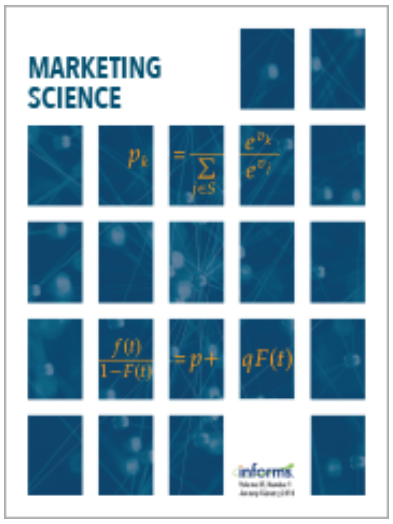

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Rising Prices Under Declining Preferences: The Case of the U.S. Print Newspaper Industry

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Abstract. Between 2006 and 2011, daily print newspapers in the United States lost 20% of their paid subscribers, partly because of the increasing availability of alternative sources of news, such as free content provided on newspaper websites and by news aggregators such as Yahoo. However, contrary to the expectation that firms respond to softening demand by lowering prices, newspapers increased subscription prices by 40%–60% during this period. In this paper, we explain and quantify the factors responsible for these price increases. We calibrate models of readership and advertising demand using data from a top-50 U.S. regional print newspaper. Conditional on these demand models, we calibrate the newspaper's optimal pricing equations and assess whether the increases in subscription prices are mainly rationalized by (a) the decline in overall reader willingness to pay (WTP) in the presence of heterogeneity among subscribers, which rendered it optimal for the newspaper to focus on the high WTP readers, or (b) the newspaper's reduced incentive to subsidize readers at the expense of advertisers, because of softening demand for newspaper advertising. We find that the decline in the ability of the newspaper to subsidize readers by extracting surplus from advertisers explains most of the increase in subscription prices. Of the three available subscription options (daily, weekend, and Sunday only), subscription prices increased more steeply for the daily option, a pattern consistent with the view that newspapers are driving away low valuation weekday readers while preserving Sunday readership and the corresponding ad revenues. Thus, our research augments theoretical propositions in two-sided markets by providing a formal empirical approach to unraveling the relative importance of the roles played by agents on the subsidy and demand sides in determining prices.

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Keywords: pricing • two-sided markets • newspaper industry • print newspapers • newspaper advertising

1. Introduction

The U.S. newspaper industry is facing unprecedented challenges due to dramatic losses in revenue and profitability. As a result of increasing availability of free news content through newspaper websites and news aggregators such as Yahoo, readers are becoming less willing to pay for print newspapers (Fallows 2010, George 2008). At the same time, U.S. newspaper publishers have responded by increasing subscription prices by 40%–60% during this period.[1] This is counterintuitive because declining willingness to pay (WTP) and the associated higher price elasticity typically render it optimal to lower prices (Tirole 2007). Furthermore, as two-sided platforms, newspapers derive their revenue from both readers and advertisers, with, historically, 80% coming from the latter. Since ad revenue is tied to readership, raising prices might accelerate the decline in print circulation and further erode advertising revenues.

A common explanation for increasing prices, even with declining overall WTP, is that firms strategically set prices to exploit differences in WTP among consumers (Hauser and Shugan 1983). A decline in the overall WTP for the print newspaper might have led to a situation where a subset of readers with very low WTP is not profitable to serve. Consequently, the higher margins realized by catering only to high WTP readers might offset losses in profits from not serving low value readers. Several highly publicized industry reports (Weber and Poyar 2012, Filloux 2012) claim that newspapers' price-based segmentation strategies on the reader side are primarily responsible for the steep increases in subscription prices.

A second, heretofore underinvestigated rationale for the increases in subscription prices stems from the two-sided nature of the newspaper industry. Since advertisers are believed to value access to readers more than readers value newspaper advertising, newspapers

have historically subsidized readers and extracted premium prices from advertisers (Rochet and Tirole 2003, Gabszewicz et al. 2005, Parker and Van Alstyne 2005). However, the advent of alternative media options such as search advertising has made print newspapers less attractive to advertisers. Thus, advertisers' waning preference for print newspaper advertising might have lowered newspapers' incentive to subsidize readers at the expense of advertisers.[2]

In this paper, we empirically examine whether (a) changes in the overall WTP among readers in the presence of heterogeneous preferences, versus (b) a lower incentive to subsidize readers as a result of declining preference for print advertising on the advertiser side, predominantly drove the increases in subscription prices. We use unique data from a top-50 regional U.S. newspaper that serves a large metropolitan area. Our data span 72 months, from January 2006 through December 2011, and contain the following pieces of information:

1. Monthly print subscriptions and prices for the three most popular options: daily, weekend, and Sunday only, corresponding to print newspaper subscriptions for all seven days; Friday, Saturday, and Sunday; and Sunday only, respectively. These data are broken down geographically by the submarkets (counties) served by the newspaper. We augment these data with subscription information for a sample of individual subscribers. These data provide us information on switching behavior between these subscription options, as well as the outside option of no subscription, over time. Access to submarket and option-level subscription data as well as individual-level data enables us to characterize the readership demand model and identify heterogeneity in readers' WTP for the newspaper, and to account for reader substitution across options.

2. Monthly data on print advertising revenues and ad rates on the three types of advertising—displays, inserts, and classifieds—to inform a model of how demand for each type of advertising changes with ad rates and readership. In addition, access to data spanning several years enables us to infer how advertising demand changed from year to year as a result of exogenous changes in competition in the advertising market.

We propose a model that describes the behavior of three sets of agents: readers, advertisers, and the newspaper. Readers choose one of the three available subscription options or the outside option of not subscribing to the print newspaper. Advertisers choose the amount of advertising to place in the three possible advertising types. Conditional on readership and advertising demand, the newspaper sets both subscription prices for readers for the three subscription options and ad rates for each advertising type. We estimate the readership and advertising models using the generalized method of moments (GMM) while accounting for the simultaneity of the decisions made by readers, advertisers, and the newspaper by employing appropriate exclusion restrictions. Conditional on the estimated readership and advertising demand model parameters, we compute the optimal price–cost margins derived under the assumption of profit maximization. We then calibrate the pricing equation by matching the observed prices with the optimal prices to infer the marginal cost. We evaluate the optimal pricing rule via out-of-sample validation. We then compare these price–cost margins under alternative scenarios to assess the extent to which the two explanations rationalize the increases in print subscription prices.

Based on our calibration of the readership demand model, we find a decline in the intrinsic preference to subscribe to the newspaper, with the decline being more pronounced for the daily option. Estimates from our advertising demand model point to a declining intrinsic attractiveness among advertisers for print newspaper advertising, suggesting a possibly weakening incentive to subsidize readers at the expense of advertisers.

Based on our estimates from the readership and advertising demand models, we compute the optimal subscription and advertising price–cost margins and calibrate the subscription pricing model. We find that the pricing model predicts the prices in the holdout period with reasonable accuracy, suggesting that the proposed model is appropriate. Our results suggest that the increase in subscription prices was driven solely by the newspaper's strategic decision to increase its price–cost margins on the reader side, rather than increases in costs. Moreover, we find that the decline in WTP among readers in the presence of heterogeneous preferences explains only a small fraction of the increase in subscription prices. On the other hand, over 90% of this increase can be traced back to a declining incentive to subsidize readers at the expense of advertisers because of waning interest in print advertising, which was possibly driven by exogenous changes in the competitive environment (i.e., after accounting for changes in ad rates and readership).

Overall, our findings provide key insights into the functioning of newspapers. When the traditional newspaper model was to maintain a large readership base, it made sense to keep subscription prices relatively low, while charging advertisers premium prices for access to readers. However, after years of declining circulation, it is optimal for print newspapers to move toward a balanced subscription-cum-advertiser funded model.[3] Thus, as advertising continues to decline, a premium pricing strategy aimed at charging its readers higher prices is possibly the way forward for newspapers (*The Guardian* 2011). The broader finding that a downward shift in the demand curve on the advertising side can

have implications for pricing on the readership side is consistent with the theoretical predictions in the literature (e.g., Rochet and Tirole 2003). However, our research is about both documenting the direction of the results (i.e., a downward shift in the demand curve on the advertising side can have implications for pricing on the readership side) and quantifying the relative magnitude. In this regard, it is surprising that the advertising side (rather than the changes on the reader side) played such a dominant role in driving subscription prices. In that sense, we augment theory by providing a formal empirical approach to unraveling the relative importance of the roles played by agents on the subsidy versus demand side in determining prices in a two-sided market. In Section 7, we discuss some possible implications of our findings beyond the specific context of our investigation.

The rest of this paper proceeds as follows. In Section 2, we briefly provide a conceptual background to our research question. Section 3 describes the data used in the estimation and provides descriptive evidence as a motivation for our research question. In Section 4, we discuss details of our proposed model. Section 5 discusses identification and the estimation strategy. Results from the model are presented in Section 6, and Section 7 concludes.

2. Conceptual Background

Our research is related to two emerging streams of literature: work studying the impact of consumer heterogeneity on firms' pricing decisions and literature on pricing in two-sided markets.

Our first explanation for the observed price increase is the commonly advanced one related to heterogeneity in WTP among readers. In contexts where customers exit the market subsequent to making a purchase, the trajectory of optimal prices would decrease (increase) over time if high WTP consumers have an incentive to purchase early (late). In the context of video games and game consoles, wherein high WTP consumers tend to purchase early, Nair (2007) and Liu (2010) argue that firms face a shrinking market and a remaining pool of low WTP buyers over time. As a result, firms employ intertemporal price discrimination by initially charging premium prices to high WTP customers and reducing prices subsequently to serve the low WTP consumers. By contrast, in his investigation of airline ticket purchases, Lazarev (2013) documents that high WTP business travelers tend to purchase their tickets later to reduce the uncertainty around their travel. In such a scenario, airlines find it optimal to increase prices over time.

In settings where customers make repeat purchases, the optimal price trajectory would respond to the changing composition of customers, possibly because of the entry of new alternatives. For example, Frank and Salkever (1997) and Ching (2010) show that prices of branded pharmaceutical drugs can increase when generics enter, although consumers are, on average, less willing to pay premium prices for branded drugs. They argue that with the entry of generics, price-sensitive customers switch to cheaper generics. As a result, branded drugs serve only the high WTP consumers, which renders it optimal to increase prices subsequent to the entry of generics. Hauser and Shugan (1983) offer a similar rationale for why it might be optimal to increase prices in response to competitive entry. Our reasoning is similar: the decline in the overall WTP for the print newspaper, possibly because of the availability of alternative sources of news, might have rendered it unprofitable to serve low WTP readers. Consequently, higher margins realizable by catering only to high WTP readers should offset profit losses from not serving low WTP readers.

We draw our second explanation for increasing subscription prices from theoretical propositions in the literature on two-sided markets. Since newspapers derive their revenues from two sources, i.e., readers and advertisers, with at least one side valuing the presence of the other, they operate in two-sided markets (Rochet and Tirole 2003). An implication of two-sidedness is that the markup on one side will depend on the elasticity of the response on both sides of the market and the markup charged on the other side (Rysman 2004, Kaiser and Wright 2006, Wilbur 2008, Song 2012, Fan 2013). As a result, theoretical work in the area of two-sided markets (Parker and Van Alstyne 2005, Rochet and Tirole 2003) predicts that the prices on one side (e.g., reader) may be subsidized at the expense of the other side (e.g., advertiser). An implication of this cross-subsidy is that a change in the demand characteristics on one side of the market can trigger an adjustment in the optimal price charged on both sides of the market.

In the context of newspapers, Seamans and Zhu (2014) empirically document that a negative shock to the advertising side (the entry of Craigslist into the newspaper's local market) is associated with increases in subscription prices. In a related paper, Angelucci et al. (2013) investigate the effect of heightened competition in newspapers' advertising markets, on their incentive to price discriminate between subscribers. Our research adds to the findings of Angelucci et al. (2013) and Seamans and Zhu (2014) on several dimensions. First, unlike Angelucci et al. (2013) and Seamans and Zhu (2014), we have access to a rich set of readership and advertising data, which enable us to characterize readership and advertising demand functions and how they have evolved over the years. Consequently, we are able to quantify the extent to which changes in the readership versus advertising demand contributed to the increase in subscription prices. Note

that Angelucci et al. (2013) and Seamans and Zhu (2014) consider only the effect of changes on the advertising side that might have been induced by breaks in the competitive environment (as opposed to actual changes in demand) on subscription prices. Furthermore, we have readership and advertising demand data broken down to the level of various options (such as newspaper subscription options and display, insert, and classified advertising). This enables us to understand the extent to which changes in demand at the individual subscription and advertising option levels led to the increase in subscription prices, and thus make richer comments regarding newspaper pricing and product portfolio management decisions. Finally, a substantive difference is that both Angelucci et al. (2013) and Seamans and Zhu (2014) investigate newspaper markets prior to 2006, which reflected a relatively stable period in the industry. On the other hand, we motivate our study based on the dramatic changes in the newspaper industry, especially related to advertising and readership demand since 2006, the year that commenced the newspaper's most pronounced advertising trough (see Edmonds et al. 2013).

3. Data

The data used in our empirical analysis comes from a leading regional U.S. newspaper that prefers to remain anonymous. The data span 72 months from January 2006 through December 2011. The newspaper ranks among the top 50 in the country by paid circulation and is a local monopoly in its market.[4] The firm also operates an online news website that was free for readers during the period of our analysis, with ad revenues from the newspaper's website accounting for less than 5% of the firm's total revenues.

On the readership side, we use aggregate circulation data at the level of the newspaper's three most popular subscription options. These data consist of monthly information on paid subscriptions for the newspaper's five major submarkets (top five counties by circulation) for the three most popular subscription options: daily, weekend, and Sunday only. Subscribers residing in these submarkets accounted for 93.4% of the newspaper's total subscription base, and the newspaper's top three subscription options accounted for 95.6% of its paying subscribers. Although the total circulation of newspapers typically consists of paid subscriptions and single-copy (newsstand) sales, we have data at the submarket level only for subscriptions. Hence, we use subscription data as a proxy for readership in our empirical analysis.[5] Subsequently, we investigate the robustness of our results to the inclusion of single-copy sales as an additional choice option for readers. In addition to these aggregate data, we use monthly subscription information for a random sample of households (details below). As we discuss subsequently, we augment our estimation by using these individual-level data in conjunction with the aggregate data to aid in the estimation of the readership heterogeneity distribution.

While our aggregate circulation data are at the submarket (county) level, subscription prices do not vary at this level of disaggregation. For each subscription option, the firm charges different prices in regions within versus outside the newspaper's core market.[6] In our data, two counties fall within the core market and account for 80%–85% of subscribers. The remaining three counties fall outside the core market. We compiled monthly subscription prices for each option within and outside the core market from the Alliance for Audited Media's (AAM) audit reports.

On the advertiser side, we have data on monthly ad revenues and rates for the print newspaper for three advertising formats: (a) display advertising, (b) newspaper inserts, and (c) classified advertising. These three advertising types constitute over 96% of newspapers' advertising revenues. Advertisers that opt for display advertising generally have prespecified advertising budgets. Classified advertisers, on the other hand, are small business owners or individuals who prefer to post information about products (e.g., "for sale—telephones," "wanted—kitchen appliances") or services (e.g., "moving services," "truck rental"). There is little overlap between newspapers' display and classified advertising revenue streams (Seamans and Zhu 2014). A majority of advertisers that purchase newspaper inserts include grocery stores and retail establishments (Smith and Wiltse 2005). Furthermore, across the three types, there are differences in ad placement/ad appearance. While display ads include graphics/firm logos and typically go alongside newspaper editorial text, classified ads generally appear in a prespecified section of the newspaper (the "Classifieds" section). Newspaper inserts, which generally include product information or intimate promotions to consumers, appear as separate add-ons to newspapers.

Finally, we discuss the representativeness of the patterns in the focal newspaper's readership and advertising of industry-wide trends in Online Appendix 6.

3.1. Descriptive Analyses

3.1.1. Readership Data. As discussed previously, our readership data contain information on newspaper subscriptions for the three most popular subscription options in the newspaper's five major submarkets (counties). Access to disaggregate readership data enables us to explore differences in subscription behavior across options and submarkets. During the period of our analysis (i.e., 2006–2011), 14% of households in the newspaper's market subscribed to the focal newspaper. Cross-sectionally, the core market contained a higher percentage of subscribing households (18.9%)

Table 1. Descriptive Statistics

(A) Readership

Option	Avg. subscription share (aggregate data) (% of households subscribing to the newspaper) (%)		Avg. subs. price (inflation adjusted) ($/month)	
	Within the core market	Outside the core market	Within the core market	Outside the core market
Daily	13.24	2.62	16.28	18.28
Weekend	0.98	0.16	11.76	12.48
Sun. only	3.97	0.86	10.12	10.88

(B) Advertising revenues

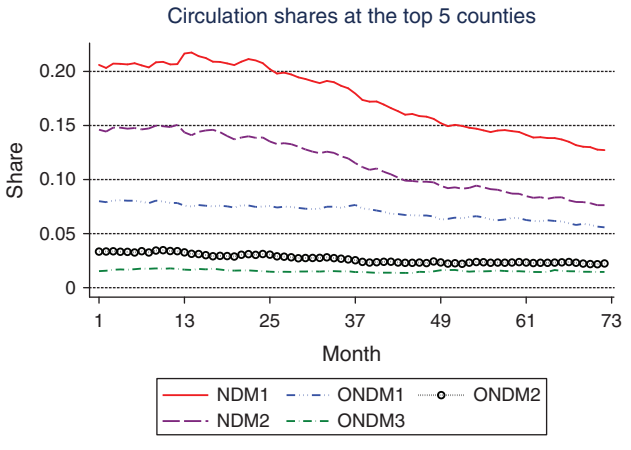
Advertising type	Year 2006 (in mill. $)	Year 2011 (in mill. $)	Change (%, with year 2006 as base)
Display	9.10	3.85	−57.7
Inserts	3.95	2.26	−43.38
Classifieds	4.04	0.47	−88.27

than regions outside the core market (3.6%). Moreover, subscription prices outside the core market are higher, possibly on account of higher delivery costs outside the core market.[7]

Subscription to the daily option provides home delivery of the newspaper on all seven days of the week and is the most expensive option (see panel (A) in Table 1). The daily option is also the most popular option among subscribers both within and outside the core market. Conditional on subscribing to the focal newspaper, 72.4% (71.6%) of readers within (outside) the core market opt for the daily option. The corresponding numbers for the weekend and Sunday only options are 5.4% (4.4%) and 22.2% (23.9%), respectively.

In panel (A) of Table 1, we report the unconditional market share (i.e., number of subscribers as a proportion of the number of households in each county) for each subscription option. These results reveal that there is substantial cross-sectional variation in the subscription shares for each option within and outside the core market. Furthermore, the temporal pattern for subscription shares in Figure 1 demonstrates that there is significant cross-sectional heterogeneity across the different submarkets within the newspaper's market.

Figure 1. (Color online) County Circulation Shares



Notes. Month 1 corresponds to January 2006, and month 72 corresponds to December 2011. ONDM, Outside the newspaper's designated (core) market; NDM, newspaper's designated (core) market.

Between 2006 and 2011, prices for all three subscription options increased sharply. In Table 2, we present the percentage increases in inflation-adjusted subscription prices over this duration for the daily, weekend, and Sunday-only options, both within and outside the core market. The daily option witnessed the steepest price increase of nearly 77%, both within and outside the core market, while prices of the weekend and Sunday-only options also increased by 52% and 38%, respectively.

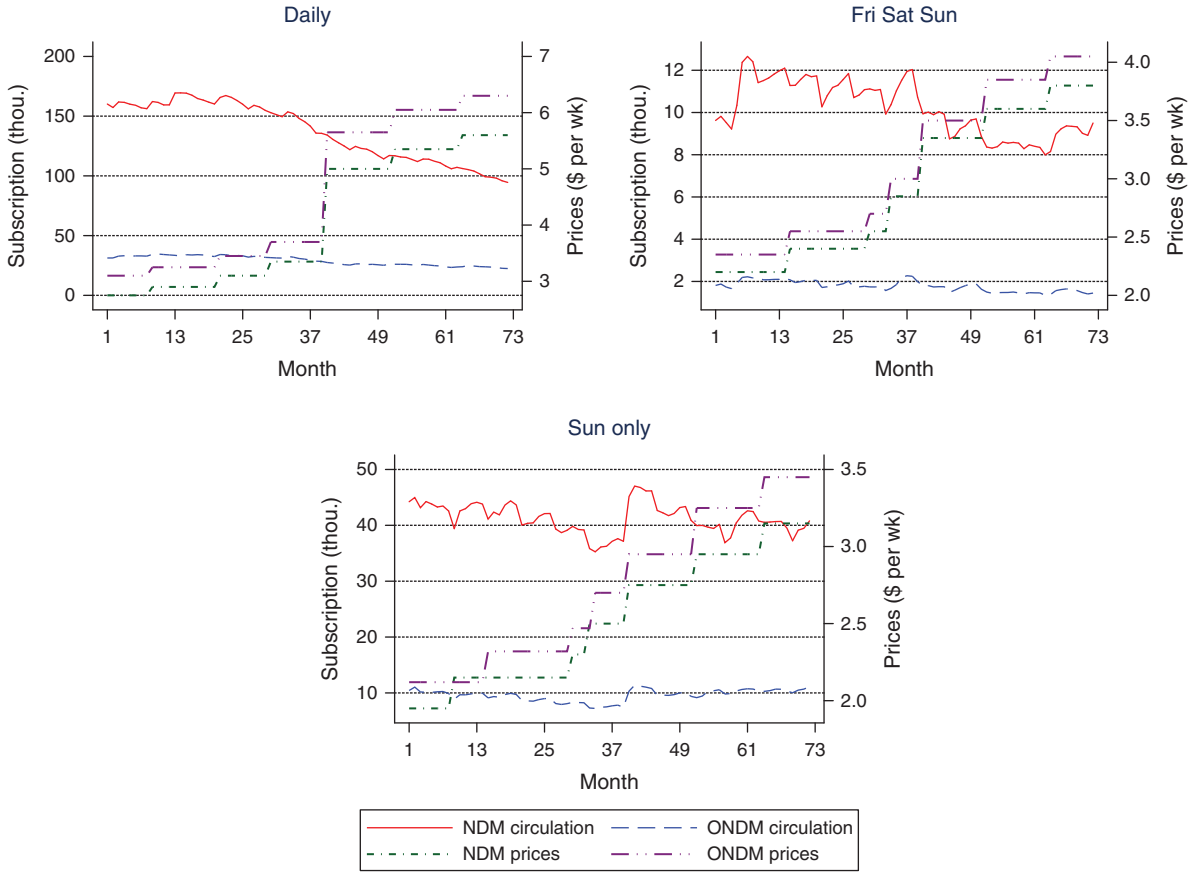
Since subscription prices vary by area within/outside the core market, we plot the share evolution by pooling across submarkets corresponding to these regions. From Figure 2, we see that the majority of the decline in print subscriptions arises from within the core market and for the daily option, which also has the argest readership base.[8] To track the temporal evolution of option-level circulation at each submarket, we computed the average annual percentage change in subscriptions over time for the five submarkets for

Table 2. Subscription Price Increase for Each Option

Option	Within core market (%)	Outside core market (%)
Daily	77.22	77.45
Weekend	52.73	52.52
Sun. only	37.74	43.70

Note. The table shows the percentage increases in inflation-adjusted prices between 2006 and 2011.

Figure 2. (Color online) Temporal Pattern of Subscriptions Within and Outside the Newspaper's Core Market



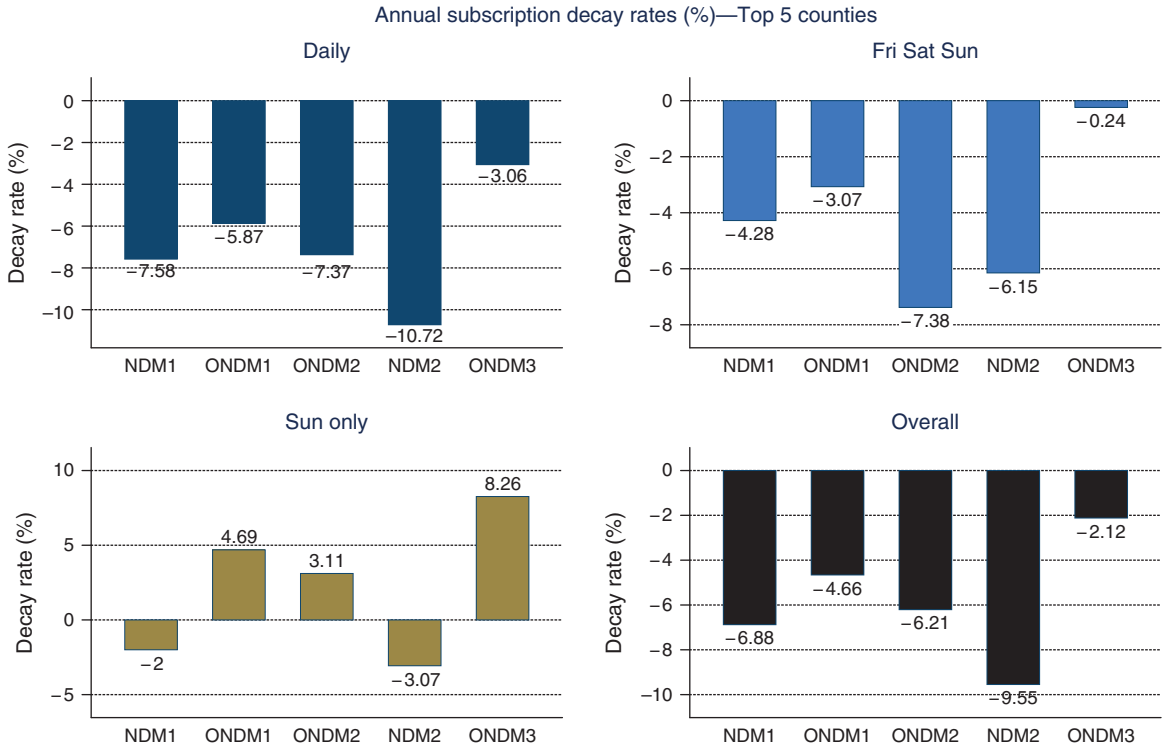
Notes. Month 1 corresponds to January 2006, and month 72 corresponds to December 2011. ONDM, Outside the newspaper's designated (core) market; NDM, newspaper's designated (core) market.

all three options and report them in Figure 3. Figure 3 shows that subscription shares for the daily option decay at a faster rate (between 8% and 11%) in counties within the core market compared to those outside (between 3% and 7%). Subscription shares for the newspaper's Sunday-only option are relatively stable (and even weakly increasing) especially in counties outside the core market. This suggests that some readers may be substituting from a daily subscription to the cheaper Sunday-only subscription over time. On average, across the three options, the newspaper's circulation witnessed steep year-on-year declines within (outside) the core market of between 7% and 10% (2% and 6%).

Examining the temporal path of newspaper subscriptions in this market, we conjecture that readers' WTP for news is declining over time, which might have had implications for subscription pricing. Nevertheless, the concomitant increase in subscription prices might also have contributed to the decline in subscriptions. While we cannot definitively state whether a decline in intrinsic preference or rising prices contributed to the drop in subscriptions without calibrating a demand model with appropriate exclusion restrictions to pin down the direction of causality, we point the reader to some suggestive evidence. First, note that of the three subscription options, the daily option witnessed the greatest circulation decline, especially within the core market (see Figure 2). At the same time, the daily option also experienced the steepest price increases (77% relative to the 40%–50% for the other two options, as described in Table 2). This suggests that price increases probably played a significant role in driving subscriptions down. On the other hand, the Sunday-only option experienced a marginal decline or even growth in subscriptions despite the increase in corresponding subscription prices, suggesting that price may not be the main reason why readership demand declined. Subsequently, we use the estimates from the readership demand model to quantify the relative role of these alternative drivers in reducing circulation.

In addition to prices, an important driver of newspaper subscription is quality. Researchers (e.g., Berry and Waldfogel 2010, Fan 2013) have used the size of the newsroom and the average number of news pages as measures of quality. In our application, we use the latter as a control for quality. Our data on the average number of (nonadvertised) news pages varies by subscription option on an annual basis. The number of news pages

Figure 3. (Color online) Plots of the Average Year-on-Year Percentage Decay Rates in Circulation Shares Across Counties Within and Outside the Core Market (Between 2006 and 2011)



Note. ONDM, Outside the newspaper's designated (core) market; NDM, newspaper's designated (core) market.

decreased by about 27% over our analysis window, suggesting that the overall quality of the newspaper did not increase over time, thereby making it less likely that an increase in quality drove the price increases.

We augment the aggregate data with individual-level subscription information for a random sample of 5,565 households, accounting for 3.4% of all subscribers. These households were drawn from the population of subscribers such that each submarket (i.e., county) was represented proportionally to its subscriber base.[9] To verify whether the individual data are representative of the population of subscribers, we consider the corresponding (conditional) subscription shares of the three options. From Table 3 we see that the individual data are fairly representative of the population of subscribers in this regard. In addition, we also compare the two data sets in terms of their temporal trajectory. In Table 4, we present the average annual rate of decay in the number of subscribers for each option for the two data sets. We find that the individual data are representative of the population of subscribers.

3.1.2. Advertising Data. The newspaper sets advertising rates for display and classified ads in dollars per column inch of advertising, while ad rates for inserts are in dollars per 1,000 newspaper inserts. By dividing the revenues by these ad rates, we computed the quantity of advertising in terms of the number of column inches for display ads and classifieds, and thousands of inserts for preprint ads. We present temporal patterns in advertising revenues, rates, and quantity in

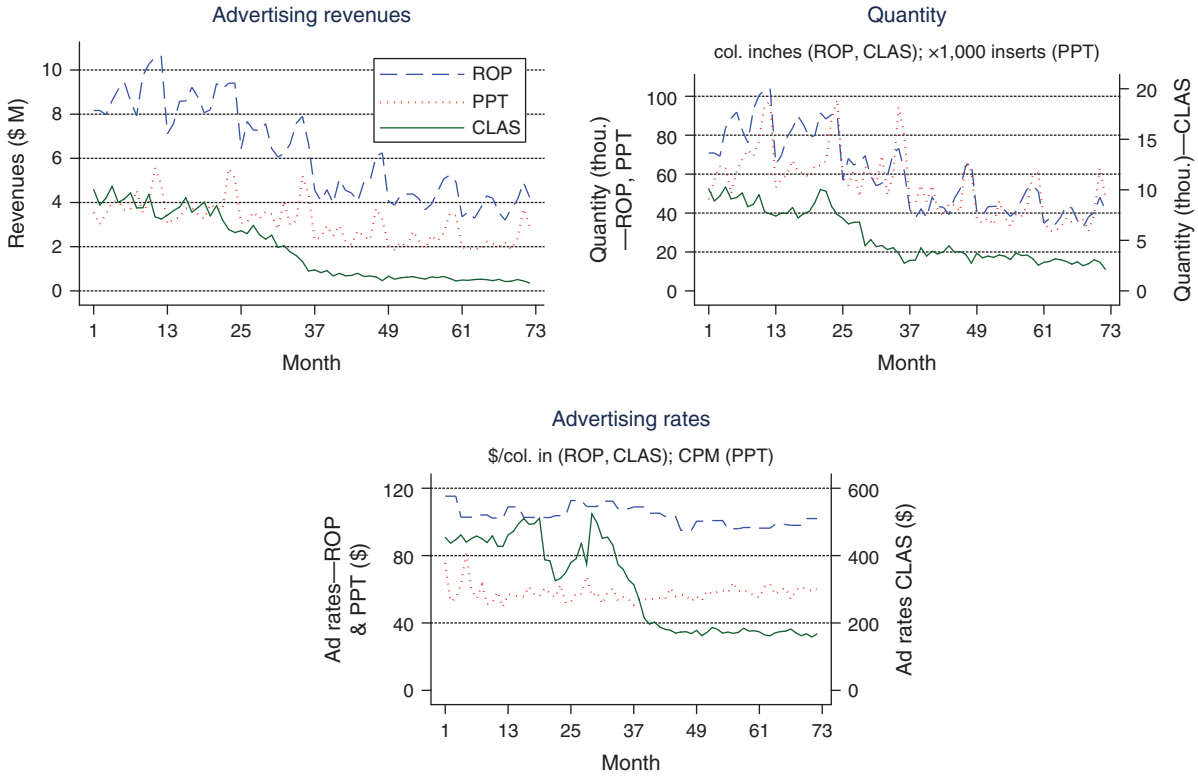
Table 3. Average Market Share of Each Option, Conditional on Subscribing to the Newspaper

	Based on aggregate data (%)		Based on individual data (%)	
Option	Within the core market	Outside the core market	Within the core market	Outside the core market
Daily	72.79	71.98	70.14	69.08
Weekend	5.39	4.40	4.87	4.38
Sun. only	21.83	23.63	25.00	26.55

Table 4. Average Year-over-Year Percentage Decay Rate in Circulation Shares (Between 2006 and 2011) Within/Outside the Core Market

	Aggregate data (%)			Individual data (%)		
	Daily	Weekend	Sun. only	Daily	Weekend	Sun. only
Core market	−8.36	−4.75	−2.27	−8.44	−4.39	−2.78
Outside core market	−6.21	−5.09	4.46	−7.14	−5.50	5.24

Figure 4. (Color online) Advertising at the Focal Newspaper



Notes. Month 1 corresponds to January 2006, and month 72 corresponds to December 2011. ROP, Run-of-print (display) ads; PPT, preprint ads; CLAS, classifieds.

Figure 4. From the first panel in Figure 4, we see that the revenues from all three types of advertising declined. Panel (B) in Table 1 presents the firm's average ad revenues from each of these advertising types in years 2006 and 2011. While display and inserts lost 57.7% and 43.4%, respectively, during our analysis period, classified ad revenues experienced the steepest decline of 88.3%. The steep decline in display and classified advertising has been attributed to the increasing shift in both advertiser and consumer interest toward nonnewspaper media such as Google/Yahoo (Sridhar and Sriram 2015) and Craigslist (Seamans and Zhu 2014), respectively. On the other hand, newspaper inserts have remained relatively stable in the face of external competition primarily because of their higher targeting ability (Sullivan 2012, Maynard 2011).

Between 2006 and 2011, classified ad rates at the focal newspaper declined by 66%, possibly as a result of the growing popularity of Craigslist. The rates for display ads and inserts experienced smaller declines of 16.7% and 10.8%, respectively. As advertisers typically use a cost per reader (CPM which stands for cost per mille) metric to inform their advertising decisions, we present the CPM for each of the advertising options in Table 5 to track variations in CPM over the course of our analysis. While the CPM for inserts was largely stable, that for display (classified) ads increased (decreased) over time.[10]

Table 5. CPM for Each Advertising Option

Year	Display	Inserts	Classifieds
2006	0.44	59.60	1.83
2007	0.42	57.27	1.75
2008	0.48	56.85	1.82
2009	0.50	54.88	0.98
2010	0.53	58.20	0.94
2011	0.57	59.30	0.97

Note. CPMs for display and classifieds are computed by dividing the corresponding ad rate (in dollars per column inches) by the number of readers (in thousands); those for inserts are in cost per thousand inserts.

4. Model

In this section, we discuss the decisions of readers, advertisers, and the newspaper firm. Readers choose one of three subscription options (daily, weekend, or Sunday only) or the outside option of not subscribing. Advertisers make quantity choices on the three available advertising types: display ads, inserts, and classifieds. The newspaper decides subscription prices for the three options and advertising rates for each of the three advertising types. We discuss how we model these decisions.

4.1. Readership Model

We begin by specifying the utility that reader i who belongs to submarket l derives from subscribing to the

print newspaper option $m \in$ {daily (Monday through Sunday), weekend (Friday, Saturday, Sunday), Sunday only} during month t as

$$U_{ilmt} = \alpha_{ilmt} + \beta_0 p_{lmt} + \beta_1 newspgs_{mt} + \xi_{lmt} + \varepsilon_{ilmt}, \quad (1)$$

where α_{ilmt} is the intrinsic preference that reader i living in submarket l has for subscription to newspaper option m at time t, p_{lmt} is the inflation-adjusted price paid by the reader in submarket l for a month's subscription of option m at time t, and $newspgs_{mt}$ is the average number of pages of news content (i.e., nonadvertising pages) available in the newspaper for subscription option m at time t. We use the number of news pages (or news hole; see Fan 2013) as a proxy for the quality of the newspaper as perceived by readers (Berry and Waldfogel 2010).[11] The indirect utility from the outside option is normalized to be $U_{i0t} = \varepsilon_{i0t}$. Given the decline in print circulation and the shift in consumer interest toward outside news options, ex ante, we expect intrinsic preferences (α_{ilmt}) for newspaper subscription to decay over time. The term ε_{ilmt} is an independent and identically distributed (i.i.d.) type 1 extreme-value-distributed error that captures user i's idiosyncratic taste for subscription option m at time t. The term ξ_{lmt} captures the effect of aggregate demand shifters unobserved to the econometrician but observed by the reader and the newspaper.[12] Examples of such unobserved factors include changes to the newspaper's popular op-ed contributor team, which might influence the quality of news. Unobserved demand shifters could be correlated with prices and the number of news pages, which might render these variables in Equation (1) endogenous. We control for this endogeneity by using instrumental variables (described in Section 5.2.2).

In the econometric model, we adopt a specification for α_{ilmt} in Equation (1) of the form

$$\alpha_{ilmt} = \alpha_{im} + \bar{\alpha}_l + \gamma_l X_{lt} + \delta_t^d I_t, \quad (2)$$

where $\alpha_{im} \sim N(\alpha_m, \Sigma)$ is the time-invariant component of utility that reader i derives from subscribing to option m. The term α_m is the mean subscription preference among readers for subscription option m, and Σ is the covariance matrix of preferences across readers. Since we do not impose any a priori restrictions on Σ, our specification allows for the possibility that households that have a high preference for the daily option also have a higher or lower (than average) preference for the other subscription options. The term $\bar{\alpha}_l$ is the fixed effect for submarket l. The vector of submarket fixed effects accounts for the differences in the mean preference for subscription across submarkets. The term X_{lt} is a vector of demographic characteristics at submarket l at time t that shift the intrinsic preference for the newspaper. In our specification, we use the time-varying median income in each submarket as a shifter of the intrinsic preference.[13] For flexibility, we allow the effect of the demographic characteristics on the intrinsic preference (i.e., γ_l) to vary by submarket l.

We allow for temporal evolution in the intrinsic preference by using flexible semiparametric controls in the form of year fixed effects (I_t).[14] The temporal evolution of preference for the newspaper is also clearly influenced by the increased propensity toward Internet news consumption. The year fixed effects capture deviations in the overall subscription preferences above and beyond changes in (i) consumer demographics, (ii) subscription prices, and (iii) quality of the newspaper. Since the three subscription options may have experienced different temporal changes in intrinsic preference, we also estimated an alternative specification that included year–subscription option fixed effects. However, since our data on the number of news pages varies at the year–subscription option level, we cannot include this as a covariate in this alternative specification. Therefore, the year fixed effects in this alternative specification also pick up changes in the quality of the newspaper.

Since subscription shares decay differentially across submarkets within and outside the core market (see Figure 2), we allow the δ's to vary over time differently across submarkets within and outside the core market ($d = 1, 0$ to signal within and outside, respectively). We also allow the price sensitivity parameter to vary for submarkets within and outside the core market to allow for differences in the rate of change of subscription shares.

The specification in Equation (1) assumes that consumers' utility is not affected by the levels of advertising in the newspaper. The rationale is that newspaper readers are unlikely to be influenced by advertising levels because newspaper ads are more easily skipped compared to other media such as radio (Argentesi and Filistrucchi 2007, Gabszewicz et al. 2004, Rosse 1970). We empirically tested for this by allowing advertising (proxied by total advertising quantity) to influence consumer utility and found that its effect was statistically insignificant across the various alternative model formulations that we tested. We provide details of the various alternative model formulations in Online Appendix 2. Thus, we assume that advertising levels do not influence readership decisions, an assumption that also breaks the circularity problem introduced by the cross-dependency between advertising and readership systems in determining optimal prices. Furthermore, this is a common assumption made by papers studying the newspaper industry (Argentesi and Filistrucchi 2007, Fan 2013, Gentzkow 2007) and motivated by a similar empirical finding that newspaper advertising quantity does not influence readers' decisions.

Given our assumption that ε_{ilmt} follows an extreme value distribution, the probability that consumer i chooses option m is given by

$$P_{ilmt} = \frac{\exp(\alpha_{ilmt} + \beta_0 p_{lmt} + \beta_1 newspgs_{mt} + \xi_{lmt})}{1 + \sum_{m'=1}^{3} \exp(\alpha_{ilm't} + \beta_0 p_{lm't} + \beta_1 newspgs_{m't} + \xi_{lm't})}. \quad (3)$$

Our assumption of extreme-value-distributed errors generates the following expression for subscription shares for submarket l and option m:

$$S^d_{lmt} = \int_{\nu} (\exp(\alpha_{im} + \beta^d_0 p_{lmt} + \beta_1 newspgs_{mt} + \gamma_l X_{lmt} + \delta^d_t I_t + \xi_{lmt})) \cdot \left(1 + \sum_{m'=1}^{3} \exp(\alpha_{im'} + \beta^d_0 p_{lm't} + \beta_1 newspgs_{m't} + \gamma_l X_{lm't} + \delta^d_t I_t + \xi_{lm't})\right)^{-1} dF(\nu), \quad (4)$$

where $\nu \sim N(0, \Sigma)$. Equation (4) provides the expression for readership subscription shares that we take to the data.

4.2. Advertising Model

Recall that while the newspaper set the rates for display and classified advertising in dollars per column inch, the rates for inserts are set in CPM. As we discuss below, this difference in pricing structure has implications for how ad rates affect advertising demand, and consequently for subscription pricing. Therefore, we adopt slightly different demand characterizations for the three types of advertising.

4.2.1. Display and Classified Advertising. Similar to Rysman (2004) and Fan (2013), we adopt a constant elasticity specification for the aggregate demand for display and classified advertising. Formally,

$$\ln(q_{kt}) = \mu_{kt} + \varphi_k \ln(r_{kt}/R_t) + \iota_{kt}, \quad (5)$$

where q_{kt} is the advertising quantity for ad type $k \in \{display, classifieds\}$, which is calculated by dividing the ad revenues for each type by the respective ad rates in period t. Recall that we define quantity in terms of the total number of column inches for display and classified ads, and thousands of inserts for preprints. The term r_{kt} is the inflation-adjusted advertising rate charged by the newspaper for ad type $k = \{1, 2, 3\}$, standing for display, insert, and classified advertising, respectively, at time t. The term R_t is a composite metric for the newspaper's readership (in thousands) at time t. Note that we use a composite metric of readership, as opposed to the readership of the different subscription options, because the advertising data are not broken down by the days of the week for the entire duration of our data. However, for a subset of the period of our analysis (January 2006 through June 2010, i.e., 54 of the 72 months used in our analysis), we have advertising data that are broken down by weekdays versus Sundays. These data suggest that the Sunday newspaper accounted for 70% to 75% of the overall ad revenues (see Table A.5 in Online Appendix 5). Therefore, we construct the composite readership metric using a weighted sum of the readership of the different subscription options such that the weights satisfy the condition that 75% of the advertising revenue came from the Sunday newspaper.[15, 16] We provide further details on this weighting in Online Appendix 1. We verify the robustness of our results to alternative assumptions regarding R_t in Section 0.2 in Online Appendix 5.[17]

Together, r_{kt}/R_t represent the cost per 1,000 readers (CPM) incurred in placing ads in the print newspaper at time t, and φ_k captures the corresponding elasticity. Since the CPM is a composite metric that captures both the cost of placing ads and the size of the audience, advertisers typically use it to compare alternative media options. The parameter μ_{kt} represents the intrinsic attractiveness of each advertising type k as perceived by advertisers and is allowed to vary over time to capture exogenous changes in the competitive environment (e.g., the growth of outdoor and Internet advertising options). Therefore, while φ_k captures the shape of the advertising demand curve as a function of the CPM, μ_{kt} allows this demand curve to shift over time. The term ι_{kt} is a normal mean-zero i.i.d. error term for advertising quantity.

4.2.2. Newspaper Insert Advertising. Our specification of the demand for insert advertising is similar to that for display and classified ads, albeit with two key differences. First, since the ad rates for inserts are already in CPM, we do not divide them by readership. Second, the realized quantity of insert advertising is likely to be constrained by the circulation of the newspaper. If a newspaper's circulation drops, so would its ability to circulate inserts, thereby resulting in lower realized demand for inserts even if the CPM did not change.[18] Therefore, we include the total readership of the newspaper, R_t, as an additional covariate to capture this capacity constraint. Therefore, the demand for inserts in month t is of the form

$$\ln(q_{k't}) = \mu_{k't} + \varphi_{k'} \ln(r_{k't}) + \varrho_{k'} \ln(R_t) + \iota_{k't}, \quad (6)$$

where k' indexes inserts. Note that the parameter ϱ captures the relationship between readership of the newspaper and the demand for insert advertising, which we conceptualize as the capacity constraint imposed by the newspaper's circulation.

In our advertising demand specification, we restrict the cross-price elasticities among the three types of advertising to be zero. This restriction implies that advertisers do not substitute or perceive synergies

between the three types of advertising. This assumption is partly dictated by the empirical reality that the CPMs for the three types of advertising are highly collinear, thereby precluding us from identifying separate own- and cross-price effects. Moreover, the assumption that advertisers do not substitute between different types of advertising is reasonable in our context because the three ad types are distinct in advertising form, the nature of target advertisers, and advertising objective (as discussed earlier in Section 3). Furthermore, managers at the newspaper revealed that advertisers rarely switch between ad types, suggesting that substitution is unlikely to be sizable. Nevertheless, synergies may arise if advertisers employ multiple types of advertising simultaneously. However, managers at the newspaper suggested that a very small proportion of advertisers (<10%) generally invest in more than one advertising type in each year.

To study the role of exogenous changes in the ad market on subscription prices, we account for the temporal evolution of intrinsic advertising attractiveness of advertising in each option. The intrinsic attractiveness reflects the relative effectiveness of advertising in that option, as perceived by advertisers; the advent of alternative media options for advertising might have altered the perceived relative effectiveness of these options over time. We adopt the following specification for intrinsic advertising attractiveness μ_{kt} in our econometric model:

$$\mu_{kt} = \mu_k + \vartheta_{kt} Y_{kt} + \varrho_k \tilde{Y}_{kt}, \tag{7}$$

where Y_{kt} are advertising type-specific year dummies. As in the readership model, these year dummies capture changes in advertising levels across years, with year 2006 as the base. The year dummies capture the influence of a wide set of factors influencing ad demand ranging from the great recession of 2008 to the growing relative popularity of outside options such as search advertising (Sridhar and Sriram 2015).[19] The term $\tilde{Y}_{kt}$ incorporates controls for seasonality in advertising demand via quarter of the year fixed effects that are specific to each advertising type. We estimate a common elasticity (φ) for the three advertising options during estimation. Ex ante, we expect the effect of Y_{kt} to decline over time, resulting in the overall advertising demand curve shifting downward as a result of increasing competition. Recovering a declining intercept for print advertising would support the possibility that the decline in advertising subsidy contributed to price increases faced by readers of the print newspaper, as discussed in detail in Section 4.3.

4.3. Pricing

We now discuss optimal newspaper prices as a function of the readership and advertising demand parameters. The profit function of the newspaper monopolist can be written as[20]

$$\pi_t = \sum_{m=1}^{3} (p_{mt}^N - c_{mt}^N) R_{mt}^N + \sum_{m=1}^{3} (p_{mt}^O - c_{mt}^O) R_{mt}^O + \sum_{k=1}^{3} (r_{kt} - \omega_{kt}) q_{kt}, \tag{8}$$

where R_{mt} and p_{mt} refer to the newspaper's print circulation and subscription price for option m, respectively (with the N and O superscripts indexing within and outside the core market, respectively), and q_{kt} and r_{kt} refer to the advertising quantity and advertising rate corresponding to display, insert, and classified advertising. The terms c_{mt} and ω_{kt} refer respectively to the marginal costs at time t associated with printing and distribution of the newspaper, and the marginal cost of selling ad space and printing advertising. The first order condition (FOC) for the prices to readers and advertisers is

$$\begin{bmatrix} p_{1t}^N - c_{1t}^N \\ p_{2t}^N - c_{2t}^N \\ p_{3t}^N - c_{3t}^N \\ p_{1t}^O - c_{1t}^O \\ p_{2t}^O - c_{2t}^O \\ p_{3t}^O - c_{3t}^O \\ r_{1t} - \omega_{1t} \\ r_{2t} - \omega_{2t} \\ r_{3t} - \omega_{3t} \end{bmatrix} = - \begin{bmatrix} \frac{\partial R_{1t}^N}{\partial p_{1t}^N} & \frac{\partial R_{2t}^N}{\partial p_{1t}^N} & \frac{\partial R_{3t}^N}{\partial p_{1t}^N} & 0 & 0 & 0 & \left(\frac{\partial q_{1t}}{\partial R_t}\frac{\partial R_t}{\partial p_{1t}^N}\right) & \left(\frac{\partial q_{2t}}{\partial R_t}\frac{\partial R_t}{\partial p_{1t}^N}\right) & \left(\frac{\partial q_{3t}}{\partial R_t}\frac{\partial R_t}{\partial p_{1t}^N}\right) \\ \frac{\partial R_{1t}^N}{\partial p_{2t}^N} & \frac{\partial R_{2t}^N}{\partial p_{2t}^N} & \frac{\partial R_{3t}^N}{\partial p_{2t}^N} & 0 & 0 & 0 & \left(\frac{\partial q_{1t}}{\partial R_t}\frac{\partial R_t}{\partial p_{2t}^N}\right) & \left(\frac{\partial q_{2t}}{\partial R_t}\frac{\partial R_t}{\partial p_{2t}^N}\right) & \left(\frac{\partial q_{3}}{\partial R_t}\frac{\partial R_t}{\partial p_{2t}^N}\right) \\ \frac{\partial R_{1t}^N}{\partial p_{3t}^N} & \frac{\partial R_{2t}^N}{\partial p_{3t}^N} & \frac{\partial R_{3t}^N}{\partial p_{3t}^N} & 0 & 0 & 0 & \left(\frac{\partial q_{1t}}{\partial R_t}\frac{\partial R_t}{\partial p_{3t}^N}\right) & \left(\frac{\partial q_{2t}}{\partial R_t}\frac{\partial R_t}{\partial p_{3t}^N}\right) & \left(\frac{\partial q_{3t}}{\partial R_t}\frac{\partial R_t}{\partial p_{3t}^N}\right) \\ 0 & 0 & 0 & \frac{\partial R_{1t}^O}{\partial p_{1t}^O} & \frac{\partial R_{2t}^O}{\partial p_{1t}^O} & \frac{\partial R_{3t}^O}{\partial p_{1t}^O} & \left(\frac{\partial q_{1t}}{\partial R_t}\frac{\partial R_t}{\partial p_{1t}^O}\right) & \left(\frac{\partial q_{2t}}{\partial R_t}\frac{\partial R_t}{\partial p_{1t}^O}\right) & \left(\frac{\partial q_{3t}}{\partial R_t}\frac{\partial R_t}{\partial p_{1t}^O}\right) \\ 0 & 0 & 0 & \frac{\partial R_{1t}^O}{\partial p_{2t}^O} & \frac{\partial R_{2t}^O}{\partial p_{2t}^O} & \frac{\partial R_{3t}^O}{\partial p_{2t}^O} & \left(\frac{\partial q_{1t}}{\partial R_t}\frac{\partial R_t}{\partial p_{2t}^O}\right) & \left(\frac{\partial q_{2t}}{\partial R_t}\frac{\partial R_t}{\partial p_{2t}^O}\right) & \left(\frac{\partial q_{3}}{\partial R_t}\frac{\partial R_t}{\partial p_{2t}^O}\right) \\ 0 & 0 & 0 & \frac{\partial R_{1t}^O}{\partial p_{3t}^O} & \frac{\partial R_{2t}^O}{\partial p_{3t}^O} & \frac{\partial R_{3t}^O}{\partial p_{3t}^O} & \left(\frac{\partial q_{1t}}{\partial R_t}\frac{\partial R_t}{\partial p_{3t}^O}\right) & \left(\frac{\partial q_{2t}}{\partial R_t}\frac{\partial R_t}{\partial p_{3t}^O}\right) & \left(\frac{\partial q_{3t}}{\partial R_t}\frac{\partial R_t}{\partial p_{3t}^O}\right) \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{\partial q_{1t}}{\partial r_{1t}} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \frac{\partial q_{2t}}{\partial r_{2t}} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \frac{\partial q_{3t}}{\partial r_{3t}} \end{bmatrix}^{-1} \begin{bmatrix} R_{1t}^N \\ R_{2t}^N \\ R_{3t}^N \\ R_{1t}^O \\ R_{2t}^O \\ R_{3t}^O \\ q_{1t} \\ q_{2t} \\ q_{3t} \end{bmatrix}. \tag{9}$$

The zeros in the first six columns in the seventh, eighth, and ninth rows in the markup matrix Ω in Equation (9) are a result of our assumption that the subscription decision does not depend on the quantity of advertising. The 3×3 block of zeros in the off-diagonal of the 6×6 matrix in the northwest corner reflect the fact that there is no overlap in readership within and outside the core market. Therefore, a change in core market subscription prices is unlikely to have an effect on readership outside the core market. The zeros in the off-diagonal elements corresponding to the last three columns of the seventh, eighth, and ninth rows are a result of our assumption that advertisers do not substitute between the three types of advertising (as discussed in Section 3 earlier). Furthermore, note that the ad rates for inserts are defined per reader. Therefore, a change in readership should not affect the quantity of inserts other than via the capacity constraint implied by the number of newspapers delivered.

For illustration, we rewrite the FOC for subscription option m, $m = 1, 2, 3$, for the core market as follows:[21]

$$(p^N_{mt} - c^N_{mt}) = \underbrace{-\frac{R^N_{mt}}{\partial R^N_{mt}/\partial p^N_{mt}}}_{1} \underbrace{-\sum_{m' \neq m} \frac{(p^N_{m't} - c^N_{m't})(\partial R^N_{m't}/\partial p^N_{mt})}{\partial R^N_{mt}/\partial p^N_{mt}}}_{2} \underbrace{-\frac{(r_{1t} - \omega_{1t})(\partial q_{1t}/\partial R_t)(\partial R_t/\partial p^N_{mt})}{\partial R^N_{mt}/\partial p^N_{mt}}}_{3} \underbrace{-\frac{(r_{2t} - \omega_{2t})(\partial q_{2t}/\partial R_t)(\partial R_t/\partial p^N_{mt})}{\partial R^N_{mt}/\partial p^N_{mt}}}_{4} \underbrace{-\frac{(r_{3t} - \omega_{3t})(\partial q_{3t}/\partial R_t)(\partial R_t/\partial p^N_{mt})}{\partial R^N_{mt}/\partial p^N_{mt}}}_{5}. \quad (10)$$

The FOC from Equation (8) with respect to advertising rates for type k is given by

$$(r_{kt} - \omega_{kt}) = -\frac{q_{kt}}{\partial q_{kt}/\partial r_{kt}}. \quad (11)$$

Equation (10) governs the subscription pricing rule for the newspaper. Recall that the term c_{mt} is the marginal cost of serving a reader of subscription option m at time t, and $p_{mt} - c_{mt}$ represents the firm's price–cost margin. The first term on the right-hand side in Equation (10) captures the extent to which the readership of a subscription option changes with a unit increase in its own price. The second term captures the positive offset derived from option m readers substituting to the other two subscription options because of the increase in option m prices. The third, fourth, and fifth terms correspond to the effects of display, insert, and classified advertising subsidies on option m's subscription prices.

The price–cost margin for advertising in Equation (11), i.e., $r_{kt} - \omega_{kt}$, is a function of both the price response of advertising demand $\partial q_{kt}/\partial r_{kt}$ and actual levels of advertising demand q_{kt}. Since we assume that readers are not influenced by the levels of advertising in the newspaper, the above expression does not contain a "direct" effect of readership on ad rates. However, for display and classifieds, where ad rates are set in the form of dollars per column inch, the optimal price–cost margin for advertising will decrease with declining readership. This is because advertising demand is a function of the advertising rate per reader in Equations (5) and (11). The intuition is that advertising types with flat ad rates become more attractive with greater reach, on account of the resulting lower CPM. At the same time, a larger readership base will also enable the newspaper to circulate more inserts, if demand exists.

4.3.1. Relationship Between Readership/Advertising Demand and Pricing on the Reader Side.

Readership Demand and Subscription Prices. We begin by considering the pricing of a single option without advertising externalities. We discuss the role of advertising externalities subsequently. The corresponding FOC will reduce to the first term in Equation (10). All else equal, a reduction in demand, i.e., R_{mt}, would render it optimal to lower prices on the reader side. This is the commonly advanced rationale for lowering prices when faced with softening demand (Tirole 2007). At the same time, note that the optimal price for option m is a decreasing function of how readership responds to subscription prices. With the arrival of alternative sources of news over time, low WTP subscribers are more likely to quit the newspaper, thereby leaving the newspaper with a less price elastic customer base. This, in turn, would render it optimal to increase subscription prices as low WTP readers quit.

Advertising Demand and Subscription Prices. Let us now consider how a shift in advertising demand can influence pricing on the reader side of the market. From Equation (10), we can see that the optimal level of advertising subsidy (the third, fourth, and fifth terms in Equation (10)) depends on two components: (a) the extent to which attracting more readers via subsidy brings in additional advertising, i.e., the magnitude of $\partial q/\partial R$, and (b) the margin on the advertising side that is realized for a unit increase in advertising demand, i.e., $r - \omega$. Let us begin by considering the second component: margins on the advertising side. From Equation (11), we can see that the optimal markup for the advertising side increases with demand. Therefore, a downward shift in the advertising demand curve (captured by the year fixed effects) would result in lower advertising demand and, hence, lower optimal markups.[22] From Equation (10), we can see that the optimal level of subsidy on the reader side of the market will

decrease if $r-\omega$ decreases. Therefore, a downward shift in advertising demand can imply higher optimal prices on the reader side.

Turning to the first component, we can see that higher levels of subsidy on the reader side are optimal if marginal readers are effective in increasing advertising demand, q. Therefore, the level of subsidy offered on the reader side will decrease if $\partial q/\partial R$ decreases over time. Our constant elasticity specification for the advertising demand implies that $(\partial q/\partial R)(R/q)$ is a constant. A larger downward shift in advertising demand relative to readership would lead to an increase in R/q over time. As a result, $\partial q/\partial R$ would decrease over time, which in turn, would reduce the effectiveness of subsidizing readers. Together, these two mechanisms imply that a downward shift in advertising demand would reduce the marginal benefit from subsidizing readers, and thus render it optimal to increase subscription prices.

Conditional on the readership and advertising demand models, we compute the optimal price–cost margins as described on the right-hand side of Equation (9). Given that we have price information for all subscription options, the only unknown in Equation (9) is the marginal cost. Since we are particularly interested in the subscription prices, we estimate the parameters of the marginal cost only for the readership pricing side. Specifically, we specify the marginal cost equation as

$$p_{mt} - M_{mt} = c_{mt} = \chi_{mt} + \Lambda_m \chi_t + \eta_{mt}, \tag{12}$$

where M_{mt} is the markup for subscription option m at time t, as implied by Equation (9), χ_{mt} is a linear time trend that captures temporal shifts in marginal cost for subscription option m, χ_t is a vector of factor costs, and Λ_m are the corresponding parameters. The term η_{mt} represents the residual component of marginal cost that is not captured by the year–subscription option time trends and the cost shifters.

State Dependence and Dynamic Pricing. The readership demand model discussed earlier assumes that there is no state dependence in newspaper subscription. However, households that subscribe to the newspaper in a given period might derive a greater utility from subscription in subsequent periods, possibly because of acquired taste. In fact, state dependence might arise on account of psychological switching costs, in the presence of high search costs or consumer learning (Dubé et al. 2010)—the latter two much less likely significant drivers in the market for newspapers. Since our empirical analysis is based primarily on aggregate data, it would be difficult to separate out heterogeneity from state dependence. Moreover, we follow the practice in the extant research on the newspaper industry (Rysman 2004, Gentzkow 2007, Fan 2013, Seamans and Zhu 2014) in terms of not considering potential state dependence in subscriptions.

If there is indeed state dependence in choice, the optimal pricing decision by the newspaper would be dynamic, rather than static, as discussed above. The premise is that, in the presence of state dependence, acquiring a customer can yield long-term payoffs. As a result, the firm would have an incentive to charge lower prices than those under a static scenario to acquire customers. This incentive to lower prices is likely to be greater when perceived quality is high (Dubé et al. 2008).

In our context, if the intrinsic preference for newspaper subscriptions is indeed declining as conjectured, with state dependence, the newspaper's incentive to charge lower than static prices is likely to decrease over time. Therefore, declining WTP can lead to higher prices under state dependence, just as it would in the presence of heterogeneity.[23]

5. Estimation

5.1. Overview of the Estimation

We estimate a system of three equations: (i) subscription decision by readers, (ii) advertising decisions by advertisers, and (iii) the newspaper's decision regarding the prices to be paid by readers and advertisers. Since the three decisions are likely to have been made simultaneously by the respective agents, we need to account for the simultaneity of these decisions using instrumental variables. There are two possible approaches to estimating the system: simultaneously, using a full information approach, or separately, using a limited information approach. The key benefit of the full information approach in our context is that it takes a stance on the exact data generating process on the supply side. If this data generating process is indeed correct, this would result in more efficient parameter estimates. On the other hand, if the assumptions made in the full information approach are incorrect, it might result in inconsistent estimates (Nevo 2000, Sudhir 2001, Berto Villas-Boas 2007).

We adopt a limited information approach in our context for the following reasons. First, given that the limited information approach makes fewer assumptions regarding the data generating process, it is prone to fewer misspecification errors. Second, as Villas-Boas (2007) documents, under general monotonicity conditions, there is a specification of the full information model that is consistent with an arbitrarily specified limited information model. Third, the main results in this paper regarding the relative roles of the readership versus advertising demand on the pricing decisions are based on counterfactual analyses that depend on the premise that the observed price trajectories are close to optimal. The limited information approach allows us to compare the optimal prices implied by the

estimated readership and advertising demand models with the actual prices to assess the appropriateness of this premise. Alternatively, under a full information approach, the readership and advertising demand models would be estimated under the assumption that the observed prices are optimal, which would render such an assessment inappropriate. Finally, the limited information approach is less computationally intensive to estimate compared to a full information approach.

We use GMM employing instrumental variables (discussed in Section 5.2) to estimate the readership demand parameters. The parameters to be estimated in the readership system are (a) those that characterize the covariance matrix corresponding to the heterogeneity distribution of subscription preferences for the three options, i.e., the Σ matrix, and (b) parameters that affect the mean utility. For the heterogeneity parameters, we estimate the elements of the lower-triangular matrix that corresponds to the Cholesky decomposition of Σ. Since we have three subscription options, Σ is a 3×3 matrix, which implies that we need to estimate six parameters that characterize the Cholesky decomposition of Σ. For the mean utility parameters, we need to recover the fixed effects for each subscription option, price sensitivity, responsiveness to changes in news pages, submarket (i.e., county) fixed effects, year fixed effects δ_t^d, and the effect of demographic shifters—average income—on readership γ^l.

Our estimation is based on aggregate subscription data at the county-month–subscription option level. We use the approach proposed by Berry et al. (1995) (henceforth, the BLP approach) to estimate the readership demand parameters. With aggregate data, the identification of the mean utility parameters is relatively straightforward. While researchers have estimated heterogeneity distribution with aggregate data using the BLP approach, we use additional micromoments from individual-level purchase histories to strengthen the case for identification. The estimation approach that we employ is similar to that of Chintagunta and Dubé (2005) and proceeds in the following steps:

(a) We start with initial guesses of the mean utilities for each county–month–subscription option combination and estimate the model of individual choices as described in Equation (1) to recover the parameters of the heterogeneity distribution (i.e., the Σ matrix; see Equation (2)). We employ maximum likelihood at this stage.

(b) Conditional on the heterogeneity parameters, we use the aggregate data to recover the mean utilities via the contraction mapping algorithm in Berry et al. (1995). We then estimate the mean utility parameters using GMM.

We iterate the two steps, (a) and (b), with the mean utilities from the previous iteration of Step (b) acting as the initial guess for the next iteration of Step (a). We treat the estimation to have converged if the maximum absolute difference between two successive values of the mean utilities in Step (b) is less than a prespecified tolerance level.[24]

In the advertising demand model, the parameters to be estimated are (a) elasticity of advertising demand to changes in readership adjusted prices φ and (b) advertisers' intrinsic attractiveness for display, insert, and classified advertising and parameters governing their temporal evolution (the year dummies corresponding to each advertising type), μ_{kt}. We estimate the advertising demand parameters using GMM, employing the orthogonality of demand shocks and instrumental variables as moment conditions. We estimate the readership and advertising demand equations sequentially.

In the pricing equation, we estimate year–subscription option fixed effects and separate parameters for the cost shifters for each subscription option. We estimate the pricing equation separately for within and outside the core market using ordinary least squares (OLS).[25] We calibrate Equation (12) for the first five years of the data (i.e., 60 months) and use the remaining 12 months of data as a holdout sample for validation.

5.2. Identification

Our objective is to assess the extent to which changes in the intrinsic preference on the reader side in the presence of heterogeneous preferences versus decreasing incentive to subsidize readers at the expense of advertisers drove the increase in subscription prices. We conceptualize the latter as a consequence of the decline in intrinsic preference for print advertising among advertisers. We seek to parse out three components: fluctuations in the intrinsic preference of print subscription separately from the effects of price and quality changes, heterogeneity in the preference for print subscription, and changes in the intrinsic preference for print advertising.

There are two key identification issues that we intend to discuss. The first issue is whether there is sufficient variation in the data to enable us to identify the three components in our estimation. The second issue is the simultaneous nature of the decisions made by three agents: readers (subscription decision), advertisers (advertising quantity decisions), and the newspaper (decision to set subscription and advertising prices and the number of pages of news).

5.2.1. Variation in the Data for Identification. On the readership side, we discuss the identification of the mean utility and heterogeneity parameters. With respect to the mean utility parameters, we are primarily interested in documenting the temporal changes in intrinsic preference for newspaper subscriptions. In our specification, we infer changes in intrinsic preference for subscriptions semiparametrically in the form

of year fixed effects. Since we have monthly subscription data, the identification of these year fixed effects is straightforward. However, since price and quality (i.e., the number of news pages) changes occur rather infrequently, the question is whether we can identify these effects separately from the year fixed effects. Intuitively, both the price and the number of news pages vary across subscription options. Since we estimate a common set of year fixed effects for all subscription options in our model specification (a), we can identify the price and quality effects separately from these year fixed effects.[26] Moreover, there are instances when subscription prices change multiple times during the year. This variation helps in identifying the price effect separately from year fixed effects. While the extent of the available price variation constrains us from identifying heterogeneity in readers' potential price responsiveness, our specification for readership demand allows for the identification of heterogeneity in readers' WTP, which is central to our research question.

To systematically assess whether the variation in the data is sufficient to recover the parameters of interest, we performed a simulation exercise. Specifically, assuming a set of mean utility parameters, we used the actual variation in the data and the assumption of extreme-value-distributed idiosyncratic shocks to simulate individual subscription choices.[27] We then estimated the demand parameters using these simulated data with the objective of recovering the mean utility parameters, as well as the distribution of heterogeneity in readers' WTP. To understand how the recoverability varies as we increase the extent of cross-sectional variation, we consider three scenarios: (i) the model is estimated using data on one option (only the daily option), (ii) the model is estimated using overall market-level data on all three subscription options, and (iii) the model is estimated on submarket (county) level data and three subscription options. Note that the last scenario has the highest degree of cross-sectional variation and mimics our data. We used 100 replications for each of these three scenarios.

We report the means, standard deviations, and mean absolute deviation of our recovered estimates from these 100 data sets for each model in Table A.3 in Online Appendix 3. These results suggest that the true parameters fall within the 95% confidence interval of the estimated values. Furthermore, recoverability improves with the availability/use of a greater number of markets and options, i.e., with more cross-sectional variation. Overall, these results give us confidence that we can recover the key mean utility parameters as well as the heterogeneity distribution with the variation in our data.

On the readership side, we use aggregate subscription data for identification. While researchers have estimated heterogeneity distributions using aggregate data (e.g., Berry et al. 1995, Besanko et al. 2003, Nair 2007, Liu et al. 2010), the argument for identification comes from off-IIA deviations, and is thus closely tied to functional form assumptions. To infer the heterogeneity distribution in subscriber preferences, we use micromoments generated by the purchase histories of a sample of individual subscribers in each of the submarkets (i.e., counties).[28] Such microdata permit the identification of parameters of the heterogeneity distribution without the need for distributional assumptions (or off-IIA deviations in choice shares) that may be needed for the identification from market-level data (Berry et al. 2004, p. 73). More specifically, our identification of consumers' heterogeneous tastes for newspaper options relies on instances in the data where we can observe consumers switching between choice options to different extents and over time. Together, these sources of variation help in identifying the heterogeneity distribution on the reader side, conditional on the mean utility parameters (Berry et al. 2004, Chintagunta and Dubé 2005).

On the advertiser side, we use data on the advertising quantity for each of the three types. We control for cross-sectional differences across type via fixed effects for each advertising type. The identification of the change in intrinsic preference for advertising in each type over time is relatively straightforward: while the type-specific year fixed effects capture any year-on-year changes in the corresponding ad demand, the within-year controls capture the remaining variation.

5.2.2. Endogeneity. *Readership Equation.* There are two potential endogenous variables here: subscription prices and the number of news pages. The endogeneity of prices arises because the newspaper anticipates readership and advertising demand shocks, such as periodic sports seasons, while setting the respective prices. To break this endogeneity, we need instruments that shift subscription prices and ad rates but are not related to the demand shocks.

To account for the endogeneity of subscription prices, we use the costs associated with printing and distributing newspapers as instruments, viz., producer price index for printing ink manufacturing (North American Industry Classification System (NAICS) Industry 32591), the cost of output from paper mills (NAICS 32212), and producer price indices of firms in industries that share similar cost structures, such as book publishers (NAICS 511130). The premise is that while these costs will drive subscription prices, they are unlikely to be related to the readership demand shocks, conditional on the endogenous variables. Liu (2010) uses similar instruments to resolve the endogeneity of prices in the video game market. To verify the strength of these instruments, we report the results from the first-stage regression of the endogenous variables on the

Table 6. First-Stage Regressions of Endogenous Variables on Instruments

(A) Readership model

Endogenous variable →	Subscription prices				No. of news pages			
Parameter	Est.	SE	Est.	SE	Est.	SE	Est.	SE
PPI paper mills			1.05**	0.14			−0.71+	0.38
PPI book publishers			−2.79	2.92			0.48	0.74
PPI printing ink mfg.			2.49	1.94			−0.61	0.49
Dummies for each option	✓		✓		✓		✓	
County demographics, year fixed effects	✓		✓		✓		✓	
R^2	0.48		0.84		0.91		0.94	

(B) Advertising model

	Readership of national newspapers instrument								Search propensity instruments							
Endogenous variable →	Advertising rates				Readership				Advertising rates				Readership			
Parameter	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE
PPI advertising agencies			−0.76	0.76			5.19**	1.89			0.31	0.08			0.74**	0.26
PPI lithographic/offset printing ink			1.38**	0.59			−0.15	0.15			0.39**	0.07			1.22**	0.18
Readership of other newspapers (%)			0.98**	0.35			7.24**	0.36								
Search propensity—"news"											0.19**	0.06			0.05	0.22
Search propensity—"⟨name of city⟩ news"											0.01	0.05			0.81**	0.20
Advertising type dummies	✓		✓						✓		✓					
Year fixed effects	✓		✓		✓		✓		✓		✓		✓		✓	
R^2	0.64		0.76		0.73		0.84		0.64		0.78		0.73		0.88	

Note. PPI, Producer price index.
+$p < 0.1$; **$p < 0.01$.

instruments in Table 6, panel (A). These results suggest that the instruments, along with other exogenous variables, explain 84% of the variation in prices, with some instruments exhibiting statistical significance. Compared to the first-stage regression without the instruments, the regression with instruments exhibits a significant improvement in R-squared. Therefore, our instruments are relatively strong (Rossi 2014).

In addition to prices, the newspaper might have changed quality based on demand shocks that are not observed by the researcher. Similar to the above approach, we account for this potential endogeneity using cost-based instrumental variables. The premise is that the newspaper's changing cost structure might drive the newspaper's decision on quality (i.e., the number of news pages). Yet, as discussed above, these costs should not be correlated with unobserved shifters of readership demand (e.g., elections, local sporting events, etc.). The first-stage regressions presented in panel (A) of Table 6 suggest that some of the instruments have a statistically significant relationship with the number of news pages.

Advertising Equation. Similar to the subscription prices, the newspaper is likely to have set advertising rates in anticipation of the realized demand shocks. To control for this endogeneity, we use instrumental variables consisting of the factor cost of lithographic/offset printing ink manufacturing (NAICS 325910) and producer price indices of advertising agencies (NAICS 541810). We collected these data from the Bureau of Labor Statistics (www.bls.gov). To verify the strength of these instruments, we report the results from the first-stage regression of the endogenous variables on the instruments in Table 6, panel (A). These results suggest that the instruments, along with other exogenous variables, explain 76% of the variation in ad rates. Compared to the first-stage regression with only the exogenous variables, but excluding the instruments, the proposed instrumental variables improve the R-squared by 12%. Therefore, we do not believe that our instruments are weak.

The other endogeneity concern in estimating the readership and advertising demand equations arises from the interlinked nature of these two decisions. Our restriction that advertising quantity does not influence the subscription decision implies that the readership demand model is identified without the need for additional exclusion restrictions. On the other hand,

readership enters the advertising demand model as a covariate in the form of the CPM variable (r_{kt}/R_t term in Equation (5)). This might lead to an endogeneity problem if factors that are omitted from the advertising demand equation are also correlated with readership. The premise is that factors such as upcoming local elections or local events such as restaurant weeks or popular street fairs may increase demand for local newspaper consumption among readers, as well as for local advertising. Therefore, the advertising demand shocks are likely to be correlated with readership, thereby resulting in biased estimates for the advertising demand model.

If the advertising demand shocks are induced by local events, the readership of print versions of national newspapers in the local market is likely to be a viable instrument. The premise is that readership of national newspapers is a proxy for the preference for print newspaper consumption in the local market, and should hence be related to the readership of the focal newspaper. However, given that 76% of advertising for the focal newspaper accrues from local advertisers, it is unlikely that readership within the local market of the national print newspapers is related to the demand shocks for advertising in the focal newspaper, especially, if they represent local omitted variables discussed above. Since the local newspaper generates 24% of its ad revenue from national advertisers, it is plausible that the focal newspaper is likely to compete with national newspapers for this part of the ad revenue. If this is true, then the readership of a national newspaper like the *New York Times* will have a direct effect on the focal newspaper's ad revenues. This would render the conditional independence assumption required for the validity of instruments questionable. While the focal newspaper and the *New York Times* may compete for ad revenue from national advertisers, we are less concerned about the possibility that this competition will be linked to the readership of the *New York Times* in the local market. Our rationale is that the local market is a very small subset of the target audience for national brands. Moreover, the *New York Times* derives less than 1% of its readership from the focal market. Therefore, we contend that national advertisers are unlikely to make their advertising decisions on the *New York Times* based on the changes in its readership in the focal market alone. Consequently, the readership of the *New York Times* in the local market is unlikely to be directly related to advertising by national brands in the focal newspaper. Based on the above rationale, we use the percentage of readers in the local market that subscribe to the *New York Times* and the *Wall Street Journal* as an excluded variable.[29] However, if the advertising demand shocks at the focal newspaper include components that are correlated with the local readership of national newspapers, such as national elections, the validity of the instrument is likely to be questionable. To minimize this concern, we incorporate strong temporal controls in the form of year fixed effects for year-on-year changes and quarter of the year fixed effects for within-year changes in our advertising demand models.

However, in the spirit of exploring the robustness of our results to alternative instruments, we explore alternative instruments that reflect the interest in the local market to consume news. The premise is that any interest in local news should drive the readership of the focal newspaper. The corresponding change in advertising should accrue from readership changes (i.e., the interest in local news is independent of advertising conditional on the readership of the focal newspaper). In particular, we use Google Trends data on online search propensities in the focal market for keywords relevant to local news ("news," "⟨name of the city⟩ news"[30]). We contend that, taken together, the search propensities should serve as a reasonable proxy for readers' interest in consuming local news content.

We find that the correlation between the subscription to the local newspaper and the local subscription to national newspapers is 0.8, suggesting that it is not a weak instrument. In addition, the corresponding correlations between the focal newspaper's readership and the search propensity instruments is 0.35 (for "news") and 0.38 (for "⟨name of city⟩ news"). We present the results from the first-stage regression of ad rates and readership on instruments in Table 6, panel (B).[31]

Overall, these results suggest that the instruments, along with other exogenous variables, explain 83% of the variation in readership. Compared to the first-stage regression with only the exogenous variables, but excluding the instruments, the proposed instrumental variables improve the R-squared by 12%–14% for ad rates and 11%–15% for readership. Therefore, we contend that we do not have a weak instruments problem.

Pricing Equation. To identify parameters governing the newspaper's pricing decision separately from the readership and advertising demand parameters, we need at least one variable each that predicts the newspaper's readership and advertising demand, but not the newspaper's pricing decision. Time-varying demographic information (median income in each county) and controls for seasonality (in the form of quarter of the year fixed effects for each ad type) included in the readership and advertising demand models, respectively, serve as such exclusion restrictions. These enable us to recover the marginal cost parameters in the pricing equation.

6. Results

6.1. Readership Results

We adopt two alternative specifications for our main readership model: (a) one with a common set of year fixed effects for all subscription options to capture the

Table 7. Readership Demand—With News Pages and a Common Temporal Trend Across Options

Parameter	Est.	SE
Daily_bundle	−2.36**	0.54
Weekend_bundle	−4.48**	0.50
Sunday_bundle	−3.23**	0.49
Core market price	−0.07**	0.01
Outside core market price	−0.05**	0.01
No. of news pages	0.18**	0.06
Year fixed effects for the core market and outside the core market	✓	
County fixed effects, county income	✓	

Est (Ltt)	SE
1.32**	0.01
0.18**	0.01
0.17**	0.02
0.30**	0.00
0.28**	0.00
0.30**	0.02

Notes. "Ltt" refers to the lower triangle of the covariance matrix of random effects across the three subscription options.
**$p < 0.01$.

evolution of the overall intrinsic preference for print subscriptions and (b) one with different year fixed effects for each subscription option to capture separate temporal paths for the intrinsic preference for each subscription option. However, since our data on the number of news pages vary at the year–subscription option level, we can include this as a covariate only in the former specification and not the latter. Therefore, the year fixed effects in the latter specification also include changes in the quality of the newspaper. In addition, while we allow the price coefficient to vary across areas within/outside the core market in specification (a), we include a single price coefficient in specification (b) to explore the importance of this assumption on our results.[32]

We report the results from both specifications in Tables 7 and 8. (The full set of estimates with fixed effects are available in Tables A.8 and A.9 in Online Appendix 7.) Across both specifications (a) and (b), the fixed effects corresponding to the three subscription options are negative, indicating the relative popularity of the outside option. In addition, in line with their relative market shares, the fixed effect corresponding to the daily option is the least negative, followed by the Sunday option and then the weekend option. The price coefficients are negative and significant in all specifications. The elements of the lower triangular matrix corresponding to the covariance matrix of the preferences for the three subscription options are significant. All of the covariance terms in the Σ matrix are positive, suggesting that households that have a high preference for one subscription option also value other subscription options.

Many year dummies are negative and significant in both specifications. Since we use 2006 as the base year, these results suggest that subscription preferences in subsequent years were lower than those in 2006. In the specification with common year fixed effects for all subscription options, the decline in intrinsic preference is pronounced for the counties within the core market. On the other hand, in the specification with option-specific year fixed effects, the intrinsic preference declined with respect to 2006 in most cases (with the exception of the Sunday-only option outside the core market, where it increased in 2010 and 2011). Moreover, the decline appears to be steepest for the daily subscription option within the core market. This pattern is consistent with our discussion regarding the steeper decline in daily option readership. However, note that the year fixed effects in the latter specification include the effect of changes in the number of news pages as well.

Based on the readership demand estimates, we quantify the extent to which changes in intrinsic preference, price, and quality contributed to the decline in print

Table 8. Readership Demand—Without News Pages, with Option Specific Year Fixed Effects and a Common Price Coefficient

Parameter	Est.	SE
Daily_bundle	−1.71**	0.19
Weekend_bundle	−4.59**	0.30
Sunday_bundle	−3.21**	0.79
Price	−0.03**	0.00
Year fixed effects for each bundle for the core market and outside the core market	✓	
County fixed effects, county income	✓	

Est (Ltt)	SE
0.07**	0.01
0.04**	0.01
0.04**	0.01
0.10**	0.01
0.09**	0.01

Notes. "Ltt" refers to the lower triangle of the covariance matrix of random effects across the three subscription options.
**$p < 0.01$.

subscriptions. We perform this quantification by calculating the subscription volume that would have accrued in 2011 if each of these factors had remained the same as they were in 2006. For the model with common year fixed effects (i.e., specification (a)), we find that price was the largest contributor (67%) to the decline in subscriptions, followed by quality (11%), and then intrinsic preferences (4%). When we consider alternative subscription options to have different year fixed effects (i.e., specification (b)), price increase accounted for 23% of the loss in subscriptions, followed by 32% for the decline in year fixed effects.[33] Recall that in specification (b), the year fixed effects reflect a composite of changes in intrinsic preference and the quality of the newspaper. Therefore, a large fraction of the loss in subscriptions seems to have been a consequence of the increase in subscription prices as opposed to a decline in interest in subscribing to the newspaper. However, this analysis does not shed much light on the extent to which changes in the intrinsic preference played a role in driving up subscription prices.

6.2. Advertising Results

We present the results from our advertising model in Table 9. The estimated advertising demand price elasticity ranges between −1.30 and −2.55, which is similar to that reported by Fan (2013) for a wide panel of U.S. newspapers. The type-specific year fixed effects for display and classified advertising are negative and significant, in conformity with the relatively steep decline in demand for these two types. Moreover, several of the year fixed effects are decreasing for these two types of advertising, suggesting a decline in intrinsic attractiveness, possibly driven by lower perceived attractiveness of print advertising relative to outside media options. In addition, the influence of the effect of readership on the demand for inserts (i.e., effect of the capacity constraint imposed by the size of the readership) is not significant when we use search propensity instruments. Therefore, we set $\partial q_2/\partial R = 0$ for inserts in Equation (9) when we compute optimal prices for that case. An implication of the insignificant relationship is that changes in demand for inserts will not play a role in readership pricing. However, the effect of readership is significant at the 10% level in the ad demand model when we use national newspaper readership as an instrument (model specification A in Table 9). We find that our main findings are robust to treating this effect as significant and employing the estimated value of $\partial q_2/\partial R$ while computing optimal markups.

Table 9. Advertising Model Results

	Model A—National newspaper readership instrument		Model B—Search propensity instruments	
Parameter	Est.	SE	Est.	SE
Ad type–specific intercepts	✓		✓	
CPM	−1.30**	0.55	−2.55+	1.38
Effect of readership for inserts	3.89+	2.35	3.97	3.31
Y2007_display	−0.13**	0.04	−0.22*	0.10
Y2008_display	−0.27**	0.03	−0.23**	0.05
Y2009_display	−0.53**	0.05	−0.44**	0.11
Y2010_display	−0.48**	0.08	−0.30	0.20
Y2011_display	−0.55**	0.11	−0.32	0.26
Y2007_inserts	−0.20*	0.09	−0.26+	0.15
Y2008_inserts	0.01	0.14	−0.10	0.26
Y2009_inserts	0.11	0.38	−0.02	0.59
Y2010_inserts	0.53	0.69	0.46	0.99
Y2011_inserts	0.71	0.87	0.63	1.24
Y2007_classifieds	−0.23**	0.06	−0.34**	0.14
Y2008_classifieds	−0.69**	0.08	−0.82**	0.14
Y2009_classifieds	−1.84**	0.39	−2.70**	0.98
Y2010_classifieds	−1.93**	0.40	−2.83**	1.01
Y2011_classifieds	−2.10**	0.39	−2.98**	0.99
Quarter of the year fixed effects for each ad type	✓		✓	

+$p < 0.1$; *$p < 0.05$; **$p < 0.01$.

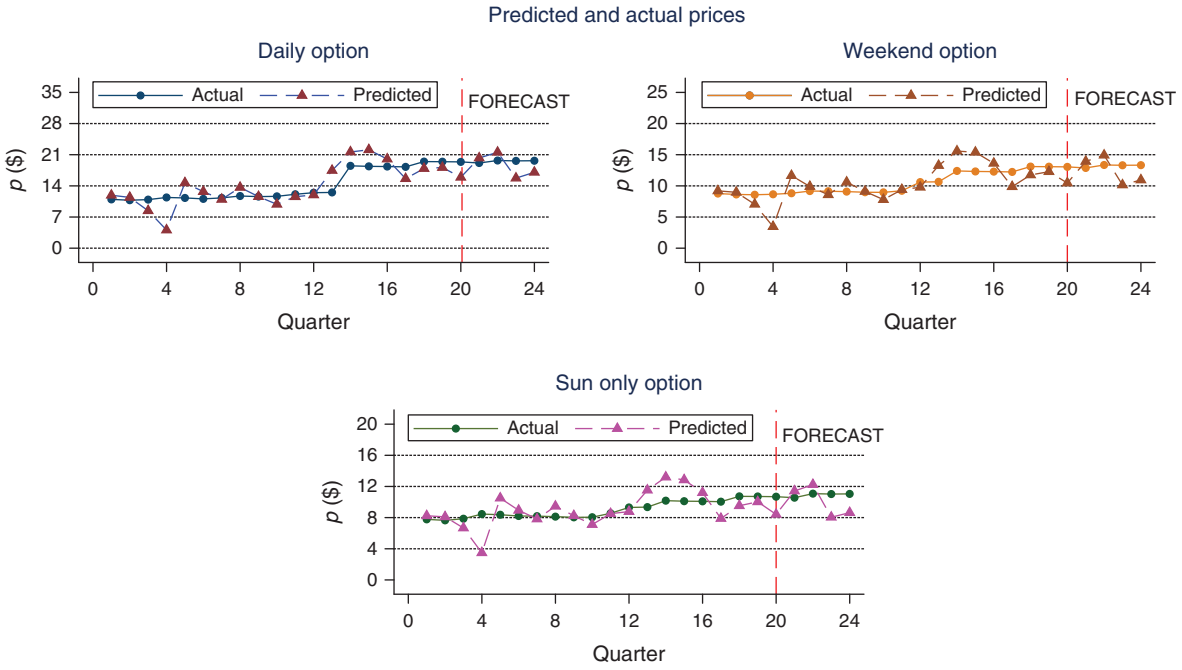
Overall, these results suggest that the decline in the intrinsic preference on the advertiser side was probably steeper than the corresponding changes on the reader side. Therefore, prima facie, it appears that the former played a greater role in driving up the subscription prices. However, we cannot conclusively make such an assessment without considering how the shifts in readership and advertising demand curves affect optimal prices.

6.3. Optimal Prices

To assess whether the optimal prices implied by our model and the readership and advertising demand estimates are reasonable, we use data from 2006–2010 (i.e., 60 months) as a calibration sample.[34] We use the remaining 12 months of data on subscription prices for out-of-sample validation. Our calibration involves computing the optimal markups on both sides of the market as described in Equation (9), conditional on the estimated readership and advertising demand parameters. We then use these estimates to generate predicted prices for 2011 and compare them with the observed 2011 prices.

We present these actual and predicted prices for the entire duration in Figure 5 for the core market. Those for the region outside the core market are similar. The prices that were predicted by the model for the year 2011 are similar to the corresponding observed prices. The mean absolute percent deviation (MAPD) between observed and predicted prices for 2011 range between 12% and 17% for the three subscription options (which are in the ballpark of MAPDs between actual and predicted prices reported by Nair 2007 and Liu 2010).[35]

Figure 5. (Color online) Holdout Sample Validation for 2011 Prices



The results from this model suggest that the marginal costs declined during the period of our analysis (Figure A.2 in Online Appendix 6). Therefore, the increase in subscription prices was driven primarily by the endogenous decision by the newspaper to increase its price–cost margins on the reader side.

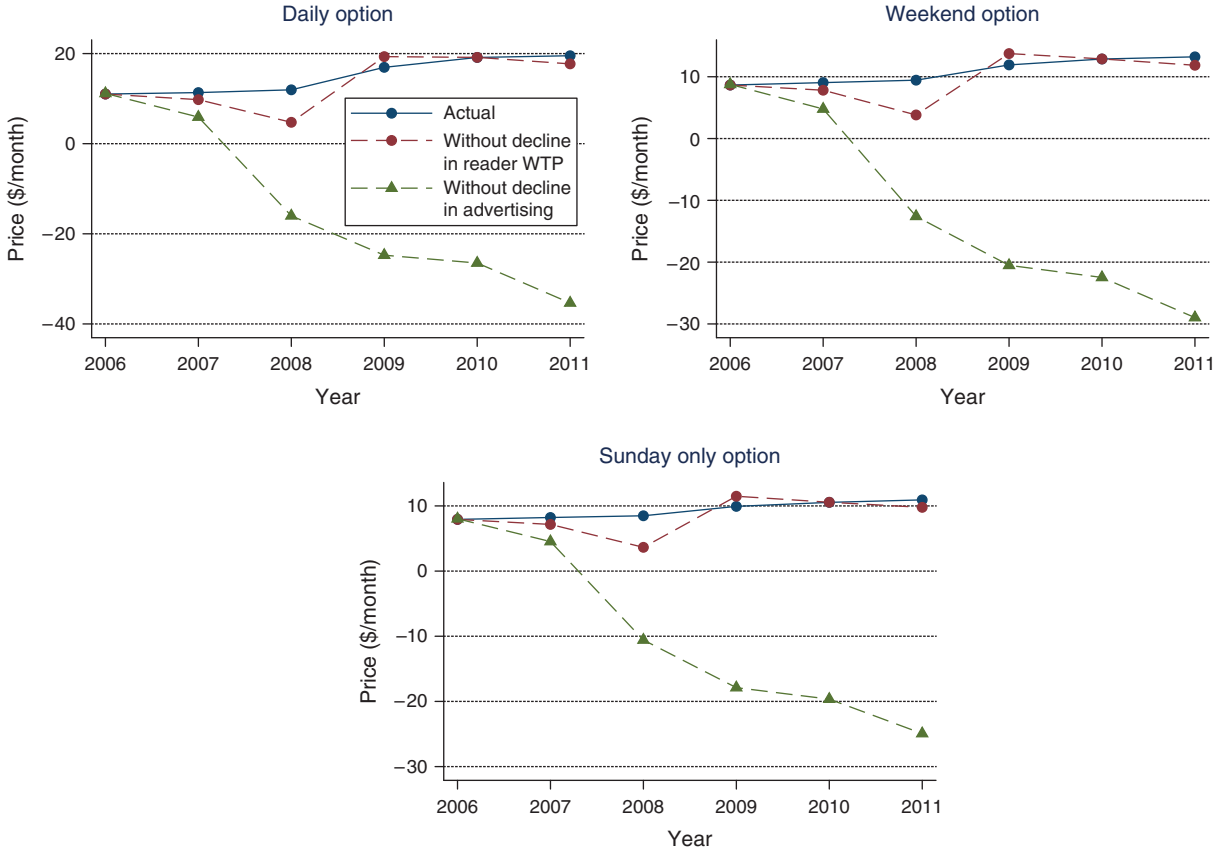
6.3.1. What Explains the Increase in Subscription Prices? Recall that we had advanced the decline in WTP for the newspaper in the presence of heterogeneous preferences and lower incentive to subsidize readers at the expense of advertisers as two reasons why it might be optimal for the newspaper to increase its subscription prices. Similar to Liu (2010), we perform counterfactual analyses to understand the extent to which the two mechanisms are responsible for the increase in subscription prices.

We first consider the role of the decline in readers' WTP. To assess the extent to which the decline in readers' WTP contributed to changes in the firm's pricing, we first compute the predicted level of readership when there is no decline in readers' preferences. To this end, we simulate the readership that would have accrued based on the estimated readership model when all of the year dummies for years 2007–2011 are set to zero (i.e., maintaining readers' preferences for the newspaper at the same levels as in 2006). We then use this readership demand to calculate the corresponding advertising demand using Equation (5). Next, to assess the extent to which the decline in the intrinsic attractiveness of advertising led to increases in subscription prices, we use the advertising demand parameters to arrive at a predicted level of advertising demand generated by maintaining perceived advertising attractiveness at the 2006 level. As in the readership case, we switch off the estimated year fixed effects for 2007–2011 at their original levels (as they were in year 2006). Recall that these year fixed effects capture the extent to which the advertising demand curve shifts downward from year to year. Using the predicted advertising demand, we computed the counterfactual markups without the witnessed decline in the intrinsic attractiveness of advertising.

To quantify the contribution of our two proposed explanations, we compare how optimal markups evolved between 2006 and 2011 in each of the three cases: actual markups (computed based on our model parameters), the case where we switched off the decline in readers' preferences, and the case where we switched off the decline in the incentive to subsidize readers at the expense of advertisers. Consider the first explanation corresponding to the decline in readers' preferences. To compute its contribution, we compare the percentage deviations between 2006 and 2011 in the markups predicted by the model when we switch off the decline in readers' preferences with the corresponding change in actual markups based on our model parameters. We use a similar procedure for the second explanation. We then compute the relative contribution of each of the explanations based on these percentage deviations.[36]

We present the results from this analysis in Table 10; we present the counterfactual predicted prices in Figure 6. These results suggest that within the core market, the decline in readers' preferences accounted for

Figure 6. (Color online) Counterfactual Prices



between 8% and 21% of the increase in subscription prices. On the other hand, nearly 79% and 92% of the increase in subscription prices between 2006 and 2011 can be traced back to the decreasing incentive on the part of the newspaper to subsidize readers at the expense of advertisers. The results for the counties outside the core market exhibit a similar pattern: decline in readers' preferences can explain only around 15% of the increase in subscription prices. Overall, these results suggest a conscious shift on the part of the newspaper from being heavily dependent on advertising to a balanced model where readers make a sizeable contribution. To internalize the actual impact of the decline in advertising, we present the relative average subscription and advertising revenue per reader, in our data, in Table 11. While advertising constituted 87% of the revenue contribution per reader in 2006, its share decreased to 69% in 2011, suggesting a shift toward a balanced revenue model. This important pattern motivated our study of the role played by advertising subsidy in determining price increases to readers.

We further explore the decreasing role of advertising subsidy and the extent to which the resulting increase in subscription prices can be traced back to different types of print advertising. We report the relative extent to which different types of advertising contributed to

Table 10. Pricing Results

	National newspaper readership instrument (%)		Search propensity instruments (%)	
	Reader model: With news pages, common year FEs	Reader model: Common price coef. and option-year FEs	Reader model: With news pages, common year FEs	Reader model: Common price coef. and option-year FEs
Decline in readers' preferences	10.13	20.70	8.18	18.01
Decline in advertising, of which:	89.87	79.30	91.82	81.99
Display ads contribute	47.63	41.59	49.72	44.92
Inserts contribute	3.36	3.40	0	0
Classifieds contribute	38.88	34.31	42.10	37.07

Note. FEs, Fixed effects.

Table 11. Relative Contributions of Reader and Advertiser Sides of the Newspaper Market

Revenue contribution per reader	Year 2006 (%)	Year 2011 (%)
Subscription	12.62	31.19
Advertising	87.38	68.81

the price increase in Table 10. These results suggest that the decline in display and classified advertising primarily drove the subscription price increases. Thus, our results add to the limited literature that has attempted to document the influence of the classified advertising trough on the changes to newspapers' marketing mix (Seamans and Zhu 2014). Note that while Seamans and Zhu (2014) document a much smaller impact of classified advertising decline on subscription prices (3.3%), the end date of their analysis (i.e., 2007) corresponds to the period when newspapers had just started increasing subscription prices. Overall, these results suggest that the increase in subscription prices represents a structural shift from a model where the newspaper used advertising revenue to subsidize readers to a balanced revenue model.

The steeper price increase for the daily subscription option suggests that the newspaper is keen to retain the low valuation readers during weekends, but not on weekdays. The rationale is that as a result of shrinking advertising, the gap between the daily and Sunday-only subscription options, in terms of the revenue generated per reader, has reduced over time; while the daily option generated \$67.57 (\$0.81) more in advertising (circulation) revenue per reader than the Sunday-only option in 2006, the gap shrank (increased) to \$37.94 (\$2.81) in 2010.[37] Thus, while the average daily option reader contributed \$41.79 in 2006, that number dropped to \$38.54 in 2010.

In sum, results from our model suggest that the decline in advertising subsidy was an instrumental driver of the steep subscription price increases faced by newspaper readers over the last five years. As a result, the newspaper is moving to a balanced revenue model where readers and advertising contribute equally in generating revenues. Furthermore, the newspaper is using price as a lever to motivate low WTP readers of the daily option to migrate to more profitable weekend subscription options. An extreme version of this strategy is where newspapers restrict circulation of the print newspaper to only weekends, a strategy adopted by many U.S. newspapers (Lendon 2008, Carmichael 2010).

7. Discussion and Conclusion

In spite of facing declining demand, newspaper publishers have increased print subscription prices for readers. The overall revenue implications for the publisher from raising prices for readers may be especially nuanced in this industry, as nearly three-fourths of its revenues derive from advertising, which depends critically on the presence of readers. So why have subscription prices substantially increased? We propose and estimate a model to answer this question, allowing for the influence of externalities created by the firm's subscription price-setting process on its advertising revenues. We model both reader and advertiser demand for the print newspaper and tie them to a model of the newspaper's pricing decision.

Our results suggest that the decline in advertising subsidy is a big reason why readers are increasingly facing higher subscription prices today. Thus, we supplement extant literature that mainly attributes price increases to heterogeneity in WTP by documenting that the platform's need to balance revenues from both sides of the market can play a dominant role in driving such changes. This basic premise has several conceptual parallels with pricing practice in other industries. For example, Bank of America proposed (but later revoked) surcharges to consumers for debit card usage to offset anticipated losses from a new rule that capped the fees that banks could charge merchants (Morran 2016). Thus, an exogenous change in demand on one side can prompt sizable changes to pricing on the other. Another example is Netflix's recent price hike to subscribing customers (Welch 2016), which was believed to be motivated in part by an inevitable reduction in content variety (Lovely 2016).

Our data are also consistent with the subsidiary explanation that the newspaper adopted a price-based segmentation strategy focused on charging higher prices to serve only the loyal readers of its most popular option, possibly in an attempt at coping with the large revenue decline witnessed over the previous five years. This indicates that newspapers may be becoming a more niche product serving a smaller readership base. Furthermore, this result is also suggestive of a change in the mainstream information dissemination role played by newspapers in society (Weibull 1992). However, a shift in newspapers' traditionally advertising-supported revenue structures toward a "balanced" subscription-cum-advertiser-funded model appears to be appropriate, especially given the nature of decline in newspaper advertising.

An appealing feature of our study is that the readership and advertising data used in the estimation are similar to data that are typically available to newspaper firms. This makes the model managerially useful, as newspaper firms can apply our model to readily available data to inform their pricing portfolio decisions, such as whether to add or remove advertising products, etc. However, our study also has some limitations, several of which can be attributed to the nature of the data we have available. On the advertising side, our ability to capture richer interactions between demand for the

three advertising options or to specify a demand model aimed at modeling individual advertisers' choice rules is restricted by the aggregate nature of advertising data we have available. Our proposed modeling framework focuses mainly on accounting for newspapers' distinct advertising revenue sources and their role in the firm's subscription pricing process.

A limitation of our model is its inability to account for possible dynamics in the newspaper advertising market. Future work focused on enriching the demand models to incorporate the differential influence of Sunday and weekday newspaper readership in a more rigorous fashion could generate interesting pricing implications for the firm. Other examples of this include (a) estimating the optimal advertising markups at the advertiser segment (local versus national advertisers) level, to inform potential targeted pricing rules for the publisher, and (b) specifying a richer structure to capture the heterogeneity in different advertisers' WTP for access to higher WTP readers. Another limitation of our model is that it is unable to account for potential dynamics introduced by the presence of state dependence in the market for newspaper readership. Such implications may be valuable to marketing managers as they design strategies to salvage dwindling readership and advertising revenues.

Previous work studying the newspaper industry (Fan 2013) has discussed the role of changes in market structure (e.g., newspaper consolidations/mergers) in influencing newspaper prices. Thus, newspaper consolidations may indeed have contributed to some of the price increases in the print newspaper industry, especially over a longer horizon.[38] Our ability to account for such explanations is constrained by the nature of our data; i.e., the newspaper that shared the data used in this analysis is not part of a large multinewspaper or mass-media group franchise. Thus, though prices in the focal newspaper's market are unlikely to be influenced by similar changes in market structure over the time frame of our analysis, it is possible that prices at other large newspapers may be. In sum, we hope our empirical study has shed academic and managerial light on price-setting practices in newspaper/media markets, and more generally in two-sided markets.

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Endnotes

[1] As we discuss subsequently in Section 6.3, the changes in marginal costs cannot explain the 40%–60% increase in subscription prices during this period. Also, commonly used quality metrics (Berry and Waldfogel 2010) such as the size of the newsroom and the average number of news pages have declined over time. Therefore, increases in quality cannot explain the price increases either.

[2] A third explanation is that when newspapers increase print subscription prices, they also consider the consequent migration of print readers to the online newspaper. For newspapers, such as ours, that do not operate newspaper paywalls, the migration of readers can bring in additional online advertising revenue even if these online readers do not directly generate subscription revenues. We subsequently show that this explanation does not rationalize the steep print subscription price increases (see Section 0.1 in Online Appendix 5).

[3] Print newspaper circulation numbers are at an all-time low. The last time newspaper circulation was at current levels was in the mid-1940s, when the population of the United States was half its current size; see http://www.journalism.org/node/1414.

[4] Blair and Romano (1993) and Dertouzos and Trautman (1990) report that most daily newspapers exist as the only published newspaper in their local market.

[5] Henceforth, we use the terms *subscription*, *readership*, and *circulation* interchangeably.

[6] The newspaper industry employs a dichotomous geographical classification of its circulation counties: within and outside the "newspaper designated market" (termed "core market" and "outside the core market" in this paper, to simplify exposition).

[7] Newspapers have been restricting delivery to geographic regions with very low demand to save on delivery costs to these far-flung areas (Mutter 2009). To assess whether the magnitude of such endogenous/"self-inflicted" circulation losses is economically significant, we collected annual data for the newspaper at the ZIP code level for our analysis period from the AAM audit reports. We found that fewer than 5% of ZIP codes drop out from the sample over the duration of our data. (A ZIP code would not figure in our data set or the AAM's audit reports for that year if the newspaper stopped serving readers from that ZIP code, or if that ZIP code accounted for less than 25 subscribers.)

[8] We plot the nominal subscription prices (i.e., before inflation adjustment) for each option in Figure 2 for comparison.

[9] In addition to these individual data, we also obtained information on the total number of households in each county that ever subscribed to any of the three options during the period of our analysis. This helped us identify the number of households that never subscribed to the focal newspaper in each county. This, in turn, enabled us to identify the proportional number of nonsubscribing households corresponding to the individual data.

[10] We present these numbers considering the total readership of the Sunday newspaper, which is the sum of readership numbers for the three subscription options that we consider (because each of these options provides newspaper access on Sundays). Since the remaining six days of the week contribute a significant fraction of ad revenues, we also explore alternative formulations of readership that internalize different percentage contributions of the Sunday newspaper

toward total ad revenues. The trajectories of CPM calculated using reweighted readership were similar.

[11] The number of pages in the newspaper containing ads also dropped by 52% over our analysis window. The correlation between the number of pages containing news and those containing ads was +0.98. This argues against the possibility that the newspaper increased the number of ad pages at the expense of news pages (or vice versa), impacting the newspaper's quality.

[12] Since the daily subscription option includes access during the weekend and Sunday, it is conceivable that the error term (i.e., ξ) of the daily option includes the weekday and weekend structural errors. If such a relationship exists, the structural errors of the three options will be correlated. The GMM estimation approach that we employ is agnostic about the correlation among the error terms of the various alternatives. Therefore, the resulting estimates should not be affected by the presence of such a correlation.

[13] We compiled these county-level median income data from the U.S. Census Bureau's American Community Survey database.

[14] For identification, we set I_t for the year 2006 to zero.

[15] We also examined the sensitivity of our key findings to alternative assumptions regarding the extent of the Sunday newspaper's contribution to overall ad revenues by varying the weights as per the discussion in Online Appendix 1. We see that our results are robust to various plausible levels of Sunday advertising contribution (50%–100%). These results are available from the authors on request.

[16] It is conceivable that advertisers respond to changes in the composition of readers. If so, it has implications for how newspapers set prices. We estimated various model specifications wherein we included the composition of readers in terms of income, high school education attainment, and English speaking abilities as an additional covariate in the advertising demand model. We did not find a significant relationship between the composition of readers and advertising in any of these specifications. We thank the senior editor for suggesting this line of investigation.

[17] We recognize that the proportion of the ad expenditure on Sundays versus weekdays is an endogenous decision made by the advertisers and is likely to be tied to the corresponding readership on these days. Subsequently, we consider a specification where we use advertising data on weekdays versus Sundays to account for differential responsiveness to weekday versus Sunday readership. However, because these data are available only for a limited time period, we do not use this as the main specification, but rather present it as part of a robustness check.

[18] We thank an anonymous reviewer for this insightful observation.

[19] A benefit of using such semiparametric controls is the reduced reliance on parametric assumptions on the nature temporal evolution in advertising demand. However, the cost of the flexible specification is that we are unable to separate out the individual influence of the effect of the recession and the increasing popularity of the outside option on ad demand. Furthermore, the effect of the recession is temporary (2008–2009), and we see a consistent decline in the intrinsic attractiveness for advertising for display and classified ads, even in periods following the recession, indicating that the outside option was indeed gaining in relative popularity over our analysis time frame.

[20] As discussed in Endnote 4, almost all U.S. daily newspapers are local monopolies. However, these local newspapers may face competition from national newspapers and other news/advertising outlets within their local markets. The outside option in our demand model helps us account for this competition. However, similar to extant work (Blair and Romano 1993, Gentzkow 2007, Fan 2013), we assume that price responses to changes in competition are small.

[21] Employing the weights discussed in Online Appendix 1, we compute the responsiveness of readership to changes in the price of option m, $\partial R_t/\partial p_{mt}$ as a weighted sum of the responsiveness of each option's readership to a change in price of option m.

[22] The optimal markup on the advertising side will also be a function of the responsiveness of advertising demand to CPM, i.e., $\partial q/\partial r$. In our data, we find that the optimal markup on the advertising side, net of the shift in ad demand and changes in $\partial q/\partial r$, decreases during the period of our analysis.

[23] In a sense, a static demand model may be interpreted as a steady state of a full dynamic model that includes state dependence. However, it is unlikely that the newspaper market is in a steady state owing to the dramatic changes in the advertising and, to a lesser extent, the reader demand markets, a limitation of the static pricing model over a fully dynamic equivalent. We thank an anonymous reviewer for pointing this out.

[24] In our estimation, we used a tolerance level of 10^{-6}.

[25] Since the right-hand side of the pricing equation is a function of exogenous cost shifters and not demand parameters, it may be estimated using OLS (Bonnet et al. 2013; Train 2009, p. 330).

[26] As discussed in Section 4.1 above, since our data on the number of news pages vary only at the annual level, we cannot estimate the corresponding effect when we allow for different temporal trends for each subscription option.

[27] We provide additional details regarding the simulation exercise in Online Appendix 3.

[28] As described in Section 3.1.1 earlier, the individual data pertain only to households that subscribed at least once during the period of our analysis. Therefore, to match the outside option in the aggregate data (defined based on nonsubscribing households within a county), we simulated a proportional number of households that always chose the outside option.

[29] Note that the demographic characteristics (median county income) also implicitly act as exclusion restrictions and aid in the identification of the effect of readership on advertising demand.

[30] To protect the identity of our data sponsor, which is a major source of print news in its market, we anonymize the name of the market.

[31] The strength of the instruments documented based on the first-stage regressions are after we account for some temporal trends in the form of year fixed effects (which are included in our demand model). Nevertheless, there is the possibility that within-year variation in the instruments and prices exhibit serial correlation, which could overstate the strength of our instruments, especially under negative autocorrelation (Granger and Newbold 1974). We find no evidence of serial correlation; across our regressions, the Durbin–Watson statistic falls within the range needed to reject the null hypothesis indicating the presence of autocorrelation (Savin and White 1977). Detailed results are available from the authors on request. We thank the associate editor for suggesting this line of investigation.

[32] We thank an anonymous reviewer for this suggestion.

[33] The smaller role played by price increases in specification (b) can possibly be explained by the lower price elasticity estimate resulting from this specification.

[34] We adopt a linear time trend to account for temporal trends in marginal costs. The predictors in the calibration regression account for 95.9% of the observed variation in marginal costs.

[35] Our in-sample MAPD ranges between 17.4% and 17.8%. The out-of-sample MAPD ranges between 12.1% and 16.8%.

[36] We perform our computations based on markups because of our earlier finding that they were the primary driver behind the increase in subscription prices. Our results remain unchanged if we computed them based on actual and predicted prices.

[37] These ad revenue per reader numbers are based on our data that span 2006–2010 for weekday and Sunday advertising.

[38] Fan (2013) documents that over 75% of newspaper consolidations in her data (which range from 1998 to 2005) occurred in the period 1998–2002.

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