- presence of children: age 0-6, age 7-11, and age 12-17.

Figure 1 shows the sample composition of the three major demographic variables, namely age, annual household income, and race/ethnicity.

The average age of survey respondents was almost 49, and the average annual income of responding households was approximately $59,400. Also, White households were 87% of the sample, a higher proportion than observed in the general population. Similarly, about 70% of survey respondents were female, also a higher proportion than that of females in the general population. [3]

Next, we created binary categorical variables for each device (for both ownership and use) and each streaming/downloading subscription service used (both paid and free). From the latter, we constructed three categorical variables: Netflix paid streaming, other paid streaming, and free streaming.

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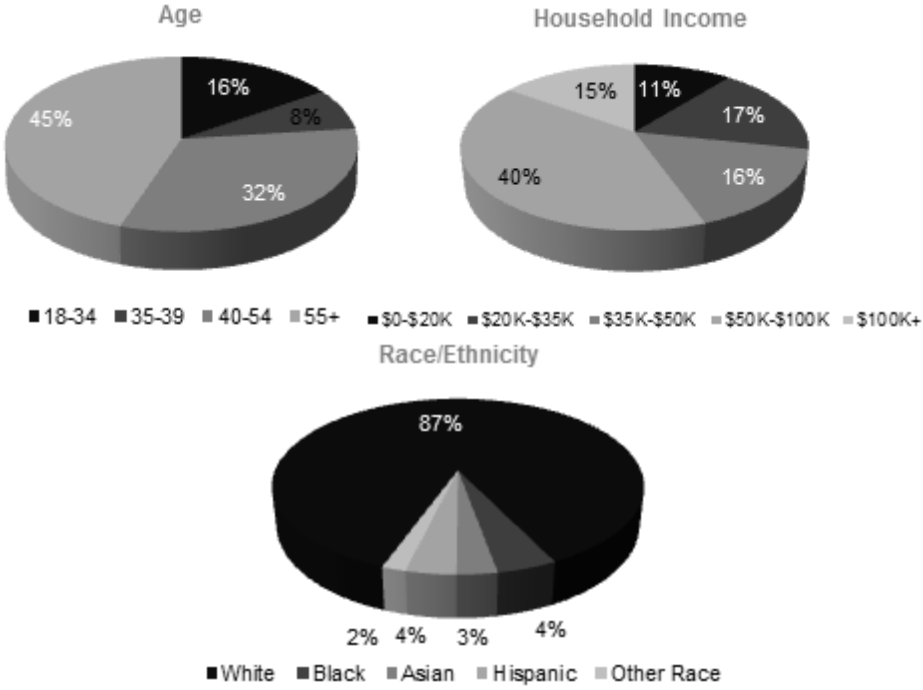
[2] The choice of these age intervals is based on how Pay TV (and, in particular, content) providers view television consumer segments in the US. Although the 35-39 years category represents a rather narrow age range, it is also considered pivotal and different from the other categories in the choices they make with respect to viewership of video content.

[3] Not too much should be made of these apparent differences between sample and population proportions. The paper reports demographics for households, rather than for individuals (for whom population demographic statistics are being used as benchmarks). Also, the drivers that lead to the selection of OTT segments by households with male or female respondents involve considerably more than purely gender or race/ethnicity. However, it is conceivable that patterns of transition among OTT segments estimated in the paper are somewhat affected by the sample (possibly) being disproportionately white or female.

Figure 1 - Sample distribution of three key demographic variables



Finally, for purposes of analysis, we set up information on device use in three different ways.

- Binary categorical variables were created for the use of the TV set (for linear viewing only), computer, smartphone, tablet, game console ("GC"), and connected media device ("CMD"). [4] Figure 2 shows the percentage of households that actually used (rather than merely owned) each of these devices to view video content during 2Q11-4Q11.

- Counts of the types of devices used, ranging from one to all six, were created for all households and converted into binary categorical variables. For example, the variable "One_device" was set to 1 if a household used only one type of device and 0 otherwise. Similarly, the variable "Six_devices" was set to 1 if a household used all six types of devices and 0 otherwise. Figure 3 shows the distribution of these device count categories in 2Q11-4Q11.

[4] CMDs (Apple TV, Roku, Boxee, etc.) provide direct access to video content over the Internet, without first connecting to computers for Internet access.

- Different combinations of devices used by households were represented by a binary categorical variable (1 if that combination was used, 0 otherwise) for each combination. With six types of devices, this resulted in 26-1 = 63 possible device combinations. Since the vast majority of these device combinations were used very sparingly by households, we retained only the ten most used such combinations for analysis. These combinations in 4Q11 are shown in table 2.

Figure 2 - Percentage of households that used selected devices to view video content, 2Q11-4Q11

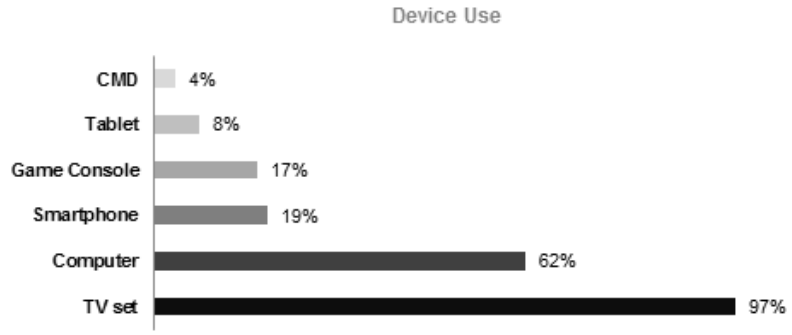


Figure 3 - Sample distribution of number of devices used for video content by households, 2Q11-4Q11

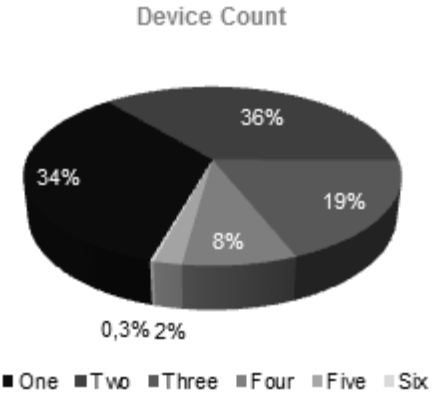


Table 2. Top ten device combinations used by households in 4Q11

Device combination	*Rank*
TV only	1
TV, computer	2
TV, computer, game console	3
TV, computer, smartphone	4
TV, computer, smartphone, game console	5
TV, computer, smartphone, tablet, game Console	6
TV, Computer, Tablet	7
TV, Computer, Smartphone, Tablet	8
TV, Computer, Tablet, Game Console	9
TV, Computer, Smartphone, Tablet, Game Console, CMD	10

■ Modeling and estimation

We relied on standard econometric techniques to answer the two questions. For the first question, we estimated one-period transition probabilities between alternative states. This was a straightforward calculation of the percentage of households that either remained in its original OTT segment or moved to a different OTT segment.

For the second question, we estimated the relationship between the dependent variable (stay/move choice) and independent variables representing demographic, device-related, and streaming-related drivers. For this, we used a regression framework that is general enough to accommodate not only different types of dependent variables but also alternative structures of dependence in intra-household responses over time. The dependent variable for the second question was a multinomial choice variable (a categorical variable with three or more nominal categories).

The generalized linear model (GLM) introduced four decades ago (Nelder and Wedderburn, 1972) greatly expanded the range of linear regression models that can be estimated from a common framework. The GLM is typically specified as

$$g\{E(y)\}=X\beta, \qquad y\sim F$$

where $g(.)$ is a "link function" for the mean response $E(y)$, $X\beta$ is a linear predictor using covariates X and is often called the "systematic component," and F is a "distributional family" for the associated error term and, hence, for

the dependent variable *y*. Depending on choices made for the link function and the distributional family, the GLM can generate a large number of familiar regression models. [5]

The GLM has been further extended into a class of models that is appropriate for grouped or clustered data with built-in correlation within the group or cluster. The generalized linear mixed model (GLMM) permits both fixed and random effects for the systematic component and is thus able to accommodate different dependence structures within clusters or groups for which there are repeated measurements, such as in longitudinal panels (McCULLOCH & SEARLE, 2001; FITZMAURICE *et al*., 2004, Ch. 11). By using random intercepts and random slope coefficients, the GLMM can be used to model multilevel or hierarchical data in which grouping occurs at successively higher levels. In the present case, there are two levels of data: households at the upper level and the quarters (time units) in which they participated in the survey at the lower level. Because household responses are likely to be correlated over time, the GLMM is well suited to account for the type of dependence most likely to prevail in those responses over time.

As with the GLM, the GLMM can accommodate models with different types of dependent variables (depending on the choice of the distributional family *F*). For the second research question, we chose the GLMM method because it can handle multinomial choice models for longitudinal panels, with F as Bernoulli and the link function as multinomial logit or probit. This method is well suited for this because the three OTT segments can be viewed as alternative "choices" that households make. Although estimation software is widely available for dichotomous choice models with multilevel data, there are fewer options for multinomial choice. One notable example is gllamm, a user-written procedure for Stata software, which we used with suitable choices of *F* and the link function. [6]

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[5] For example, if *F* is Gaussian and *g*(.) is the identity function (i.e., *g*{E(*y*)} = E(*y*)), then the GLM reduces to the standard linear regression model with normally distributed errors. Alternatively, if *F* is Bernoulli and *g*(.) is the log-odds or logit function(i.e., *g*{E(*y*)}=log $(\frac{E(y)}{1-E(y)})$), then the GLM reduces to the standard logistic regression model. Several other types of regression models can be derived from the GLM in this way. See FITZMAURICE *et al*. (2004, Ch. 10).

[6] See a full description of this procedure in RABE-HESKETH *et al*. (2002). Stata®/MP for Windows 12.1 - the statistical software used for all model estimation in this paper - is a product of StataCorp LP of College Station, TX, USA.

■ Analysis

OTT segment profiles

To investigate the two research questions, we constructed some OTT profiles to provide context for the analysis. The first set of profiles in table 3 shows the distribution of households among the three OTT segments over the three quarters in 2011.

Table 3 - Distribution of households by OTT segment, 2Q11-4Q11

OTT segment	*Number of households*	*Percent*	*Cumulative percent*
Cord loyalists	10,329	52.83	52.83
Non-pay TV	1,572	8.04	60.87
Cord couplers	7,650	39.13	100.00
All	**19,551**	**100.00**	

Clearly, OTT-only households - the non-pay TV households - were a relatively small fraction of all households in 2011. However, the size of that segment alone greatly understates the size of overall OTT activity. Since cord couplers also used OTT, the true extent of OTT use among US households was actually close to half of those households.

Second, we computed the sample distributions of age, annual household income, and race/ethnicity by OTT segment. These are shown in table 4.

Next, we computed composite profiles of households that had the highest, median, and lowest probabilities of belonging to any of the three OTT segments. These are shown in table 5. [7] The composite profiles have the important virtue of depicting OTT segment choices as functions simultaneously of a number of household characteristics, rather than of those characteristics one at a time. The household profile with the median probability can be thought of as reflecting the "typical" household in any given OTT segment, with the caveat that because table 5 is constructed

[7] These probabilities were computed by estimating binary choice (logit) models for each OTT segment using various demographic variables (including the four that appear in table 5) and the number of devices used for video content. The estimated models were then used to simulate each household's probability of belonging to each OTT segment. The profiles were constructed from only the variables shown in table 5, while holding all other household characteristics fixed.

from a sorting of simulated probabilities, the profile with the highest, median, or lowest probability need not represent a significant number of households.

Table 4 - Distribution of key demographic variables by OTT segment, 2Q11-4Q11

Demographic variable	*Cord loyalists*	*Non-pay TV*	*Cord couplers*	*All segments*
Age 18-34	7.8%	26.8%	23.6%	15.5%
Age 35-39	5.5%	10.2%	9.8%	7.6%
Age 40-54	30.1%	34.5%	34.7%	32.2%
Age 55 and over	56.6%	28.4%	32.0%	44.7%
Average age	**52**	**44**	**45**	**49**
Income $0-$20K	12.0%	20.2%	7.5%	10.9%
Income $20K-$35K	18.8%	21.9%	14.7%	17.4%
Income $35K-$50K	17.1%	16.2%	14.8%	16.1%
Income $50K-$100K	39.3%	32.5%	43.4%	40.4%
Average income	**$55,926**	**$48,522**	**$63,150**	**$59,418**
White	90.3%	81.3%	84.2%	87.2%
African-American	4.0%	4.6%	5.0%	4.4%
Asian-American	1.4%	6.8%	4.2%	2.9%
Hispanic	2.8%	4.8%	4.7%	3.7%
Other race	1.5%	2.5%	2.0%	1.8%

Table 5 - OTT segment profiles by key demographic variables and number of devices used for video, 2Q11-4Q11

OTT segment	*Probability status*	*Composite profile*
Cord loyalists	Highest	Female, age 55+, income $35K-$50K, African-American, one device
	Median	Male, age 35-39, income $100K+, Hispanic, three devices
	Lowest	Male, age 18-34, $0-$20K, Asian-American, five/six devices
Non-pay TV	Highest	Male, age 18-34, $0-$20K, Asian-American, two devices
	Median	Female, age 35-39, income $50K-$100K, Hispanic, five devices
	Lowest	Female, age 55+, income $100K+, African-American, six devices
Cord couplers	Highest	Male, age 18-34, income $100K+, White, six devices
	Median	Female, age 40-54, income $50K-$100K, Asian-American, four devices
	Lowest	Female, age 55+, $0-$20K, African-American, one device

Finally, since probabilities were computed for each household of choosing all three segments (even though a household could actually choose only one at any given time), it was still possible for a household to have the highest probability of choosing one OTT segment and, at the same

time, have an even higher probability of choosing another segment. Thus, despite having the highest probability of choosing one segment, that household could end up choosing a different segment. To eliminate all such "dominated" choices, we computed composite profiles only for "non-dominated" choices. That yielded the three profiles shown in table 6. The first row, for example, shows the profile of a household that had the highest probability of being a cord loyalist while, at the same time, having a lower probability of choosing either the cord couplers or non-pay TV segment.

Table 6 - OTT segment profiles for dominant (chosen) segments, 2Q11-4Q11

OTT segment chosen	*OTT segments dominated*	*Composite profile*
Cord loyalists	Cord couplers, non-pay TV	Female, age 55+, income $35K-$50K, African-American, one device
Non-pay TV	Cord couplers, cord loyalists	Female, age 18-34, $0-$20K, Asian-American, two devices
Cord couplers	Cord loyalists, non-pay TV	Male, age 18-34, income $100K+, White, six devices

OTT transition patterns: implications for video cord-cutting

The first research question concerned whether households alter or maintain their ways of viewing video over time. For this, being able to track individual households within a longitudinal panel was particularly useful. One obvious way was to estimate transition probabilities between pairs of the three major OTT segments, namely, cord couplers, non-pay TV, and cord loyalists. That is, we estimated Pr $\left(Y_{i,t}\middle|Y_{j,t-1}\right)$,*i,j=1,2,3*, where *Y* is the OTT segment state variable, *i* and *j* each represent the three segments, and Y_i or Y_j equals 1 if a household is in OTT segment *i* or *j*, and 0 otherwise. These transitions were measured over three quarters and accounted for all forms of two-quarter transitions (as well as the three-quarter transition for households that appeared in the panel in all three quarters).

How fixed are households in their OTT status? For this, the transition probabilities shown in table 7 reveal that while movement *into* the pure OTT-only non-pay TV segment was still relatively a trickle in 2011, there was a comparatively more impressive movement from the pure non-OTT cord loyalists to the hybrid status represented by cord couplers.

Approximately three-quarters of households in each OTT segment stayed in place between 2Q11 and 4Q11. Of the households that did move out of their OTT segments, it is interesting that movement into the non-pay TV

segment was relatively minor. Table 7 shows that households moving out of the cord couplers segment were seven times more likely to drop OTT (i.e., become cord loyalists) than to become OTT-only (i.e., non-pay TV). Similarly, households that moved out of the cord loyalists segment were nearly four times more likely to combine OTT with pay TV (i.e., become cord couplers) than to become OTT-only (i.e., non-pay TV). This suggests that the last three quarters of 2011 marked a period of experimentation among nearly a quarter of US households, some trying out OTT without canceling pay TV and an almost similarly sized cohort abandoning OTT to return to pay TV status.

Table 7 - Probabilities of transition among OTT segments, 2Q11-4Q11

OTT segment	*Cord couplers*	*Non-pay TV*	*Cord loyalists*
Cord couplers	75%	3%	22%
Non-pay TV	17%	71%	12%
Cord loyalists	18%	5%	77%
Total	39%	9%	52%

In contrast, the impetus to cut the video cord remained muted during this period. Only about 9% of US households were in the non-pay TV segment, of which roughly half were true "cord-cutters." Moreover, about 2.6% of households left the non-pay TV segment for the other two segments, which mostly offset the 3.8% of households which went in the opposite direction. The evidence in tables 3 and 7 suggests a relatively small and almost dormant non-pay TV movement even as OTT penetration among US households reached impressive levels. That is, greater OTT use did not automatically translate into video cord-cutting.

Drivers of the choice to stay within or move from an OTT segment

Households in any time period were assumed to have three choices for the next time period: (1) stay in their current OTT segment, (2) move to the first alternate OTT segment, or (3) move to the second alternate OTT segment. For households that responded to the survey over the three-quarter period between 2Q11 and 4Q11, 27 choices were possible, whereas households that responded in only two of the three quarters selected from among nine possible choices. As table 1 shows, roughly 55% of households in the longitudinal panel had the 27 choices available to them, while the remaining 45% had nine choices available.

With three possible categories of choice (i.e., the three OTT segments) and an unbalanced panel, a multinomial panel data choice model was set up to investigate the drivers of the stay/move choice. Independent variables included household demographics expressed as categorical variables (as described above) and various configurations of the variables for the use of devices and of streaming/ downloading services.

The GLMM procedure for multinomial choice (with multinomial logit as the link function) was used to estimate four alternative model specifications, which differed only in the manner of device use and streaming/downloading-related variables were specified. We did so for two reasons. First, the three variables representing streaming/downloading were collinear with device-related variables, particularly those used specifically for streaming and downloading. Therefore, the device-related and streaming/downloading variables could not be all loaded into the same regression model. Second, as shown later, models estimated with different configurations of the device-related variables yielded alternative insights about the stay/move choice that were simply not apparent from any single model.

To interpret the findings from the estimated GLMM multinomial logit models, we relied on the relative risk ratio ("RRR"). The RRR is constructed as follows.

Consider a multinomial choice model in which the dependent discrete (nominal) variable y can have one of three outcomes 1, 2, and 3. Suppose outcome 1 is the "base category," i.e., probabilities of outcomes 2 and 3 for any given state variable (or covariate) are measured relative to it. Suppose *X* is a categorical state variable or covariate that can take on either 0 or 1 as values. Then, the "relative risks" for outcome 2 (relative to outcome 1) for each state of *X* are defined as

$$RR1 = \frac{\Pr(y = 2|X = 0)}{\Pr(y = 1|X = 0)} \quad \text{and} \quad RR2 = \frac{\Pr(y = 2|X = 1)}{\Pr(y = 1|X = 1)}$$

where, in a multinomial logit environment specifically,

$$\Pr(y = 2|X = 0) = \frac{e^{\beta_{20}}}{1 + e^{\beta_{20}} + e^{\beta_{30}}}$$

$$\Pr(y = 1|X = 0) = \frac{1}{1 + e^{\beta_{20}} + e^{\beta_{30}}}$$

$$\Pr(y = 2|X = 1) = \frac{e^{\beta_{20}+\beta_{21}}}{1 + e^{\beta_{20}+\beta_{21}} + e^{\beta_{30}+\beta_{31}}}$$

$$\Pr(y = 1|X = 1) = \frac{1}{1 + e^{\beta_{20}+\beta_{21}} + e^{\beta_{30}+\beta_{31}}}$$

β_{20} and β_{30} are fixed intercepts in the regressions for outcomes 2 and 3, respectively, and β_{21} and β_{31} are the coefficients of *X* when at value 1 for outcomes 2 and 3, respectively. The relative risks for outcome 3 (relative to outcome 1) for both values of *X* can be defined analogously.

The RRR for outcomes 2 and 1 for the values *X* can take is then the ratio of *RR2* and *RR1*. [8] Being a ratio of probabilities, the RRR is always non-negative. More importantly, it expresses the degree to which the odds of outcome 2 are higher or lower than those of outcome 1 when the covariate *X* switches from its default value of 0 to 1. Those odds are higher, equal, or lower as RRR is greater than 1, equal to 1, or less than 1.

To illustrate the RRR concept, consider three outcomes: 1=cord couplers, 2=non-pay TV, and 3=cord loyalists. Assume X is a binary variable for gender, 0 if male (default case) and 1 if female. Suppose cord couplers represent the base category. Then, if the RRR for non-pay TV relative to cord couplers, given the gender variable, is, say, 1.27, that implies that females are 27% more likely than males to be in the non-pay TV segment relative to the cord couplers segment (and the odds are correspondingly lower for males than for females).

In general, comparing choice *A* to choice *B*, if the RRR exceeds one then *A* is more likely to be the chosen than *B*. Moreover, as the margin by which the RRR exceeds one increases, so does the likelihood of *A* being chosen over *B*. If, instead, that RRR is less than one, then *B* is more likely to be chosen over *A*, and the closer the RRR gets to zero, the greater is the likelihood of *B* being chosen over *A*. When the RRR is at or hovers near one, the odds of either choice are about even. The RRR also has the reciprocal property, i.e., an RRR greater than one in a comparison of *A* to *B* is equivalent to an RRR less than one in the reverse comparison of *B* to *A*. Thus, an RRR conveys both the direction and the magnitude of the relative likelihood of one outcome over another.

We estimated RRRs between pairs of OTT segments for the independent variables using each of our four model specifications.[9] There were three

[8] With dichotomous choice, the RRR reduces to the more familiar concept of the odds ratio.

[9] To conserve space, we do not report details regarding the RRRs in this paper. They are available from the lead author upon request.

OTT segment transitions: cord couplers to non-pay TV, cord couplers to cord loyalists, and cord loyalists to non-pay TV. The four models for each OTT segment transition had different sets of independent variables. In the cord couplers to non-pay TV transition, model 1 had household demographics and streaming-related variables, model 2 had demographics and device use variables, model 3 had demographics and device count variables, and model 4 had demographics and device combinations. In the other two OTT segment transitions, models 2-4 were specified similarly, but model 1 had no streaming-related variables because cord loyalists have no streaming activity.

All estimated RRRs were statistically significant at the 5% level, except those for "Six Devices" in all three OTT segment transitions and for the (TV,computer,smartphone,tablet,game console,CMD) combination in the first and third OTT segment transitions, which were statistically significant at the 10% level. The RRR for the (TV,computer,smartphone,tablet,game console,CMD) combination in the second OTT segment transition was not statistically significant.

Estimates of RRR for the demographic variables were, for the most part, robust across the four models. This helped to focus attention on the device-related and streaming-related variables that entered the four model specifications in different ways. Models 2-4 all concerned devices used for viewing TV/video programs, but variables representing that use were constituted differently. For example, in model 2, the focus was on whether households used any of the six specific devices, regardless of whether they used any other. The stay/move choice among OTT segments could then be understood in terms of the use of each type of device. In model 3, the focus was on how many devices households use to view TV and video programs. In that model, the identity of the device was not important, rather it was the count of devices used (signifying how technologically equipped the households were). Finally, in model 4, only specific combinations of devices households use mattered. From prior analysis, we identified the top ten most used device combinations and introduced them into model 4 for measuring their impacts on the stay/move choice among OTT segments.

The estimated RRRs offer considerable information about the risks and the most likely directions of transition between OTT segments. However, the concise summary presented by table 8 is useful for comparing how the independent variables shape the risks of the three types of transition shown (and, by extension, the three reverse transitions).

Table 8 - Risks of transition (or reverse transition) between OTT segments

	Transition between OTT segments		
Independent variable	*Cord couplers to non-pay TV*	*Cord couplers to cord loyalists*	*Cord loyalists to non-pay TV*
Age	18-34 group has highest risk of transiting; risk diminishes with age	18-34 group has lowest risk of transiting; risk rises with age up to 55 but remains low	Young households up to age 39 have highest risk of transiting
Household income	Lowest income households (up to $35K) have highest risk of transiting; risk falls with income and reverse transition becomes more likely after $50K	Model 1 shows lowest income households have almost neutral to slightly positive risk of transiting, but models 2-4 show that risk of transiting is low and diminishes with income (risk of reverse transition rises with income)	Lowest income households (up to $35K) have highest risk of transiting; risk falls with income and reverse transition becomes more likely after $50K
Household size	Risk of reverse transition rises with household size	Neutral for risk of transition	Risk of reverse transition rises with household size
Race/ethnicity	Asian-Americans have highest risk of transiting; Whites and African-Americans have a greater risk of reverse transition; Hispanics have neutral risk	Whites, African-Americans, and Hispanics have moderate to high risk of transiting; Asian-Americans are at risk of the reverse transition	Asian-Americans have highest risk of transiting; Whites, African-Americans, and Hispanics have high risk of reverse transition
Presence of children	Risk of transiting exists for households with children 7-11 (not clear why)	Neutral for risk of transition	Risk of transiting exists for households with children 7-11, but risk of reverse transition exists for households with children 12-17
Streaming/ Downloading	Risk of reverse transition associated with free streaming; Netflix and other paid streaming have neutral risk	Not applicable	Not applicable
Device use	Only CMD is associated with high risk of transiting; other devices make reverse transition more likely	All streaming-capable devices create significant risk of the reverse transition	Some streaming-capable devices (not smartphone) raises the risk of transiting; the TV set by itself causes risk of reverse transition
Device count	Risk of reverse transition increases with device count (greater affordability?)	Risk of reverse transition rises with device count (i.e., as more streaming-capable devices are used)	Risk of transition increases with device count (greater affordability?)
Device combination	No risk of transiting with device combinations considered; risk of reverse transition rises monotonically with size of device combination	Households only using TV set are at high risk of transiting; device combinations with streaming-capable devices create high risk of reverse transition	Device combinations that include the CMD create the highest risk of transiting

The transitions from the cord couplers and cord loyalists segments to non-pay TV status show several similarities, which is as expected because the same demographic composite (younger, lower-income, small households, Asian-American) equipped with a variety of streaming-capable devices is most likely to feature among non-pay TV households. Also, as

expected, drivers of the risk of transiting from cord couplers to cord loyalists have almost exactly the opposite profile. [10]

Based on table 8, we focus next in some detail on how streaming and device-related variables affect households' stay/move choice with respect to OTT segments.

Transition from cord couplers to non-pay TV

Streaming and downloading

The effect of streaming/downloading services on the stay/move decision is inconclusive. With an RRR of 0.99, Netflix paid streaming appears to have a neutral effect on that decision. That is not surprising since a significant fraction of Netflix's almost 25 million subscribers in 2011 must already have been in the cord couplers segment. In fact, approximately a third of both cord couplers and non-pay TV households in the longitudinal panel were Netflix subscribers. With 17% of cord couplers already subscribing to other paid streaming, as opposed to fewer than 13% of non-pay TV households, there is no evidence of a major push to move to non-

[10] Following a referee's suggestion, we investigated alternative specifications of the models for the three OTT segment transitions by considering interactions among various demographic variables as independent variables in place of simply the individual variables (main effects) by themselves. The intuition behind this approach was the possibility that the effects of separate variables like age, household income, and race/ethnicity on transitions among OTT segments did not arise independently but rather, because of correlations among those variables. For example, the finding that transition from cord loyalists to non-pay TV was most pronounced among younger, low-income, Asian-American households could simply be reflecting the fact that, in the sample, Asian-Americans were also among the youngest respondents or that household incomes tended to be lower for younger households and higher for older households. To test this possibility, we first calculated tetrachoric correlations among the categories of the three key demographic variables and the device use and device count variables. Those calculations revealed that correlations were actually quite low except for some categories within age/race, device use/age, and device count/age pairs. We then replaced the main effects for age with interactions among categories for age and race/ethnicity, age and device use, and age and device count, and re-estimated the various models for the three OTT segment transitions. Unlike the case for the main effects, only a fraction of the RRRs for the interaction effects were found to be statistically significant. Moreover, the interactions that did have statistically significant RRRs merely confirmed (and, more importantly, did not contradict) the pattern of findings reported for models with only the main effects. For example, as expected, interactions among Asian-American households and age categories 18-34, 35-39, and 40-54 revealed the same pattern of risks of transition that was inferred from the original RRRs for main effects. Accordingly, the findings in, and inferences from, models with only the main effects were confirmed. To conserve space, we do not report in this paper the correlations among various variable pairs or the models with interaction effects replacing main effects, but they may be requested from the lead author.

pay TV status because of other paid streaming alone. That impetus is even less for free streaming, given an RRR of 0.68 and that 72% of cord couplers already avail of free streaming as opposed to 63% of non-pay TV households. If anything, free streaming may actually bring some households back from non-pay TV to cord couplers because adding streaming to existing pay TV service has no incremental cost (apart from the cost of streaming-capable devices, many of which may already be owned or available for other, non-video viewing purposes).

Device use

Can the use of specific devices actually trigger migration from cord couplers to non-pay TV? As noted earlier, every device apart from the non-Internet enabled TV set is capable of streaming and downloading, and some among them also serve as screens for viewing video. However, except for CMDs, all other types of devices are multifunctional and viewing videos may not be the primary reason why they are purchased (although, once purchased, there is no incremental cost of using them to view TV/video programs). Hence, it is no surprise that, except for CMDs, the RRR of moving from cord couplers to non-pay TV is well below one for the major multifunctional devices/screens, such as the computer, the smartphone, and the tablet. The RRR of zero found for the TV set is expected because, by definition, possession and use of a TV set amounts to use of pay TV service and an end to non-pay TV status. [11]

More complex are the RRRs for the game console and the CMD, which merely facilitate streaming but do not provide viewing screens. An RRR of 1.39 for the CMD suggests a significant propensity for users of that device to migrate to non-pay TV status, using that device to meet all their streamed video viewing needs. CMDs have the sole function of providing direct access to video content from various streaming sources. Therefore, it would appear that their greatest appeal is for households that rely solely on streamed video content rather than pay TV, i.e., the non-pay TV households.

Unlike the CMD, however, a game console is neither dedicated solely to accessing online video content nor a provider of access to a wide variety of such content. Even though it is a facilitator of such access, particularly for

[11] Of course, it is possible for a non-pay TV household to acquire a TV set to use purely as a screen for viewing streamed/downloaded video or, if the TV set is Internet-enabled, to stream video directly to it. However, with an estimated RRR of zero, it appears that those were not serious possibilities in the longitudinal panel used for this study.

movies and TV shows, its primary use for most households is likely to remain the playing of video games. An RRR of 0.66 confirms that, in and of itself, the game console is unlikely to be a major factor in driving any migration from cord couplers to non-pay TV.

Device count

Possession and use of multiple devices appear to provide more impetus to move from non-pay TV status to cord couplers than the other way around. In fact, that impetus increases (the RRR falls for the cord couplers to non-pay TV move, and rises for any move in the opposite direction) as more devices are used to view TV and video programs. This may be a finding more about affordability than about streaming behavior. Possession of the different types of devices is more likely to be driven by higher household incomes than by their inherent utility for streaming or downloading. As table 4 shows, cord couplers are generally more affluent than non-pay TV households and may, therefore, use a wider variety of devices to meet their streaming needs.

Device combination

The most noteworthy finding is that the RRR is well below one for all device combinations considered (suggesting a greater risk of moving back from non-pay TV to cord couplers than of moving in the opposite direction). Second, the highest RRR (0.52) is for households that only use the TV set and lowest (0.07) is for households that use all six devices. The RRR declines almost monotonically as the device combinations (whatever their makeup) grow larger – reflecting our findings for device counts. This suggests that the risk of households leaving the cord couplers segment for the non-pay TV segment declines as they invest in a wider variety of devices. Both tables 5 and 6 also indicate that households with the highest probability of being cord couplers use the six-device combination.

Transition from cord couplers to cord loyalists

Device use

With RRRs below one for all devices used (and at or close to zero with TV set use and computer use), there is little risk of households leaving cord couplers for cord loyalists. The obverse of this finding is more interesting. The use of streaming-capable devices, particularly the computer and the

game console, creates a significant risk of moving from cord loyalists to cord couplers.

Device count

Very low RRRs, particularly as the variety of devices used grows, signify an almost inconsequential risk of leaving cord couplers for cord loyalists. This is expected because a household using two or more types of devices to view TV/video programs must be using at least one, and possibly more, streaming-capable devices. Its willingness to acquire and use more streaming-capable devices would be inconsistent with staying solely with pay TV service as cord loyalists.

Device combination

The RRRs for device combinations tell a similar story. Households that only use the TV set are at significant risk of leaving cord couplers (if they were ever in that segment) to become cord loyalists. The opposite is true for households that use device combinations, which include streaming-capable devices, and truer still as the number of devices in their combinations increases.

Transition from cord loyalists to non-pay TV

Device use

Certain streaming-capable devices, such as the computer, tablet, game console, and CMD make cord loyalists more likely to switch to non-pay TV status. Use of the smartphone, however, does not appear to make households move much in either direction. That is probably because, in 2011, smartphone use to view video content was still an occasional activity and not sufficient reason to switch off pay TV service altogether.

Device count

Possession and use of a wider variety of streaming-capable devices significantly raise the risk of moving from cord loyalists to non-pay TV status. That risk is particularly high for households that have at least five types of devices (of which four may be streaming-capable).

Device combination

For some specific device combinations, the risks of leaving cord loyalists for non-pay TV are better than even or higher. All of these combinations have the game console in common. Arguably, the game console, which can be used to stream video content from several sources, is a major triggering device for any decision to leave for non-pay TV.

■ Conclusions

The paper's two research questions investigated whether households migrate among different OTT segments over time and which factors (related to household demographics, streaming activity, use of connected devices, variety of devices, and device combinations) are most associated with households' migration decisions. Longitudinal panel data on US households for the period spanning 2Q11 to 4Q11 were used to investigate these questions. The relative risk ratio was found to be an appropriate and useful way to assess whether (and how strongly) any given factor could be responsible for driving household migration from one OTT segment to another (or even in the reverse direction). Relative risk ratios were estimated from econometric models suitable for unbalanced longitudinal panel data with correlation in intra-household responses over time.

Not surprisingly, the factors found to matter most for driving migration among OTT segments varied by the nature of the migration itself. For example, migration from non-pay TV status to cord couplers represents a form of "upsizing" (since pure OTT access to video content is augmented by the use of pay TV), while migration in the opposite direction is a form of "downsizing" (as pay TV is dropped). The impact of connected device use on these migrations is asymmetric. The use of devices and a greater variety of devices are more likely to drive the migration from non-pay TV to cord couplers than the other way around. Rather, any impetus to move from cord couplers to non-pay TV appears to come more from demographic cohorts, such as relatively young, less affluent, or Asian-American households.

Devices appear to play an important role in any migration from cord loyalists and cord couplers, but have no role whatsoever in any migration in the reverse direction. Possession and use of streaming-capable devices make it more likely that cord couplers stay in their segment, rather than move to cord loyalists. In contrast, if any migration occurs at all from cord

couplers to cord loyalists, it is likely to be most associated with older households and least associated with Asian-American households (particularly relative to White or Hispanic households).

Given the clear either/or divide between cord loyalists and non-pay TV, the use of a wider variety of devices (especially the computer or CMD) by some key demographic cohorts (younger, lower-income, and Asian-American households) appears to most favor any move from cord loyalists to non-pay TV, while the remaining factors appear to have little effect.

The salient overriding conclusions from this study are as follows.

- Longitudinal household studies are important for understanding whether, and why, consumers of video content migrate among different OTT segments.

- Household characteristics (including demographics, streaming activity, and device use and variety) determine how households choose among OTT segments, but the influence exerted by individual characteristics varies by the OTT segment chosen.

- The key demographic characteristics to watch are age, annual household income, and race/ethnicity (whether individually as main effects or in the form of interactions among them). Generally, younger, lower-income, Asian-American households are most associated with non-pay TV, while more affluent households that can afford both pay TV and multiple streaming-capable devices are most associated with cord couplers. In contrast, cord loyalists tend to be mainly older, White, and device-poor households.

- The ownership and use of connected devices (besides the TV set) is a complex issue. Except for the CMD, all other such devices considered in this study are multi-functional and most also provide viewing screens. Thus, regardless of the original purposes for which those devices are purchased, they may all be used for streamed access to video content. While they all extend video-viewing options for consumers, there is no single device that can be held responsible for any shift to OTT video access (either alongside or in place of pay TV). Lifestyle and other demographic factors also play a role in determining which device(s) households actually use for OTT video access. The lone exception is the CMD, the sole purpose of which is to stream video content, but it is also the least used among all devices.

- While there may be no standout connected device responsible for OTT behavior, the number or variety of devices used clearly matters. In general, cord couplers rely on a wider variety of streaming-capable devices,

while non-pay TV households make do with fewer. However, because the cord couplers segment is so large (over 39% of households in 2011), actual OTT (and device) use is actually quite widespread even though pure video cord-cutting is confined to the much smaller non-pay TV segment (8% in 2011).

- Although a variety of streaming/downloading services (subscription-based or free) have emerged to meet OTT demand, their impact on decisions to migrate between the cord couplers and non-pay TV segments (both of which have OTT use) is inconclusive. That is probably because households in both segments make use of the popular paid and free streaming services, leaving little incentive for households in one segment to move to the other purely to obtain streamed video content.

This study was based on data from 2011. There are emerging anecdotal indications that the diffusion of OTT and device use for video content has been rapid since then. While it is unclear whether the pure video cord-cutting phenomenon has grown significantly since then, OTT use has expanded. This suggests a television and video environment of the future in which most households use both traditional pay TV and streamed video to meet their needs, particularly as both modes of viewing also enhance their options for both live and time-shifted viewing and, as well, for viewing both in fixed locations and while mobile.

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