

News Media Channels: Complements or Substitutes? Evidence from Mobile Phone Usage

The media industry has undergone a fundamental shift over the past decade as new online distribution channels have proliferated in an unprecedented manner. Although mobile devices have experienced rapid adoption among consumers, their effect on consumer behavior and their subsequent implications for publishers and advertisers have yet to be understood. The authors examine consumers' news consumption behavior on mobile news websites in response to the introduction of a mobile news app. Pseudo-panel analysis based on repeated cross-sectional data suggests that the introduction of a mobile app by a major national media company leads to a significant increase in demand at the corresponding mobile news website. In addition, the authors report that this effect is greater for consumers with (1) greater appreciation for concentrated news content, (2) stronger propensity for a particular political viewpoint, and (3) fewer time constraints. The results are consistent with the interpretation that the adoption of a provider's news app stimulates corresponding mobile news website visits. The authors discuss the implications of these findings for advertisers, media publishers, and policy makers.

Keywords: online media consumption, mobile news app, mobile news website, complementarity, pseudo-panel analysis

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The increasing digitization of news is fundamentally reshaping the news industry: U.S. newspaper advertising revenues fell 47% from 2005 to 2009 (Athey, Calvano, and Gans 2013; Waldman and the Working Group on Information Needs of Communities 2011) as online advertising spending climbed to more than \$100 billion in 2012 (eMarketer 2013).¹ The changing news channel envi-

¹Other theories have also been used to explain the decline in advertising. For example, one theme has highlighted an increase in the supply of advertising space (e.g., Rice 2010). Some authors have also argued that online ads are less effective, although this view is inconsistent with some recent evidence (e.g., Goldfarb and Tucker 2011a).

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ronment has raised a classic problem for marketers: how to appropriately target and reach consumers in a multichannel environment. This problem has been intensified by the proliferation of new digital media outlets, which has increased the number of consumers who meet their news needs through multiple outlets, or "multihome" (Gentzkow and Shapiro 2011; Varian 2010). As a result, although new online digital tracking technologies such as web bugs and cookies have made it possible for advertisers to track online consumers (e.g., Goldfarb and Tucker 2011b), they must still place ads on multiple online properties to ensure impressions, potentially reaching the same consumer multiple times (Athey, Calvano, and Gans 2013).

With the emergence of a potentially disruptive channel, it is imperative for marketers to monitor changes in consumer behavior and to understand such changes' implications for marketing strategy (Ahonen 2011). Advertisers, for example, may need to adjust their cross-channel advertising strategies so that they can reach their target audience effectively and efficiently. To that end, they must begin by understanding the most basic and critical question: whether a new media channel complements or substitutes for existing channels. We follow prior literature in economics in stating that two products or services are complements when the utility of consuming them together is greater than the combined utilities of consuming them separately; similarly, two products are substitutes when the utility of consuming them together is less than the combined utilities of consuming them separately (e.g., Gentzkow 2007). If there is substitution or switching across new and existing media channels (e.g., Deleersnyder et al. 2002; Gentzkow 2007; Geyskens, Gielens,

and Dekimpe 2002), it may be more difficult for advertisers to reach their target audience because it would be more dispersed across channels. However, if a new media channel complements an existing channel (e.g., Chiou and Tucker 2011; Smith and Telang 2009), advertisers that are active on both channels will face the possibility of wasted impressions.

In this article, we empirically investigate consumer response to the introduction of a new mobile news app on mobile devices and discuss its implications.² To that end, we focus on the introduction of the Fox News app in 2010 and analyze whether consumers who adopted it increased or decreased their news consumption at the corresponding Fox News mobile website. We then study consumer characteristics that explain heterogeneity in consumer response to the new channel.

Our study of the news category in general and Fox News in particular is guided by several considerations. First, the news category is one of the most popular mobile data activities among U.S. consumers after e-mail and texting (comScore 2012). Therefore, it is critical for advertisers to understand any changes in consumers' news consumption behavior in response to the additional news channel. Second, Fox News is a popular news outlet with a large audience base: its cable news subsidiary has been ranked as the most popular news outlet for more than a decade (Fox News 2012) and its online website attracted more than 32 million unique monthly visitors in 2012 (Schneider 2012). Furthermore, among major news outlets, Fox News has the highest proportion of readers who report being politically conservative (Gentzkow and Shapiro 2011). Therefore, in addition to our main research question, our empirical setting offers a unique opportunity to study how differences in media tastes across consumers—in particular, their tastes for a particular political viewpoint—influence their response to the new mobile channel (Gentzkow and Shapiro 2010).

For our empirical analysis, we use a quarterly survey of U.S. mobile smartphone users during 2009 and 2010. We use repeated cross-sectional data and thus are unable to introduce individual-level fixed effects to remove unobserved time-invariant consumer characteristics to help identify our focal effect. To overcome this data limitation, we use a pseudo-panel data analysis approach (Deaton 1985) in which we transform the cross-sectional data into a synthetic panel by grouping individuals into cohorts. That is, the unit of our empirical analysis is cohorts rather than individuals. Although the pseudo-panel method has been widely used in areas such as labor economics, in which repeated cross-sectional data are common, to the best of our knowledge, its use in marketing has been more limited.³ Our study provides an example of this method for marketing researchers.

We find that the adoption of the Fox News app leads to increased news consumption at the Fox News mobile website, providing strong evidence of complementarity between the Fox News app and mobile website. We further show that

this average effect masks significant heterogeneity in consumer response. Drawing from recent literature on audience fragmentation and ideological segmentation in online media consumption, we find that the complementarity is stronger among groups of consumers with more focused tastes in media consumption, in terms of a penchant for selective exposure (Webster and Ksiazek 2012) and preferences for a particular ideological “slant” to news (Gentzkow and Shapiro 2010; Mullainathan and Shleifer 2005). Finally, we also find that consumers who are time-constrained exhibit weaker complementarity between different media channels.

Our research aims to provide the following substantive contributions to the area of mobile advertising and news media channels. First, we aim to enhance our understanding about the media consumption behavior of consumers in the emerging area of mobile channels. With a few notable exceptions (e.g., Ghose, Goldfarb, and Han 2012; Ghose and Han 2011), to the best of our knowledge, there is little prior empirical work on cross-channel news consumption behavior on mobile devices. Given the rapid growth of the mobile Internet in general and mobile news media consumption in particular, we believe this is an important gap in the field's understanding. In addition, by showing that consumers with focused and more politically aligned tastes are more likely to exhibit complementarity, we identify consumer segments for whom segmentation and targeting will be easier and for whom the value of advertising will be greater (Bergemann and Bonatti 2011). This finding has important implications for publishers and marketers and their advertising decisions.

Research Setting

We empirically investigate consumer responses to conventional mobile websites in response to mobile apps introduced by news providers. Before investigating whether and to what extent complementarity or substitution occurs between both channels, we first discuss how news apps differ from news websites on mobile devices. To begin, we briefly discuss mobile apps and mobile websites, two distinct ways for consumers to access digital content on mobile devices such as smartphones and tablet computers.

Apps have comparative advantages and disadvantages compared with mobile websites. Figure 1 shows the bottom part of the front pages from the Fox News mobile website (Panel A) and the Fox News mobile app (Panel B). As Figure 1 suggests, on the one hand, mobile apps tend to be more user-friendly than mobile websites because apps enable publishers to take full advantage of mobile operating systems. In contrast, content on a mobile web page is rendered in a more generic environment that is not necessarily tailored for specific mobile operating systems (Alang 2010). This limits a publisher's ability to customize its content. On the other hand, mobile websites typically offer more news content than apps.⁴ The marginal cost of

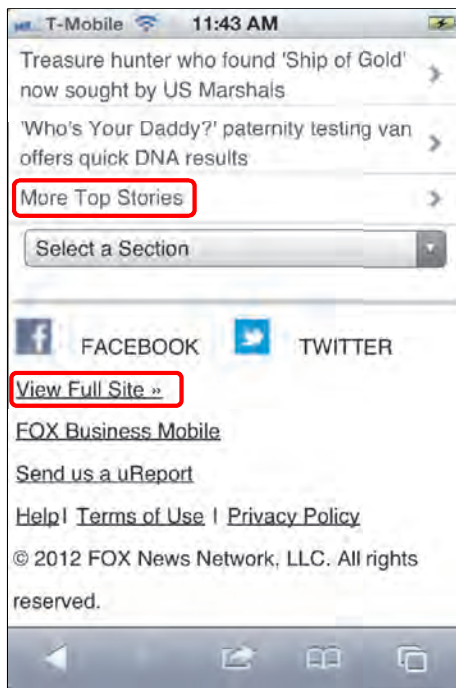
²A mobile application (“app”) is a software application designed to run on smartphones, tablet computers, and other mobile devices.

³Indeed, to the best of our knowledge, our article is the first marketing application of the pseudo-panel approach.

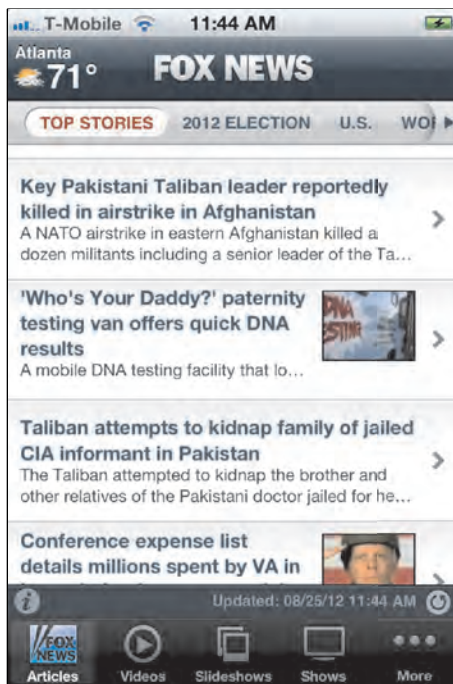
⁴Among the 22 providers in our sample that have mobile apps and mobile websites, 17 provide more diverse content on their mobile websites than on their applications. For the other 5 providers, the amount of content is the same across the two channels.

FIGURE 1
Screenshots of the Bottom Part of the Fox News Mobile Website and the Fox News App

A: Fox News Mobile Website



B: Fox News App



Notes: We obtained these screenshots by scrolling down to the bottom of the first page on the Fox News website and Fox News mobile app. The number of top stories shown on the Fox News app is approximately 10, whereas the number of top stories that can be found on the Fox News mobile website is almost 100.

adding a new article on a mobile app is higher than that for a mobile website. It is easier to convert news content from a traditional website to a mobile website because a mobile website is similar to any other website in that it consists of browser-based HTML pages (Summerfield 2011). However, adding content to a mobile app requires additional programming effort (Alang 2010; Summerfield 2011). Therefore, the news content of a mobile website and that of a traditional website are similar, but mobile apps typically offer fewer news articles. Another advantage of a mobile website is that it can be easily reached from other websites, such as social media, search engines, and news aggregators. Mobile apps cannot be accessed from other external websites, and during our sample period the Fox News app did not link to any articles on its own mobile website.

In summary, given the strengths and weaknesses of each channel, it is unclear a priori whether one will complement or substitute for the other. A recent industry report indicates that a substantial percentage of mobile consumers access content from both apps and mobile websites (comScore 2012), suggesting that one channel may not completely substitute for the other. In this article, we provide a more systematic answer to this question by carefully analyzing a large survey data set using the pseudo-panel data analysis technique.

Related Literature

The effect of a new channel on the demand for an existing channel is often a priori unknown and thus is treated as an empirical question (Deleersnyder et al. 2002; Gentzkow 2007; Smith and Telang 2009). For example, recent research continues to discuss the various relationships between Internet commerce and brick-and-mortar commerce (e.g., Ansari, Mela and Neslin 2008; Avery et al. 2012; Geyskens, Gielens, and Dekimpe 2002) and between free file-sharing services and recorded music (Liebowitz 2008; Smith and Telang 2009). In this section, we review the relevant literature on new and existing channels from multiple disciplines and relate them to our research setting.

Substitution Versus Complementarity

Our main research question—whether the use of apps complements or substitutes for the use of mobile websites—is empirical because prior research on consumer response to new channels has found evidence in support of both alternatives. Consumer adoption of a news app may lead to lower demand for the provider’s corresponding mobile news website if the new channel closely duplicates the capabilities of the existing channel (e.g., Deleersnyder et al. 2002) or offers new capabilities (Alba et al. 1997). More pertinent to our setting, multichannel media research has shown that new technology-enabled media channels have consistently substituted for older channels; this has been the pattern for television (Mendelsohn 1964), cable television (Sparkes 1983), and Internet news and traditional print media (e.g., Athey, Calvano, and Gans 2013; Deleersnyder et al. 2002). Substitution also occurs when people have a limited amount of time to spend on media consumption (Deleersnyder et al. 2002). Therefore, if consumers perceive a mobile news app

to be similar to the mobile website along key dimensions, the adoption of the mobile app may substitute for demand for the mobile news website.

It is also possible that consumer adoption of a provider's mobile news app results in a higher demand for the provider's corresponding mobile news website. A separate stream of multichannel research has noted different comparative advantages among channels. For example, the Internet may offer convenience, selection, and price (Forman, Ghose, and Goldfarb 2009) relative to traditional brick-and-mortar retail stores, whereas traditional stores provide instant gratification and lower transaction costs (e.g., shipping and handling charges) (Avery et al. 2012). Different channels can also serve as a form of advertisement for one another (Avery et al. 2012; Jacoby and Mazursky 1984; Keller 1993). Within the media category, it is well documented that consumers who borrow or rent access to music, television, or movies may later choose to buy them (Liebowitz 1985; Peitz and Waelbroeck 2004); in this context, consumers use the lower-cost channel to sample products or services for later choice, which is usually referred to as a "sampling effect" (Liebowitz 1985). In our research setting, the corresponding mechanism is that consumers may learn about a news topic using the app due to its superior user interface and later visit the corresponding mobile website to obtain more news. Under these conditions, the mobile news app articles would serve as "samples" for articles offered by the news provider at its mobile news website. These findings support the view that when different channels have different comparative advantages, the use of one may increase the use of the other. That is, a new channel may complement the existing channel.

We note that substitution and complementary effects might operate on the same consumer simultaneously. Although our data do not allow us to identify these competing effects separately, we are able to study the net effect of adopting mobile news apps on mobile news website visits.

Implications of Consumer Heterogeneity for Substitution or Complementarity

In this subsection, we review and discuss recent research on online content supply and demand to identify consumer segments that may exhibit greater substitution or complementarity between the two mobile channels. Our discussion and empirical analysis are motivated by recent research on content diversity and audience fragmentation in digital media (Gentzkow and Shapiro 2011; Webster and Ksiazek 2012) as well as research on the ideological segregation of online consumers (Mullainathan and Shleifer 2005; Yildirim, Gal-Or, and Geylani 2013). Our main interest in this section is to identify consumers who will show higher or lower complementarity or substitution between mobile apps and mobile websites, if any.

The digitization of media content on the Internet has led to a large increase in the media sources available to consumers. The main question in this research stream has been whether the increasing content availability leads people to consume a steady diet of their preferred news genre or a

diverse range of materials (Gentzkow and Shapiro 2011; Webster and Ksiazek 2012). One key finding is that consumers have responded to the increase in content using a strategy of "selective exposure" in which they consume greater quantities of similar news from a small number of news providers rather than consuming a greater variety of content by sampling from a larger number of news providers (Hollander 2008; Iyengar and Hahn 2009; Ksiazek, Malt-house, and Webster 2010). Whereas much of the prior research in this area has focused on the dispersion of online content consumption across different sources at one point (e.g., Fox News website and Facebook), our setting enables us to study consumer responses to increased content availability through multiple channels from the same provider (i.e., Fox News app and Fox mobile website) and observe how their responses depend on their news tastes. That is, we investigate whether substitution or complementarity is stronger or weaker among consumers with narrower news tastes, conditional on a news provider's app adoption. Building on the research in audience segmentation, we posit that, conditional on mobile news app adoption, consumers with narrow news tastes are more likely to display higher levels of complementarity between channels, whereas we posit consumers with diverse news tastes are more likely to substitute channels. If our expectation about the content demand relationship between the mobile app and the corresponding mobile website holds, it implies that the selective exposure documented in audience fragmentation holds not only across news providers but also across different channels for one provider. These results will have targeting implications for content providers in terms of advertising reach and frequency.

Our empirical analysis is also informed by the latest developments on the ideological segregation of online consumers, especially in the news category (Gentzkow and Shapiro 2011; Mullainathan and Shleifer 2005). This stream of research argues that, due to the increasing proliferation of news outlets, consumers with a particular political preference will be more likely to consume from news outlets that match their own value beliefs. This behavior results in a penchant for ideological segregation (e.g., Ksiazek, Malt-house, and Webster 2010; Stroud 2008).⁵ Applying these findings to our context, we expect stronger channel complementarity for consumers whose political preferences are better aligned with that of the news provider. In contrast, all else being equal, we expect that consumers whose political preferences are less aligned with that of a content provider will exhibit weaker complementarity or even substitution between the mobile news app and website. Given that marketers are beginning to recognize the implications of the ideological propensity on online consumer behavior and media company strategy (Yildirim, Gal-Or, and Geylani 2013), we believe that this study adds more insights on this topic.

Finally, we consider the effects of a consumer's temporal budget on the degree of complementarity or sub-

⁵Empirical evidence on ideological segregation is mixed (see, e.g., Gentzkow and Shapiro 2011).

stitution conditional on mobile app adoption. As prior literature has shown, time-constrained consumers are more likely to substitute new and existing channels (e.g., Alba et al. 1997; Deleersnyder et al. 2002). Assuming that consumers' overall temporal budgets for a news category do not change over time, which we believe is a reasonable assumption during a relatively short time window, we expect more time-constrained consumers to be less likely to exhibit complementarity between the mobile news app and website.

Data

We begin by discussing comScore MobiLens, the data source for our study. Next, we discuss in detail the construction of the pseudo-panel data from the MobiLens data.

comScore MobiLens

For our empirical analysis, we use a large quarterly data set, comScore MobiLens, which is based on a detailed survey of the mobile Internet activities of a nationally representative sample of the U.S. population. Participants in the survey are recruited from a large, demographically diverse population of approximately 30,000 people assembled through a variety of recruitment methods. Participants answer questions about basic demographic information, ownership of mobile devices, and behavior on the mobile Internet.⁶ The data are a repeated cross-section (consumers usually do not overlap over time), and for our study, we use data from the fourth quarter (Q4) of 2009 and the second quarter (Q2) of 2010. Because not all respondents own smartphones, our data contain information on news consumption on mobile websites and apps for approximately 5,600 smartphone users. The survey queries these smartphone users on their use of news apps and mobile news websites. In particular, it asks whether the user accessed a particular mobile news website (e.g., CNN, Yahoo, Fox), and whether he or she adopted and used a particular app to access news.

Our decision to focus on consumer response to the introduction of the Fox News app is guided in part by some limitations of our data. comScore began measuring app adoption among consumers during the second quarter of 2010; however, most of the popular news providers introduced their apps before this period. Because our empirical approach requires data on changes in consumer behavior over time, this makes analysis of these providers unsuitable for our empirical approach. Therefore, we focus on Fox News, a major news provider that released its app in early 2010, and we compare use of the Fox News website before (Q4 2009) and after (Q2 2010) the introduction of the Fox News app (March 2010) to study the effect of app adoption on Fox mobile website consumption.

Like other prior research based on self-reported measures, a potential concern of our survey data is that they

may be subject to respondent errors. Respondent errors would introduce measurement errors in the dependent and independent variables. If the measurement error is uncorrelated among the explanatory and dependent variables, it would lead to an attenuation bias (e.g., Hausman 2001) that would bias our estimates toward zero. However, if measurement error for the key independent (Fox News app adoption) and dependent (Fox News website visits) variables are correlated, this could lead to a spurious finding of complementarity. In this section, we discuss why we believe the potential measurement error generated by respondents is likely to be small and unlikely to influence our estimates. Next, we present a series of econometric tests that empirically investigate whether our findings could be the result of the correlation between the measurement error and key variables.

First, the survey is organized in multiple steps that force respondents through a few gateways before reaching the target questions. This helps the instrument elicit more reliable answers from the respondents. For example, for each category of mobile phone usage, the survey first asks a question about general frequency of use (e.g., whether the respondent consumed news media during the previous month), regardless of access method. The survey next asks a question about the access method (app or web) for that category and then follows up with questions about the "brand" of websites visited, followed by a similar question for apps. News website and app questions follow questions about social networking and information search on mobile phones. This helps reduce the likelihood of "title confusion," in which respondents might confuse a news app with a news website. Second, whereas MobiLens data are aggregated on a quarterly basis, the survey occurs each month and asks respondents about their mobile phone usage behavior in the preceding month. Focusing on the previous month, rather than the prior three months, limits the recall bias and elicits a more accurate response.

A series of detailed data analyses also suggest that the effect of measurement error may be limited. First, the average number of installed news apps for a smartphone consumer in the data is .85, and the average number of news websites accessed is 1.92. Thus, we observe that consumers are very selective regarding which news apps and news websites they visit. This suggests that a positive bias in our measurement in the key dependent and explanatory variables resulting from the effects of title confusion is likely to be small. Second, we conducted a set of analyses within the MobiLens data to obtain evidence of overall data integrity. Although this may only serve as indirect evidence for validity of the reported Fox News app adoption rate in the current research, we view this as a critical test evaluating the validity of the reported values in a broader context. Specifically, we computed and compared the adoption rates of major apps (e.g., Fox News app, CNN app) and their corresponding mobile website consumption. We found that the app adoption rate is highly correlated with the corresponding mobile website consumption rate within our data: Spearman's rank correlation for app adoption and mobile website consumption rate is .88. We believe these

⁶For data accuracy, comScore conducts the survey across three months in a given quarter. That is, a survey respondent recruited at the end of each month is asked about his or her behaviors in the preceding month and not the past quarter, a method designed to minimize the potential respondent errors in the survey.

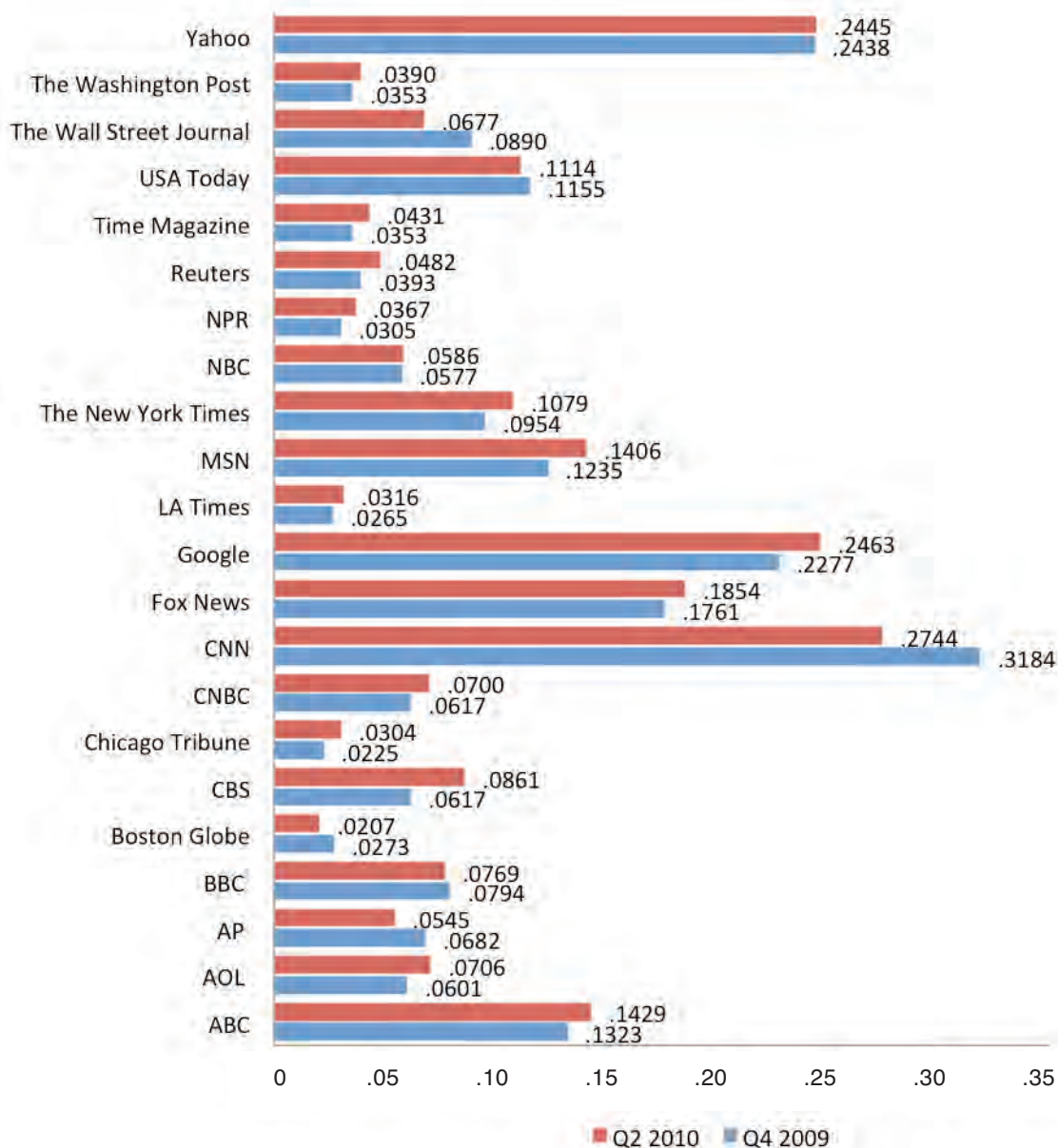
comparisons provide indirect but strong evidence for the validity of the measures on app adoption and mobile web consumption. Third, we compared the probability of visiting different online news providers during the time periods in our data. Figure 2 shows that the probability of visiting the Fox News website increased from .176 in Q4 2009 to .185 in Q2 2010. This compares with Fox News app adoption of .045 in Q2 2010 and suggests that the overall traffic to Fox News sites on the mobile platform increased over our sample period. We also compared our data with several public data sources on news consumption through traditional web browsers (Pew Research Center 2012, 2013).

Direct comparisons are difficult because of differences in time period and the way digital traffic is measured. However, despite these disparities, there is substantial overlap among the top providers in our data set and those viewed through desktop browsers as measured by comScore, Nielsen, and Pew Research Center.

Pseudo-Panel Data

The main empirical challenge in evaluating whether consumer behavior exhibits complementarity or substitution between channels is to separate their effects from correlation in consumer preferences (Arora, Forman, and Yoon

FIGURE 2
Percentage of Smartphone Users in Our Sample Visiting Mobile Websites



Notes: Data are constructed as the sample average of users in each of the two quarters who indicate they had visited the website in the previous month.

2010; Gentzkow 2007). In our empirical setting, some consumers may have a greater taste for certain news content or a particular news provider. A potential source of identification in the presence of correlated preferences is panel data in which repeated observations of the same consumer will enable us to separate correlation and complementarity (Gentzkow 2007).⁷ However, as we discussed in the preceding section, the MobiLens survey participants do not overlap in each quarter, so the data are not a panel but rather a series of cross-sectional data. To facilitate panel-type analysis, we adopt a pseudo-panel approach. Originally proposed by Deaton (1985) and further developed in subsequent studies (e.g., Browning, Deaton, and Irish 1985; Campbell and Cocco 2007; Verbeek and Vella 2005), the pseudo-panel method has been widely used in macroeconomics and labor economics, in which repeated cross-sectional data are relatively common (e.g., U.S. Consumer Expenditure Survey and British Family Expenditure Survey). Pseudo-panel analysis is undertaken by aggregating the observational units in the cross-sectional data into “cohorts,” matching cohorts across time, and running panel analysis on the synthesized cohorts. Therefore, our analyses are conducted at the cohort level rather than at the individual level. For a more detailed econometric discussion on pseudo-panel analysis, we refer to the Web Appendix.

Constructing a pseudo-panel requires identifying a set of reliable, time-invariant criteria to identify cohorts so that the same person remains in the same cohort over time (Prince and Greenstein 2011). We construct our cohorts using demographic characteristics in the data that we believe will give rise to stable cohorts over a short period of time. Our choice of demographic variables to construct the cohorts—age group, income, education, and location (urban vs. rural)—are in line with prior analyses (e.g., Blundell, Browning, and Meghir 1994; Campbell and Cocco 2007; Prince and Greenstein 2011). Each characteristic is coded as a categorical variable. For example, the categories for the age group variable are 18–24 years, 25–34 years, 35–44

⁷This is similar to the “reflection” problem that arises when a researcher observing the distribution of behavior in a population tries to infer whether the average behavior in some group influences the behavior of the people who comprise the group (Manski 1993).

years, 45–54 years, 55–64 years, and 65 years and over.⁸ Among the cohorts in our pseudo-panel, one cohort consists of consumers who range in age from 25 to 34 years, have an income of \$50,000–\$75,000, have a bachelor’s degree, and live in an urban area. In our pseudo-panel data, the average number of consumers per cohort is 44, with a standard deviation of 16.⁹ Table 1 provides summary statistics for the cohorts in our pseudo-panel.

Empirical Analysis

Model

As we discussed previously, the main empirical challenge in our identification strategy is to separate true substitutability or complementarity from intrinsic or correlated consumer preferences. For example, in our empirical context, a consumer who simply likes the “news” category will be more likely to consume news using both apps and mobile news websites in a purely cross-sectional data set. A potential solution to this problem is the use of instrumental variables. If we could identify variables that are correlated with mobile news app adoption but not with mobile news website consumption, we could use those variables to estimate the effect of app adoption on mobile news website demand. Unfortunately, after careful and extensive searching, we were not able to identify such instrumental variables.

We use an alternative approach for causal inference: difference-in-difference estimation. The idea behind difference-in-difference estimation is to examine a set of treated units before and after some treatment. Given that other factors often change around the time of the treatment, researchers use a control group to control for such factors to try to isolate the effects of the treatment. Indexing units by *d* and time by *t*, the basic framework is as follows:

⁸Similarly, the categories for the income-level variable are less than \$25,000, \$25,000–\$50,000, \$50,000–\$75,000, \$75,000–\$100,000, and greater than \$100,000. The categories for education level are grammar school or less, some high school, high school completed, some college, associate’s degree, bachelor’s degree, and postgraduate degree. We define urban locations as those located within a metropolitan statistical area.

⁹In our empirical analysis, we experimented with alternative cohort definitions, such as including employment status in our cohort definition. Our results are robust to these changes.

TABLE 1
Descriptive Statistics: Cohort-Level Summary Statistics

Variable	Q4 2009				Q2 2010			
	M	SD	Min	Max	M	SD	Min	Max
Fox News app adoption	.00	.00	.00	.00	.05	.17	.00	1.00
Number of household members	2.92	.59	1.00	5.00	2.98	.54	1.00	5.00
Length of mobile phone use (years)	3.69	.27	1.00	4.00	3.71	.22	2.00	4.00
Monthly cost of mobile phone service (USD)	105.69	13.64	36.67	150.00	112.69	12.69	50.00	150.00
First to buy new technology (1–10)	5.21	.88	.33	10.00	5.32	.90	2.00	8.33
Ask for opinion to buy new e-product (1–10)	5.55	.86	1.40	9.33	5.58	.92	2.33	10.00
Keep track of cell phone technology (1–10)	5.43	.91	.75	10.00	5.48	.86	2.00	8.29
Number of cohorts	151							

$$\begin{aligned} \text{Outcome}_{dt} = & \lambda_0 + \lambda_1 \text{TreatmentGroup}_d + \lambda_2 \text{AfterTreatment}_t \\ & + \lambda_3 \text{TreatmentGroup}_d \times \text{AfterTreatment}_t \\ & + \theta \text{RegressionControls}_{dt} + \varepsilon_{dt}. \end{aligned}$$

We can plug in 0s and 1s for the various binary variables in this equation, and the difference across units after treatment is λ_3 . If λ_3 is positive, it is viewed as having a positive effect on the outcome (e.g., Angrist and Pischke 2009).

In our setting, Outcome_{dt} is whether a person visits the Fox News mobile website, TreatmentGroup_d is whether the person adopts the Fox News app, and AfterTreatment_t indicates the second period of our sample period. In this case, the control group is the set of Fox News app nonadopters. Specifically, an equation that we could estimate using this approach would be as follows:

$$y_{dt} = \alpha + \beta \text{FoxApp}_d \times \text{time}_t + \gamma \text{time}_t + \theta X_{dt} + \tilde{\mu}_d + \varepsilon_{dt},$$

where TreatmentGroup_d (FoxApp_d) is absorbed in the fixed effect $\tilde{\mu}_d$. Under this model, $\tilde{\mu}_d = \mu_d + \mu_d^F$, μ_d indicates individual d 's preference for news and extent to which she uses her smartphone more generally (i.e., the extent to which she is a "technology savvy" user). In contrast, μ_d^F indicates a preference for Fox News (i.e., the fit between the user and the ideological slant provided by Fox News). Note that omitting these variables could create biased estimates for β .

To address this issue, we use another source of variance within our data: namely, differences in the effects of the Fox News app adoption on the Fox News website visits compared with the effects of visiting other mobile news websites. This estimation approach is in the spirit of other studies that have compared the effects of a treatment across heterogeneous contexts to obtain identification (e.g., Chevalier and Mayzlin 2006). Specifically, we model y_{djt} , individual d 's likelihood of visiting mobile news website j in time t , as

$$\begin{aligned} (1) \quad y_{djt} = & \alpha + \beta_1 \text{FoxApp}_d \times \text{time}_t + \beta_2 \text{FoxWeb}_j \times \text{time}_t \\ & + \beta_3 \text{FoxApp}_d \times \text{FoxWeb}_j \times \text{time}_t + \gamma \text{time}_t + \theta X_{dt} + \mu_{dj} + \varepsilon_{djt}, \end{aligned}$$

where FoxApp_d is an indicator variable equal to 1 if individual d adopts the Fox News app,¹⁰ FoxWeb_j is an indicator variable equal to 1 if j is the Fox News mobile website, and time_t is an indicator variable equal to 1 if t equals to the second period and 0 otherwise. The coefficient β_1 captures the effect of the Fox News app on the average likelihood of visiting all mobile websites, β_2 measures the time trend for the Fox News mobile website, and β_3 measures the effect of the Fox News app on visits to the Fox News mobile website—our focal mobile website. If β_3 is positive, the Fox News app causes higher media consumption at the Fox News mobile website. X_{dt} is a vector of individual-level control variables that could vary over time. The term μ_{dj} is an individual website fixed effect that captures individual-level preferences for news in general (μ_d in our earlier notation) as well as individual preferences for particular news sources that may vary with income and education; for example, a recent report showed that 38% of *New York*

Times readers had a household income of \$75,000 or more, whereas only 23% of the Fox News audience had household incomes in this range (Pew Research Center 2012). In a nutshell, our approach measures changes in the visits to the mobile Fox News website (foxnews.com) resulting from Fox News app adoption compared with changes in the visits to other mobile news websites (e.g., CNN.com, news.google.com, news.yahoo.com) after Fox News app adoption.

Although our difference-in-difference estimation model is formulated at the individual level, as noted previously, we cannot observe the same person over time in our MobiLens data. Therefore, we follow Deaton (1985) in estimating a pseudo-panel model in which we compute and use cohort-level averages of Fox News app adoption, Fox News web adoption, and our control variables to estimate the following model:

$$\begin{aligned} (2) \quad y_{ijt} = & \alpha + \beta_1 \text{FoxApp}_i \times \text{time}_t + \beta_2 \text{FoxWeb}_j \times \text{time}_t \\ & + \beta_3 \text{FoxApp}_i \times \text{FoxWeb}_j \times \text{time}_t + \gamma \text{time}_t + \theta X_{it} + \mu_{ij} + \varepsilon_{ijt}, \end{aligned}$$

where i indexes cohort, y_{ijt} indicates the cohort-level average value of website visits and other variables are corresponding cohort-level averages and computed comparably. Under a set of conditions established by Deaton (1985) and described further in the Web Appendix, estimation of the model in Equation 2 will deliver consistent estimates of the individual-level parameters in Equation 1. We use heteroskedasticity-robust standard errors for ε_{ijt} because there may be heterogeneity in the distribution of unobservables across cohorts and websites.

Our identification strategy requires the assumption that, along with the adoption of the Fox News app, there are no coinciding time-varying changes in unobserved factors that materially affect the probability of visiting the Fox News mobile website relative to other websites. These unobservables could be changes in preferences for Fox News or changes in measurement error as described previously. To be clear, to bias our results, these time-varying unobservables would need to influence the probability of visiting the Fox News mobile website but have no effect on the probability of visiting other websites. However, in a series of robustness checks (discussed subsequently in the following section), we probe the validity of our core identification assumption.

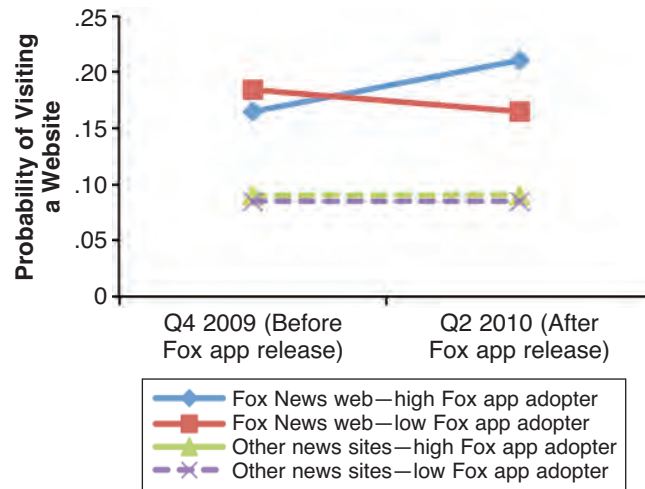
Results

Before discussing the results of our empirical analysis, we first demonstrate how the variance in the data identifies the core relationship of interest without imposing functional form restrictions. To that purpose, we conduct a nonparametric difference-in-differences analysis of the probability of visiting the Fox News mobile website between Q4 2009 and Q2 2010. We use a median-split strategy; if the cohort's average adoption rate of the Fox News app during the second quarter of 2010 is greater than the median adoption rate across all cohorts during the same quarter, we define the cohort as the treated group, or "high Fox News app adopter." If not, we define the cohort as the control group, or "low Fox News app adopter." We study changes in the average probability of visiting the Fox News mobile website for these two groups. Figure 3 shows that whereas high

¹⁰Because the Fox News app did not exist in 2009, its adoption rate in 2009 is 0.

FIGURE 3
Probability of Visiting News Websites by Year and Extent of Fox News App Adoption

A: Difference-in-Differences Analysis of the Probability of Visiting News Websites



B: Difference Calculations

	Before Fox News App Introduction (Q4 2009)	After Fox News App Introduction (Q2 2010)	First Difference (Row)
Probability of Visiting Fox News Mobile Website			
High Fox News app adopter	.1647	.2109	.0462*
Low Fox News app adopter	.1843	.1649	-.0194*
First difference (column)	-.0196*	.0460*	.0656*
Average Probability of Visiting Other Mobile News Websites			
High Fox News app adopter	.0902	.0907	.0005
Low Fox News app adopter	.0851	.0850	-.0001
First difference (column)	.0051	.0057	.0006
Difference between Fox News and others	-.0248*	.0403*	.0650*

*Significant at 1%.

Fox News app adopters increase their probability of visiting the Fox News website by 4.62 percentage points, low Fox News app adopters decrease their probability of visiting by 1.94 percentage points. The change in high Fox News app adopters' probability of visiting the Fox News mobile website is 6.56 percentage points (or 40.02%) higher than that of low Fox News app adopters (statistically significant at the 1% level). This provides preliminary evidence in support of potential complementarities between consumption of the app and website. We next explore this finding in further detail using the regression model described in Equation 2.

Table 2 shows the coefficient estimates of Equation 2. Columns 1 and 2 show the estimated coefficients of the main models. We focus on the results in Column 1, which includes the complete set of controls. The coefficient of $FoxApp_i \times FoxWeb_j \times time_t$ in Column 1 is .2936, meaning that the probability of visiting the Fox News mobile website (vs. other mobile news websites) increases by 29.36 percentage points for a cohort in which 100% of users adopt the app, compared with an equivalent cohort in which no users adopt. Given that the average probability of visiting

the Fox News mobile website is .1761 in our sample before the introduction of the Fox app (Figure 2), this coefficient translates into a 66.72% increase. From this finding, we show that adoption of the mobile Fox News app stimulates visits to the Fox News mobile website. Note that the positive and statistically significant coefficient (.0403) on $FoxApp_i \times time_t$ suggests that cohorts that adopted the Fox News app also visited other mobile websites more often than cohorts that did not adopt the app; however, the incremental change of visits to other mobile websites is far less than the incremental change of visits to Fox News website. In contrast, the coefficient for $FoxWeb_j \times time_t$ is significantly negative (-.0538), suggesting that in our data, there was a systematic decline in visits to the Fox News mobile website compared with other mobile news websites during our testing period. In short, our analysis strongly supports the notion that the adoption of the mobile news app complements visits to the mobile news website in our empirical setting. Column 2 includes a model without controls to address the potential concern that changes in these controls could be correlated with other unobserved factors influencing Fox News mobile website visits and, thus, might be endogenous. Our results are robust to this change.

TABLE 2
The Probability of Visiting the Fox News Mobile Website Increases with Fox News App Adoption

Variables	1 Baseline Results	2 Baseline Results: No Controls	3 Bootstrap Sampling (Bootstrap SD)	4 Smaller Cohort Size	5 Smaller Cohort Size: No Controls
Time dummy of 2010	-.0046 (.0049)	-.0043 (.0046)	-.0042** (.0062)	-.0079* (.0045)	-.0083* (.0044)
FoxApp × time	.0403** (.0200)	.0315** (.0196)	.0170** (.0126)	.0244 (.0204)	.0276 (.0200)
FoxWeb × time	-.0538* (.0302)	-.0538* (.0301)	-.0197* (.0213)	.0019 (.0284)	.0019 (.0284)
FoxApp × FoxWeb × time	.2936** (.1371)	.2936** (.1347)	.1824*** (.0304)	.2746** (.1248)	.2746** (.1221)
Controls	Yes	No	Yes	Yes	No
Constant	.1371** (.0651)	.0941*** (.0022)		.0281 (.0487)	.0964*** (.0020)
Observations	6,644	6,644		10,208	10,208
R-square	.6159	.6141		.6161	.6073
Number of cohorts	151	151		232	232

*Significant at 10%.

**Significant at 5%.

***Significant at 1%.

Notes: Controls: the number of people in the household, the length of the mobile service usage, the monthly cost of the mobile service, and variables measuring users' technological sophistication. R-square includes the explanatory power of the fixed effects in the R-square computation. Heteroskedasticity-robust standard errors appear in parentheses.

Robustness Checks

Because we use a pseudo-panel data set for our empirical analysis, a potential concern exists that our results may not be robust to various sampling strategies from the cross-sectional data, cohort size, and cohort composition. Although the theoretical literature stream supports the large sample properties of the pseudo-panel analysis (e.g., Cuesta, Nopo, and Pizzolitto 2011; Verbeek and Vella 2005), we conduct various checks to ensure that our results are robust in the presence of potential errors in our raw data sampling as well as our cohort composition in the pseudo-panel.

First, we investigate the sampling robustness of our model. A potential concern is that comScore data may be subject to macrosampling errors such as oversampling the Fox News app or the Fox News website users among the smartphone users. This, in turn, can bias our coefficient estimates. To that end, we conduct a bootstrap test by resampling from the data. The resampling probability of an individual from the cross-sectional data is assigned by comScore's evaluation of that person's representative weight: each person is separately weighted and projected to appropriately reflect independent census estimates of the U.S. population's demographic profiles by comScore. We replicate the process of resampling individuals, grouping them into cohorts to form a pseudo-panel, and for each replication, we repeat the same regression analysis. Column 3 of Table 2 presents the bootstrap regression results from 500 replications. In this column, the coefficient of interest is positive and significant, suggesting that our complementarity findings in the preceding section are not caused by potential macrosampling errors by comScore.

Second, we conduct a set of robustness checks on cohort composition, similar to prior studies (Cuesta, Nopo, and Pizzolitto 2011). That is, we construct our pseudo-panels by grouping individuals into cohorts on a different set of observable demographics (e.g., Prince and Greenstein 2011; Verbeek and Vella 2005). Under the current composition strategy, our pseudo-panel results in 151 cohorts with an

average of 44 people per cohort in our main analysis. In an alternative cohort composition strategy, we include additional demographic variables, such as employment status. Under this alternative definition, we have 232 cohorts and an average 25 observations per cohort. Columns 4 and 5 of Table 2 present the regression results for this alternative cohort strategy. From the results in the table, we conclude that our estimates are robust to different cohort composition plans.

Third, we provide evidence for one of our key identification assumptions: that there was no change in unobservable cohort characteristics before and after the introduction of the Fox News app that could systematically affect the demand of the Fox News mobile website relative to other news websites. This is an important assumption to validate because the positive effect of Fox News app adoption on the probability of visiting the Fox News mobile website may be attributed to time-varying factors that were not captured in the analysis. We probe the salience of this assumption through a series of falsification analyses. To that end, we examine the impact of Fox News app adoption on visits to other Fox websites, such as Fox Financial and Fox Weather mobile websites. We reason that because the Fox News app does not have a separate financial news category, the adoption of the app should not increase visits to the Fox Financial News mobile website, because adoption of the Fox News app does not allow consumers to sample Fox Financial News. Similarly, the adoption of the Fox News app should not stimulate visits to the Fox Weather News mobile website, because the weather content is usually similar across the two platforms.

In Table 3, we show the results of falsification tests based on Fox Financial and Weather mobile websites. In our regression model, we use a specification similar to Equation 2 but that differs in several ways. First, the dependent variable in these analyses is the probability of visiting financial or weather news websites rather than the probability of visiting news websites. Second, and similarly, because we

TABLE 3
The Probability of Visiting the Fox News Mobile Website for Weather and Financial News Does Not Increase with Fox News App Adoption

Variables	Weather	Financial
Time dummy of 2010	.0011 (.0065)	-.0052*** (.0017)
FoxApp × time	.0316* (.0206)	.0204*** (.0052)
FoxWeatherWeb × time	.0128 (.0123)	
FoxApp × FoxWeatherWeb × time	.0282 (.0896)	
FoxFinancialWeb × time		.0012 (.0048)
FoxApp × FoxFinancialWeb × time		.0243 (.0196)
Constant	.0067 (.0815)	-.0055 (.0280)
Observations	4,832	6,040
R-square	.6589	.6581
Number of cohorts	151	151

*Significant at 10%.

**Significant at 5%.

***Significant at 1%.

Notes: All regressions include the following controls: the number of people in the household, the length of the mobile service usage, the monthly cost of the mobile service, and variables measuring users' technological sophistication. R-square includes the explanatory power of the fixed effects in the R-square computation. Heteroskedasticity-robust standard errors appear in parentheses. The list of financial news websites in our sample is as follows: ABC, AOL, Associated Press, Bloomberg, Business Week, CBS, CNBC, CNN, *The Economist*, Fox News, Google, MarketWatch, MSNBC, MSN, *The New York Times*, Reuters, *USA Today*, *The Wall Street Journal*, Yahoo, and NBC. The list of weather news websites in our sample is as follows: ABC, Accuweather, AOL, CBS, CNBC, CNN, Fox News, Google, MSNBC, National Weather, *USA Today*, The Weather Channel, Weather Underground, WeatherBug, Yahoo, and NBC.

are interested in knowing whether the introduction of the Fox News app causes increases or decreases in the probability of visiting the Fox Financial or Weather websites, the coefficients of interest are $FoxApp_i \times FoxWeatherWeb_j \times time_i$, and $FoxApp_i \times FoxFinancialWeb_j \times time_i$. Table 3 shows that both coefficients are statistically insignificant. That is, we do not find any evidence to support the view that Fox News app adoption increases the demand for the Fox Financial or Weather mobile websites relative to other mobile websites. This finding is consistent with the theoretical mechanism described previously that might give rise to complementarity, and it is less consistent with an alternative hypothesis that the presence of unobserved cohort-level characteristics (or measurement errors) might be correlated both with Fox News app and Fox News mobile adoption. For this alternative hypothesis to be true, it would need to be the case that these unobservables influence visits to the Fox News mobile website but not visits to the Fox Weather or Fox Financial News websites, which we believe is less tenable than our conclusion.

In summary, our various robustness checks for sampling and cohort composition provide evidence in support of our

conclusions. Although we cannot completely rule out a role for omitted variable bias, our falsification analyses lend additional support to the notion that adoption of the Fox News app results in complementary visits to the corresponding mobile news website.

Consumer Characteristics for Complementarity

We have reported that the adoption of the Fox News app triggers complementary consumer demand at the Fox News mobile website. We next consider what types of consumers exhibit stronger or weaker complementarity between the two channels, conditional on Fox News app adoption. Motivated by recent research in audience fragmentation and ideological segregation in online media consumption, we examine customer segmentation using two variables, media consumption diversity and political propensity.

Prior research has shown that the average consumer uses a diverse range of materials for news consumption (Iyengar and Hahn 2009; Webster and Ksiazek 2012). To measure a person's preference for diversity in news content, we use the number of different news websites that he or she visits across different news categories in the second quarter of 2009 (before the beginning of our sample). We measure diversity using presample behavior because the number of news websites visited in our estimation sample may be correlated with our dependent variable in the regression model. By using presample behavior, we avoid a potential endogeneity issue. The set of news categories that we use includes general news (e.g., world, national, local news), entertainment news, technology news, and sports news.

Because we observe the same cohorts rather than the same individuals over time, we must construct a cohort-level measure of diversity. Motivated by prior literature (e.g., Prince and Greenstein 2011; Verbeek and Vella 2005), we compute measures of diversity for each person in the presample period and then compute cohort-level averages. In particular, we first use a median-split strategy to create a dummy variable for each person in Q2 2009. The dummy variable is equal to 1 if the person visits a greater number of websites than the median value across all people in Q2 2009 (4.4), and 0 otherwise.¹¹ For a cohort i , we then create a diversity measure ($Diversity_i$), which is equal to the average across these individual-level dummy variables within the cohort.

To capture consumer political propensity, we first classify the 22 general news websites in our sample into three categories—right-leaning, left-leaning, and neutral—in line with prior research (Gentzkow and Shapiro 2011). We classified two websites as right-leaning (Fox News and *The Wall Street Journal*), five as left-leaning (BBC, *The Boston Globe*, *The New York Times*, *The Washington Post*, and MSNBC), and the rest as neutral. As we did for the diversity measure, we first compute the shares of right-leaning or left-leaning news website visits for each person in Q2 2009 as a proxy for consumer political propensity (Gentzkow and Shapiro 2011). We then define two individual-level binary

¹¹The results are similar if we define the dummy using the sample mean rather than the median.

variables using a median split strategy. The first variable is equal to 1 if the person's share of right-leaning news websites visits is greater than the median right-leaning share across all people in Q2 2009 (.13) and 0 otherwise; the other is equal to 1 if the person's share of left-leaning news websites visits is greater than the median left-leaning share across all people in Q2 2009 (.17) and 0 otherwise. For each cohort i , we create a variable $Right_i$ that takes the average value across all of the individual right-leaning dummies within the cohort. Similarly, we create a variable $Left_i$ that takes the average value across all of the individual left-leaning dummies within the cohort. Note that 51 of 151 cohorts are neither right-leaning nor left-leaning.

To capture consumer time constraints, we use a demographic variable in the comScore survey that indicates the consumer's employment status, coded categorically as full-time employed, part-time employed, not employed, full-time student, full-time student employed, or retired. We define $TimeConstraint_i$ as cohort i 's full-time employment share in Q2 2009.

Because some of our key moderators may be correlated with each other, we focus our analysis on the full regression model that includes all three intermediate variables:

$$\begin{aligned}
 (3) \ y_{ijt} = & \alpha + \beta_1 FoxApp_i \times time_t + \beta_2 FoxWeb_j \times time_t \\
 & + \beta_3 FoxApp_i \times FoxWeb_j \times time_t + \delta_0 Diversity_i \times time_t \\
 & + \delta_1 FoxApp_i \times time_t \times Diversity_i \\
 & + \delta_2 FoxWeb_j \times time_t \times Diversity_i \\
 & + \delta_3 FoxApp_i \times FoxWeb_j \times time_t \times Diversity_i \\
 & + \lambda_0 Right_i \times time_t + \lambda_1 FoxApp_i \times time_t \times Right_i \\
 & + \lambda_2 FoxWeb_j \times time_t \times Right_i \\
 & + \lambda_3 FoxApp_i \times FoxWeb_j \times time_t \times Right_i + \rho_0 Left_i \times time_t \\
 & + \rho_1 FoxApp_i \times time_t \times Left_i + \rho_2 FoxWeb_j \times time_t \times Left_i \\
 & + \rho_3 FoxApp_i \times FoxWeb_j \times time_t \times Left_i \\
 & + \sigma_0 TimeConstraint_i \times time_t \\
 & + \sigma_1 FoxApp_i \times time_t \times TimeConstraint_i \\
 & + \sigma_2 FoxWeb_j \times time_t \times TimeConstraint_i \\
 & + \sigma_3 FoxApp_i \times FoxWeb_j \times time_t \times TimeConstraint_i \\
 & + \gamma time_t + \theta X_{it} + \mu_{ij} + \varepsilon_{ijt}.
 \end{aligned}$$

Empirically, our strategy is to hold the effects of demographic characteristics across segments constant but to allow for heterogeneity in the probability of visiting the Fox News mobile website and in the effects of adopting the Fox News app. The coefficients of interest show how the effects of the Fox News app on the Fox News website are moderated by diversity, right- and left-leaning political preferences, and time constraints (i.e., coefficients β_3 , δ_3 , λ_3 , ρ_3 , and σ_3). As a robustness check, we also estimate models that show the effects of each moderating variable separately.

Column 1 of Table 4 shows the estimated coefficients of Equation 3. First, we note that the mean effect of Fox News app adoption estimated from coefficients β_3 , δ_3 , λ_3 , ρ_3 , and σ_3

is $.1333 [\beta_3 + \delta_3 \times \text{meanDiversity} + \lambda_3 \times \text{meanRight} + \rho_3 \times \text{meanLeft} + \sigma_3 \times \text{meanTimeConstraint}] = .3873 + (-.2861 \times .3412) + (.1154 \times .4057) + (-.4513 \times .3782) + (-.0928 \times .3503) = .1333$, which is positive, in support of our conclusion in the previous subsection. We next discuss the moderating effects of media diversity, political propensity, and time constraint on Fox News mobile website consumption conditional on Fox News app adoption. The coefficient of $FoxApp_i \times FoxWeb_j \times time_t \times Diversity_i$ is negative (-.2861) and statistically significant. This means that, conditional on Fox News app adoption, cohorts that are more media-diverse visit the Fox News mobile website less frequently compared with less media-diverse cohorts. These results suggest that media diversity in a consumer's news consumption weakens the complementary effect between a provider's mobile news app and mobile news website.

Table 4, Column 1 also contains the coefficient that shows how political propensity influences the effects of Fox News mobile app adoption on Fox News mobile website visits. Our parameter estimates show that the complementary effect of Fox News app on the probability of visiting the Fox News mobile website (a right-leaning news provider) is stronger among cohorts with right-leaning political preferences. The coefficient for $FoxApp_i \times FoxWeb_j \times time_t \times Right_i$ is positive (.1154) and statistically significant. In contrast, the coefficient of $FoxApp_i \times FoxWeb_j \times time_t \times Left_i$ is $-.4513$. To put these results in perspective, cohorts without left- or right-leaning preferences and with mean levels of Fox News app adoption will be 1.98 percentage points more likely to visit the mobile website than those with no Fox News app adoption; in contrast, those with right-leaning preferences will be 2.12 percentage points more likely to visit, whereas those with left-leaning preferences will be 1.26 percentage points less likely to visit. That is, whereas Fox News app adopters with right-leaning preferences will exhibit stronger complementarity, those with left-leaning preferences will exhibit substitution between the app and mobile website. This finding has important implications for audience targeting, which we discuss in detail in the following section.

Finally, we discuss the effect of a consumer's temporal budget on Fox News mobile website consumption, conditional on Fox News app adoption. Our results show that complementarity is stronger among less time-constrained cohorts because the coefficient of $FoxApp_i \times FoxWeb_j \times time_t \times TimeConstraint_i$ is $-.0928$. The results suggest that customers' time constraints weaken the complementary effects between a provider's mobile news app and website. In Table 4, Columns 2–4, we present results showing the effects of each of the moderators separately. The sign of the coefficients and their significance is the same as in the baseline specification. The magnitudes are also similar across specifications.

We also examined how cohort demographic variables (including income, age, education and urban/rural segments, which we used to construct our cohorts) may influence the complementary effect between the mobile news app and website. We did not find any evidence that the

TABLE 4

Complementarity Is Stronger for Cohorts with Lower Diversity of News Consumption, with a Right-Leaning Propensity of News Media, and with a Lower Percentage of Users Who Are Employed Full-Time

	1 All Interactions	2 News Diversity	3 Right/Left	4 Full-Time Employment
FoxApp × FoxWeb × time	.3873** (.2059)	.2872** (.1201)	.4252** (.1871)	.2986** (.1098)
FoxApp × FoxWeb × time × diversity	-.2861** (.1254)	-.3235** (.1752)		
FoxApp × FoxWeb × time × right	.1154* (.0990)		.1824* (.0981)	
FoxApp × FoxWeb × time × left	-.4513** (.2009)		-.4968** (.2211)	
FoxApp × FoxWeb × time × TimeConstraint	-.0928* (.0590)			-.0981* (.0531)
Constant	.1064** (.0654)	.1269** (.0653)	.1037** (.0655)	.1360** (.0653)
Observations	6,644	6,644	6,644	6,644
R-square	.6312	.6182	.6315	.6128
Number of cohorts	151	151	151	151

*Significant at 10%.

**Significant at 5%.

***Significant at 1%.

Notes: Table 4 presents key coefficients. The coefficients of other variables are available upon request. All regressions include the following controls: the number of people in the household, the length of the mobile service usage, the monthly cost of the mobile service, and variables measuring users' technological sophistication. R-square includes the explanatory power of the fixed effects in the R-square computation. Heteroskedasticity-robust standard errors appear in parentheses. The full table is available upon request.

complementary effect varies significantly among consumers with different age levels, education levels, or locations (urban vs. rural). This may be because, as previous studies have found (e.g., Van den Poel and Buckinx 2005), there may be little association between behavioral heterogeneity and observable demographic characteristics in our empirical setting. Alternatively, our data may also lack the statistical power to identify the behavioral heterogeneity from consumer characteristics. However, we do find that complementarity is systematically weaker for higher-income cohorts. This is consistent with research reports that have shown that higher-income people are less likely to visit Fox News (e.g., Pew Research Center 2012), and so these results could reflect differences in tastes for conservative news.¹²

Discussion and Conclusion

Summary

In this research, we analyzed the impact of mobile news apps on consumer demand at the corresponding mobile news websites. We believe this is an important topic for marketers to understand to achieve better advertising policies across mobile news distribution channels. Using large-scale survey data, we find robust empirical evidence that the adoption of a mobile news app significantly increases the probability of visiting the provider's corresponding mobile website. In doing so, we overcome data limitations by adopting a pseudo-panel technique in which we transform our repeated cross-sectional data into a panel of cohorts. In addition, we find that the complementarity is stronger for consumers who favor less diverse news content, whose political propensity is aligned to that of the news provider, and who are less time constrained. Building on recent theoretical and empirical findings, our findings

support the view that ideological segregation makes it easier for advertisers to segment and target audiences in a multichannel environment.

Managerial Implications

Our findings have several important managerial implications for content providers and advertisers on their mobile advertising decisions across multiple channels. They also hold insights for policy makers on current media "silo" effects among online consumers. We begin by discussing the implications of our findings on various aspects of advertising such as spillover, reach, and frequency on the mobile platform. Given the rapid growth of mobile advertising (International Data Corporation 2013) and the challenges mobile advertisers face (Lohr 2013), our findings offer valuable insights. First, our analysis shows that there is positive traffic spillover from the Fox News app to its mobile news website. Our analysis suggests that the app may be an effective channel for media companies to sustain their traffic levels in the increasingly crowded mobile web landscape.

Second, because our analysis shows that Fox News app adopters are more likely to visit the Fox News websites and consume content on both channels, the app may contribute more to "frequency" than "reach" in mobile advertising metrics. That is, advertisements placed across channels are more likely to have repeated impressions on the same audience than a single impression on a broader set of audiences. Consequently, media planners who pursue frequency more than reach should consider placing ads on both apps and mobile websites. Advertising on multiple platforms substantially increases consumers' ability to remember an advertising campaign compared with when the advertisement is viewed on, for example, television alone (Nielsen 2011). In contrast, it may be more cost efficient for media planners who pursue reach to consider placing ads only on the mobile website to minimize duplicated impressions.

Third, our analysis shows that among Fox News app adopters, right-leaning news readers typically consume

¹²We thank an anonymous reviewer for encouraging this exploration. These results are available from the authors upon request.

more content at the Fox News mobile news website. This finding has two important implications. First, from a media planner's perspective, ads placed on both channels can be expected to repeatedly reach consumers with ideological propensity aligned to that of the news provider—in our case, a conservative audience. Therefore, our results suggest that ideological segregation will aid advertisers who want to target segmented consumers on multiple mobile channels.

Second, from a policy maker's perspective, our result suggests that an additional channel on mobile devices contributes to a higher degree of segregation or media "silo" among online audiences with similar political propensity. In our empirical setting of Fox News, the right-leaning audience exhibits a stronger channel complementarity, whereas the left-leaning audience exhibits the opposite and shows substitution between the two mobile channels. The contrast with recent research is informative. Recent theoretical models have shown that increases in media competition—enabled by the digitization of news content—might lead consumers to self-segregate ideologically (e.g., Mulainathan and Shleifer 2005). However, Gentzkow and Shapiro (2011) find no evidence that the Internet is becoming more ideologically segregated over time, in part because a significant share of consumers get news from multiple outlets. Our findings suggest that the introduction of new channels may increase some consumers' visits to their preferred news channels.

Finally, we suggest that the best strategy for news providers to attract more traffic on mobile devices is to manage the two distribution channels differently—that is, to offer more news stories on the mobile website than the app rather than simply devoting most of their resources to developing apps. Marketers may gain significant benefits from having different digital media strategies across the two platforms, even though the cost might be high. A company could, for example, have different types of advertisements on the two platforms (i.e., simple banner advertisements on apps and more detailed advertisements on mobile websites) and, consistent with our findings, rely on complementarities to encourage consumers to visit both platforms.

Further Research

Our findings of complementarity offer several directions for further research. First, further study of the existence of complementarity or substitution across news media channels is necessary. Our study, like some prior work in this lit-

erature stream (e.g., Gentzkow 2007), focuses on a small number of providers in a specific market. Given findings of both complementarity and substitution in different contexts, more research is needed to identify when complementarity is most likely to be most prevalent. This echoes calls in other areas of the marketing literature on channels to identify whether and when one channel complements or substitutes for another (e.g., Avery et al. 2012).

Relatedly, researchers can extend the current study by investigating the mechanism behind the source of complementarity between two channels. Although we discuss similarities and dissimilarities between two mobile channels and report the extent of complementarity in our empirical analysis, the MobiLens data do not allow us to study in detail the mechanism responsible for the reported complementarity. If future researchers have access to panel data as well as the data on articles that are consumed on the two different channels, they will be able to study consumer behavior in greater detail. For example, future studies can identify the different news consumption patterns on two channels, which may evolve differently over time as consumers become more familiar with the particular app or the mobile website. Findings in this area may help news providers with their content management decisions between different channels.

Last, further research could take a similar approach to examine the interrelationships across different content providers or different channels that are associated with social networking sites. Given the wide adoption of social networking sites among consumers, these sites' relationships with existing online media sites would be of managerial importance to many media planners. In this context, researchers could study the relationships between Facebook and online news providers by measuring the effect of Facebook usage on news consumption. For example, if consumers meet their news needs at Facebook, their news consumption at the traditional online news sites may be lower. Alternatively, researchers can study the multichannel relationship conditional on Facebook: consumers who use their computers or laptops to access social networking websites might also be more likely to consume social networking apps on their mobile devices to take advantage of a mobile device's ability to access online social networking anytime and anywhere. In summary, the increasing proliferation of news sources and news channels offers many opportunities for further research, and we hope our findings spur other work in this important area.

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