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ABSTRACT

Between 2006 and 2011, daily print newspapers in the U.S. lost 20% of their paid subscribers, partly due to 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 increase in subscription prices are mainly rationalized by: a) the decline in readers' willingness to pay (WTP) in the presence of heterogeneity among subscribers, or b) the newspaper's reduced incentive to subsidize readers at the expense of advertisers, due to 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 role played by agents on the subsidy and demand side in determining prices.

Keywords: Pricing, two-sided markets, newspaper industry, print newspapers, newspaper advertising.

*This paper is based on the first essay of the first author's doctoral dissertation at the University of Michigan.

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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 the print newspaper (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 traditionally 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.[2]

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). 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. In fact, several highly-publicized industry reports (Weber and Poyar, 2012; Filloux, 2012) have claimed that newspapers' price-based segmentation strategies on the reader side are primarily responsible for the steep increase in subscription prices.

A second, heretofore under-investigated rationale for the increase 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

[1] As we discuss subsequently, 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 newspages have declined over time. Therefore, increase in quality cannot explain the price increases either.

[2] Report "Circulation Pricing" dt. Mar 17, 2009 retrieved from the NAA's website: www.naa.org.

subsidize readers at the expense of advertisers.[3]

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 increase 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 subscription on all seven days, Fri/Sat/Sun, and Sunday, respectively. These data are broken down geographically by the sub-markets (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 sub-market and option-level subscription data as well individual-level data enables us to characterize the readership demand model and identify heterogeneity in readers' willingness to pay for the newspaper, and 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 between 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

[3] 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 (in section 6.4.1).

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 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 in order 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 competing 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 were solely driven by the newspaper's strategic decision to increase its price-cost margins on the reader side, rather than due to increase in cost. 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 due to 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 towards a more balanced

subscription-cum-advertiser funded model.[4] Thus, as advertising continues to decline, a premium pricing strategy aimed at charging its readers higher prices is possibly the way forward for newspapers.[5] 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), as well as 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. Therefore, our quantification of the relative importance of the advertising side vis-à-vis the reader side is not imminently obvious or guessable without a formal empirical investigation. In that sense, we augment theory by providing a formal empirical approach to unravel the relative importance played by agents on the subsidy versus demand side, in determining prices in a two-sided market. Towards the end of the paper, we discuss some possible implications of our findings beyond the specific context of our investigation.

The rest of the 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 and robustness checks 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 increase (decrease) over time if high

[4]Print newspaper circulation has recently encountered an all time low. The last time newspaper circulation was at current levels was in the mid-1940s, when the population of the U.S. was half its current size - see http://www.journalism.org/node/1414.

[5]http://www.thedrum.com/news/2011/09/19/guardianrsquos-editor-chief-robustly-justifies-his-newspaperrsquos-latest-cover

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 inter-temporal price discrimination by initially charging premium prices to high WTP customers and reduce prices subsequently to serve the low WTP consumers. In 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 due to 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 due to 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 increase 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 in 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 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 vs. 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 in 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, as well as display, inserts, and classifieds advertising). This enables us to understand the extent to which changes in demand at individual subscription and advertising options 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 come 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.[6] 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 sub-markets (top five counties by circulation) for the three most popular subscription options: Daily, Weekend, and Sunday only. Subscribers residing in these sub-markets 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 sub-market level only for subscriptions. Hence, we use subscription data as a proxy for readership in our empirical analysis.[7] 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 have 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 sub-market (county) level, subscription prices do not vary at this level of disaggregation. For each subscription option, the firm charges different prices to readers residing in regions within vs. outside the newspaper's core market.[8] 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 Audit Reports.

On the advertisering side, we have data on monthly ad revenues and rates on the print newspaper in three advertising formats: a) display advertising, b) newspaper inserts, and c) classifieds advertising. These three advertising types constitute over 96% of newspapers' advertising revenues.

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

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

[8] 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).

Advertisers that opt for display advertising are generally business establishments with pre-specified advertising budgets. Classifieds advertisers, on the other hand, are usually 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 generally very 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). Further, 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 appears in a pre-specified section of the newspaper (the "Classifieds" section). Newspaper inserts, which generally include product information or intimate consumers about promotions, appear as a separate add-on to newspapers.

Although our research question is motivated by the industry-wide phenomenon of increasing print subscription prices, the data used in our empirical analysis come from one newspaper. We assess the representativeness of the focal newspaper by considering the temporal patterns in the total circulation and advertising revenues of the focal newspaper with those for all U.S. newspapers. To this end, we collected the data on the U.S. print newspaper industry from the Newspapers Association of America (website: www.naa.org). The temporal patterns in Figure 1 suggest that the trends in circulation and advertising revenues reflect the general state of the U.S. newspaper industry. Furthermore, the correlation in both total circulation and advertising revenues of the focal newspaper with those metrics for all U.S. newspapers is high (0.967 and 0.998 respectively). Together, these data patterns suggest that the focal newspaper is representative of the population of U.S. print newspapers.

3.1 Descriptive Analyses

3.1.1 Readership Data

As discussed before, our readership data contain information on newspaper subscription for the three most popular subscription options at its five major sub-markets (counties). Access to dissaggregate readership data enables us to explore differences in subscription behavior across options and sub-markets. 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 con-

tained a higher percentage of subscribing households (18.9%) 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.[9]

Subscription to the Daily option provided home-delivery of the newspaper on all seven days of the week and is the most expensive option (see section 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 Section (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. Further, the temporal pattern for subscription shares in Figure 2 demonstrates that there is significant cross-sectional heterogeneity across the different sub-markets within the newspaper's market.

Between 2006-2011, prices for all three subscription options increased steeply. In Table 2, we present the percentage increase 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 areas within/outside the core market, we plot the share evolution by pooling across sub-markets corresponding to these regions. From Figure 3, we see that the majority of the decline in print subscriptions arise from within the core market and for the Daily option, which also has the largest readership base.[10] To track the temporal evolution of option-level circulation at each sub-market, we computed the average annual percentage change

[9]Newspapers have been restricting delivery to geographic regions with very low demand, to potentially 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 zipcode level for our analysis period from the AAM Audit Reports. We found that less than 5% of zipcodes drop out from the sample over the duration of our data (a zipcode would not figure in our dataset or the AAM's Audit Reports for that year if the newspaper stopped serving readers from that zipcode, or if that zipcode accounted for less than 25 subscribers).

[10]We plot the nominal subscription prices (i.e., pre-inflation adjustment) for each option in Figure 3 for comparison.

in subscriptions over time at the five sub-markets for all three options and report them in Figure 4. Figure 4 shows that subscription shares for the Daily option decay at a faster rate (between 8-11%) in counties within the core market compared to those outside (between 3-7%). 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 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 7-10% (2-6%).

Examining the temporal path of newspaper subscriptions in this market, we conjecture that readers' WTP for news might be 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 subscription, i.e., increasing prices drove down demand. While we cannot definitively state whether decline in intrinsic preference or rising prices contributed to the drop in subscription 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 (please see Figure 3). 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 subscription down. On the other hand, the Sunday-only option experienced marginal decline or even growth in subscription 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 (non-advertised) news pages varies by subscription option on an annual basis. The number of news pages 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 increase in quality drove the price increases.

We augment the aggregate data with individual-level subscription information for a random sample of 5565 households, accounting for 3.4% of all subscribers. These households were drawn from the population of subscribers such that each sub-market (i.e., county) was represented proportional to its subscriber base.[11] In order 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 datasets 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 datasets. Once again, we find that the the individual data are representative of the population of subscribers.

3.1.2 Advertising Data

The newspaper sets advertising rates for display and classifieds ads in dollars per column inch of advertising while ad rates for inserts are in dollars per 1000 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 and classifieds, and thousands of inserts for pre-print ads. We present temporal patterns in advertising revenues, rates, and quantity in Figure 5. From the first panel in Figure 5, we see that the revenues from all three types of advertising declined. Section (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, Classifieds ad revenues experienced the steepest decline of 88.3%. The steep decline in display and classifieds advertising has been attributed to the increasing shift in both advertiser and consumer interest towards non-newspaper 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 due to their higher targeting ability (Sullivan, 2012; Maynard, 2011).

[11] 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 non-subscribing households corresponding to the individual data.

Between 2006 and 2011, classifieds 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) 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 (classifieds) increased (decreased) over time.[12]

4 Model

In this section, we discuss the decisions made by the three agents in our framework: readers, advertisers, and the newspaper firm. Readers choose one of three newspaper subscription options (Daily, Weekend, and Sunday only) or the outside option of not subscribing. Advertisers make quantity choices on the three available advertising types: display, inserts, and classifieds. The newspaper decides subscription prices for the three options and advertising rates for each of the three advertising types. Below, we discuss how we model these decisions.

4.1 Readership Model

We begin by specifying the utility that reader i who belongs to sub-market l derives from subscribing to the print newspaper option $m \in$ {Daily (Mon through Sun), Weekend (Fri, Sat, Sun), Sun only} during month t as:

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

where α_{ilmt} is the intrinsic preference that reader i living in sub-market l has for subscription to newspaper option m at time t. p_{lmt} is the inflation-adjusted price paid by the reader in sub-market 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., non-advertising pages) available in the newspaper for subscription option m at time t. We use the number of news pages (or news hole - cf. Fan, 2013) as a proxy for the quality

[12] 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 towards total ad revenues. The trajectories of CPM calculated using reweighted readership were similar.

of the newspaper as perceived by readers (Berry and Waldfogel, 2010).[13] 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 towards outside news options, ex ante, we expect intrinsic preferences (α_{ilmt}) for newspaper subscription to decay over time. The term ε_{ilmt} is an 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.[14] 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 later).

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

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

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 sub-market l. The vector of sub-market fixed effects accounts for the differences in the mean preference for subscription across sub-markets. X_{lt} is a vector of demographic characteristics at sub-market l at time t, that shift the intrinsic preference for the newspaper. In our specification, we use the time-varying median income

[13] 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.

[14] Since the Daily susbcription 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 would 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.

in each sub-market as a shifter of the intrinsic preference.[15] 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 semi-parametric controls in the form of year fixed effects (I_t).[16] The temporal evolution of preference for the newspaper is also clearly influenced by the increased propensity towards 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 sub-markets within and outside the core market (see Figure 3), we allow the δ's to vary over time differently across sub-markets 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 sub-markets 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 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

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

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

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 choses option m is given by:

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

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

$$S^d_{lmt} = \int_{\nu} \frac{exp(\alpha_{im} + \beta^d_0 p_{lmt} + \beta_1 newspgs_{\,mt} + \gamma_l X_{lmt} + \delta^d_t I_t + \xi_{lmt})}{1 + \sum_{m'=1}^{3} exp(\alpha_{im'} + \beta^d_0 p_{lm't} + \beta_1 newspgs_{\,m't} + \gamma_l X_{lm't} + \delta^d_t I_t + \xi_{lm't})} \partial F(\nu). \tag{4}$$

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 on subscription pricing. Therefore, we adopt slightly different demand characterizations for the three types of advertising.

4.2.1 Display and Classifieds Advertising

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

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

where q_{kt} is the advertising quantity for ad type $k \epsilon \{display, classifieds\}$, 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 Classifieds, and thousands of inserts for pre-prints. The term r_{kt} is the inflation-adjusted advertising rate charged by the newspaper for ad type $k = \{1, 2, 3\}$ standing for display, inserts, and classifieds 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 vs. Sundays. These data suggest that the Sunday newspaper accounted for 70% to 75% of the overall ad revenues (see Table 7). 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.[17],[18] We provide further details on this weighting in Appendix 1. We verify the robustness of our results to alternative assumptions regarding R_t in section 6.4.2.[19]

Together, r_{kt}/R_t represents the cost per 1000 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

[17]We also examined the sensitivity of our key substantive 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 Appendix 1. We see that our results are robust to various plausible levels of Sunday advertising contribution (50-100%). These results are available with the authors on request.

[18]It is conceivable that advertisers respond to changes in the composition of readers. If such dependencies between advertising and readership do exist, it can have 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 all these specifications. We thank the Senior Editor for suggesting this line of investigation.

[19]We recognize that the proportion of the ad expenditure on Sundays vs. on 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 vs. on Sundays to account for differential responsiveness to weekday vs. Sunday readership. However, because these data are only available for a limited time period, we do not use this as the main specification, but rather present it as part of a robustness check.

curve as a function of the CPM, μ_{kt} allows this demand curve to shift over time. ι_{kt} is a normal mean-zero i.i.d error term for advertising quantity.

4.2.2 Newspaper Inserts Advertising

Our specification of the demand for inserts advertising is similar to that for display and classfieds, 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 inserts 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.[20] 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:

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

where k' indexes inserts. Note that the parameter ϱ captures the relationship between readership of the newspaper and the demand for inserts 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 different in advertising form, the nature of target advertisers and advertising objective (as discussed earlier). Furthermore, our conversations with managers at the newspaper revealed that advertisers rarely switch between ad types, suggesting that substitution is unlikely to be sizable. Nevertheless, it is conceivable that synergies may arise if advertisers employ multiple types of advertising simultaneously. However, our interviews with managers at the newspaper

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

suggested that a very small proportion of advertisers (<10%) generally invest in more than one advertising type in each year.

In order to study the role of exogenous changes in the ad market on subscription prices, it is important to account for the temporal evolution of intrinsic advertising attractiveness of advertising in each option. The intrinsic attractiveness reflects the relative effectivess 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:

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

where the 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 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).[21] The term $\widetilde{Y}_{kt}$ 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 downwards 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.

[21] A benefit of using such semi-parametric controls is the reduced reliance on parametric assumptions on the nature temporal evolution in advertising demand. However, the cost of the flexible specification is 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 classifieds, even in periods following the recession indicating that the outside option was indeed gaining in relative popularity over our analysis time frame.

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:[22]

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

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, inserts, and classifieds 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 rows 7 through 9 in the markup matrix Ω in Equation (9)

[22] As discussed before in footnote 6, 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.

are a result of our assumption that the subscription decision does not depend on the quantity of advertising. The 3 x 3 block of zeros in the off diagonal of the 6 x 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 rows 7 through 9 are a result of our assumption that advertisers do not substitute between the three types of advertising (as discussed 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 re-write the FOC for subscription option m, $m = 1, 2, 3$, for the core market as

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

23

The FOC from equation (8) with respect to advertising rates for type k are given by:

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

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

[23] Employing the weights discussed in 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.

extent to which the 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 due to the increase in option m prices. The terms 3, 4, and 5 correspond to the effect of display, inserts, and classifieds advertising subsidy 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 $(\frac{\partial q_{kt}}{\partial r_{kt}})$ 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, 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 first order condition 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, i.e., $\left|\frac{\partial R_{mt}}{\partial p_{mt}}\right|$. In order to understand how a declining intrinsic preference for newspaper subscription would affect optimal prices via $\left|\frac{\partial R_{mt}}{\partial p_{mt}}\right|$, consider the simplest case where the market is comprised of two segments of customers that differ in terms of their WTP with segment 1 comprising of the high WTP type. The subscription share of option m at time t can be written as $R_{mt} = \lambda^1 R^1_{mt} + \lambda^2 R^2_{mt}$. In this representation, λ^1 and $\lambda^2 (= 1 - \lambda^1)$ are the relative sizes of the high and low WTP customer

segments respectively and R^1_{mt} and R^2_{mt} are the corresponding shares of subcription option m in these segments. Under such a scenario, $\frac{\partial R_{mt}}{\partial p_{mt}} = \lambda^1 \frac{\partial R^1_{mt}}{\partial p_{mt}} + \lambda^2 \frac{\partial R^2_{mt}}{\partial p_{mt}}$. Given their lower WTP for the newspaper, we expect that $\left|\frac{\partial R^2_{mt}}{\partial p_{mt}}\right| > \left|\frac{\partial R^1_{mt}}{\partial p_{mt}}\right|$. With the arrival of alternative sources of news over time, low WTP subscribers are more likely to quit the newspaper, leading to lower λ^2, and hence higher λ^1 over time. The resulting decrease in $\left|\frac{\partial R_{mt}}{\partial p_{mt}}\right|$ would render it optimal to increase subscription prices as low WTP readers quit. The same intuition will apply when we consider continuous heterogeneity.

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 (terms 3, 4 and 5 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.[24] From Equation 10, we can see that the optimal level of subsidy on the reader side of the market would 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 would decrease if $\frac{\partial q}{\partial R}$ decreases over time. Our constant elasticity specification for the advertising demand implies that $\frac{\partial q}{\partial R}\frac{R}{q}$ is a constant. A larger downward shift in advertising demand relative to readership would lead to an increase in $\frac{R}{q}$ over time. As a result, $\frac{\partial q}{\partial R}$ 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

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

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, it is conceivable that 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 (Dube et al., 2010) - the latter two much less likely a significant driver in the market for newspapers. Since our empirical analysis is primarily based on aggregate data, it would be difficult to separate out heterogeneity from state dependence. Moreover, we follow the practice in the extant research on newspaper industry (Rysman, 2004; Gentzkow, 2007; Fan, 2013; Seamans and Zhu, 2014) in terms of not considering potential state dependence in subscription.

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 static scenario in order to acquire customers.

This incentive to lower prices is likely to be greater when perceived quality is high (Dube et al., 2008).

In our context, if the intrinsic preference for newspaper subscription 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.[25]

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 generated 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; Villas-Boas, 2007b).

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 (2007a) 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 the paper regarding the relative roles of the readership vs. advertising demand on the pricing decisions are based on counterfactual analyses that depend on the premise that the observed price trajectories

[25] 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 steady state owing to the dramatic changes in the advertising, and to a smaller extent, the reader demand market; a limitation of the static pricing model over a fully dynamic equivalent. We thank an anonymous reviewer for pointing this out.

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 in order 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 the next sub-section) 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, b) parameters that affect the mean utility. As regards 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 3x3 matrix, which implies that we need to estimate six parameters that characterize the Cholesky decomposition of Σ. As regards the mean utility parameters, we need to recover the fixed effects for each subscription option, price sensitivity, responsiveness to changes in news pages, sub-market (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 the approach proposed by Berry et al. (1995) (hence forth BLP approach) to estimate the readership demand parameters. With aggregate data, the identification of the mean utility parameters is relatively straight forward. While researchers have estimated heterogeneity distribution with aggregate data using the BLP approach, we use additional micro-moments from individual-level purchase histories to strengthen the case for identification. The estimation approach that we employ is similar to Chintagunta and Dube (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 pre-sepcified tolerance level.[26]

In the advertising demand model, the parameters to be estimated are: a) elasticity of advertising demand to changes in readership adjusted prices (φ), b) advertisers' intrinsic attractiveness for display, inserts and classifieds 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 OLS.[27] 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 hold out 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 vs. decreasing incentive to subsidize readers at the expense of advertisers drove the increase in subscription prices. Of these, we conceptualize the latter as a consequence of the decline in intrinsic preference for print advertising amongst 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.

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

[27] 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)

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 subscription. In our specification, we infer changes in intrinsic preference for subscription semi-parametrically in the form of year fixed effects. Since we have monthly subscription data, the identification of these year fixed effects in isolation is relatively straight forward. 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 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.[28] Moreover, there are instances when subscription prices change multiple times during a 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' willingness to pay, which is central to our research question.

To systematically assess whether the actual 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.[29] 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. In order to understand how the recoverability varies as we increase the extent of cross-sectional variation, we consider three scenario: (i) model estimated using data on one option (only the Daily option), (ii) model estimated

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

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

using overall market-level data on all three subscription options, and (iii) model estimated on sub-market (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 (MAD) of our recovered estimates from these 100 datasets for each model in Table A.3 in 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 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. In order to infer the heterogeneity distribution in subscriber preferences, we use micro-moments generated by the purchase histories of a sample of individual subscribers in each of the sub-markets (i.e., counties).[30] Such micro data 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 Dube, 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

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

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. In order to break this endogeneity, we need instruments that shift subscription prices and ad rates, but are not related to the demand shocks.

In order 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 (NAICS 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 games market. In order 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 8 section (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-squares. Therefore, we believe that 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). But, 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 section

(A) of Table 8 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. In order 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). In order 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 8 section (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, 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 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.[31] 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. In order 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 reflects 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

[31]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.

relevant to local news ("news", "<name of the city> news"[32]). 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 of the local newspaper and the local subscription of 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 results from the first-stage regression of ad rates and readership on instruments in Table 8 section (B).[33]

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

In order 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.

[32]In order 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.

[33]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 possiblity 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 with the authors on request. We thank the AE for suggesting this line of investigation.

6 Results

6.1 Readership Results

We adopt two alternative specifications for our main readership model: (a) with a common set of year fixed effects for all subscription options in order to capture the evolution of the overall intrinsic preference for print subscription and (b) with different year fixed effects for each subscription option in order to capture separate temporal paths for the intrinstic preference for each subscription option. However, since our data on the number of news pages varies at the year-subscription option level, we can include this as a covariate only in the former specification, but 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.[34]

We report the results from both specifications in Tables 9 and 10. 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 least negative, followed by Sunday and then Weekend. 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 the covariance terms in the Σ matrix are positive, suggesting that households that have a high preference for one subscription option also value other subcription 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

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

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 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 subscription, 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 subscription, followed by 32% for the decline in year fixed effects.[35] 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 subscription 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 11. 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 classifieds 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,

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

we set $\frac{\partial q_2}{\partial R} = 0$ 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 11). We find that our main findings are robust to treating this effect as significant and employing the estimated value of $\frac{\partial q_2}{\partial R}$ while computing optimal markups.

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

In order to assess whether the optimal prices implied by our model and the readership and advertising demand estimates, we use data from 2006-2010 (i.e., 60 months) as a calibration sample.[36] 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 6 for the core market. Those for the region outside the core market are similar. The prices that were predicted by the model for 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%-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).[37]

The results from this model suggest that the marginal costs declined during the period of our analysis (Figure 7). Therefore, the increase in subscription prices were driven primarily by the

[36] 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.

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

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 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. In order 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 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, in order 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 switch off the decline in readers' preferences, and the case where we switch 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. In order 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.[38]

We present the results from this analysis in Table 12. These results suggest that within the core market, the decline in readers' preferences accounted for between 8-21% of the increase in subscription prices. On the other hand, nearly 79-92% 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 only explain 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 more balanced model where readers make a sizeable contribution too. In order to internalize the actual impact of the decline in advertising, we present the relative average susbcription and advertising revenue per reader, in our data, in Table 6. While advertising constituted 87% of the revenue contribution per reader in 2006, its share decreased to 69% in 2011, suggesting a shift towards a more 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 the price increase in Table 12. These results suggest that the decline in display and classifieds advertising primarily drove the subscription price increases. Thus, our results add to the limited literature that has attempted to document the influence of the classifieds 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 classifieds 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 represent a structural shift from a model where the newspaper used advertising revenue to subsidize readers, to a more balanced revenue model.

[38]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. We present these counterfactual predicted prices in Figure 8.

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.[39] 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 more balanced revenue model where readers and advertising contribute equally in generating revenues. Further, 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 only to weekends, a strategy adopted by many U.S. newspapers (Lendon, 2008; Carmichael, 2010).

6.4 Robustness Checks

6.4.1 The Effect of Online Ad Revenue

The above analyses assume that the readers that quit the print newspaper as a result of increasing subscription prices do not generate any revenue. However, it is conceivable that some of the readers that quit the print version migrate online. Although the newspaper in question did not charge online visitors for news consumption, these marginal readers could still generate advertising revenue. If this extra online ad revenue is substantial and the newspaper internalized this while increasing its subscription prices, our explanation for these price increases is likely to be contaminated.

Nevertheless, incorporating the additional ad revenue formally would require us to (a) characterize the switching pattern between online and print news, albeit within the same newspaper and (b) parse out the extent to which the subscribers quitting the print newspaper and moving online are incremental online readers. Since we do not have individual data on joint online and print

[39]These ad revenue per reader numbers are based on our data that span 2006-2010 for Weekday and Sunday advertising.

readership, the case for the inference of these two effects is likely to be tenuous. In order to circumvent this problem, we make the following generous assumptions on the extra online ad revenue generated as a result of print subscription price increases: a) all the print subscribers that quit the print newspaper move to the newspaper's online edition and b) these readers are all incremental readers of the online newspaper. In reality, given that there in typically some overlap in print and online readership, not every incoming online reader would be incremental.[40] We obtained monthly online ad expenditures for the newspaper from the firm and backed out the advertising revenue generated by each unique visitor to the newspaper's website. Then we use price elasticities based on our model to compute the switching rate corresponding to a unit price increase to the daily newspaper.

Based on these assumptions, we compute the projected online revenue for this new higher level of online readership. We find an incremental online revenue of 3.42% in 2006, which drops down to 2.02% for 2011, given the switching patterns. This represents an insignificant 0.07% (0.51%) increase over print advertising (circulation) revenues. As a final reality check, we compute optimal markups for the three subscription alternatives if the firm considered online revenues as an additional revenue source while setting print subscription prices. We then compare these markups, as earlier, to quantify the contribution of each of the three explanations.[41] We present this comparison in column (1) in Table 13. The relative contribution of the motive to gain online advertising revenues is small, at around 5.7%, when compared with that of the decline in advertising. Furthermore, consistent with our earlier finding, changes in the advertising side of the market played a more prominent role in driving up the subscription prices.

6.4.2 Considering Differential Responsiveness of Advertising to Weekday and Sunday Readership

In our empirical specification, we computed the total readership metric based on the assumption that 75% of the ad revenue came from the Sunday newspaper. However, the percentage of ad revenue that the newspaper derives from the Sunday newspaper is a consequence of endogenous

[40] Interviews with managers at the newspaper revealed that between 20-25% of print readers also visited the online edition over our analysis horizon.

[41] We present the comparison of markups for the case with readership reweighting, with Sunday accounting for 75% of ad revenues.

decisions made by advertisers in response to the changing composition of readership during different days of the week. In order to capture this phenomenon, we need to allow advertising demand to respond differently to weekday and Sunday CPMs, and consequently to the corresponding readership volumes. Given that our advertising data were not broken down by the days of the week, the cleanest approach to addressing the differential extent to which circulation on various days of the week generate ad revenues would be infer how advertising changes in response to variation in readership on different days of the week over time. The premise is that the cross-sectional and temporal variation in subscriptions during different days of the week will help us infer how advertisers value readers within a week. However, empirically, we were unable to uncover significant differences in advertiser sensitivity to readership on different days of the week.

It is somewhat common in the newspaper industry to price Sunday advertising at a premium over non-Sunday ads (ranging from an average of 26%, 33% and 51% respectively for display, inserts and classifieds in our data).[42] While we do not have advertising data broken down by weekdays vs. Sundays for the entire period of our analysis, such data were available for a part of our time frame (i.e., 54 months from Jan 2006-Jun 2010). The variation in these data enables us to estimate a richer advertising demand model that allows for different responsiveness of weekday and Sunday advertising to the corresponding changes in weekday and Sunday CPMs. We then use the estimates of this demand model (presented in Table A.4 in Appendix 4) to compute the contribution of our proposed explanations.[43] We see that our results are substantively unchanged (Table 13 column (2)), with the decline in the incentive to subsidize advertisers accounting for a large share of the increase in subscription prices.

6.4.3 Accounting for Single Copy Sales

In reality, the total circulation of the newspaper would comprise of both subscription and single copy sales. As discussed earlier, while we have subscription data at the county level, single copy (newsstand) sales data are available only at the overall market level. In order to investigate the robustness of our results to the inclusion of single copy sales, we used the single copy sales data at

[42] This forms the basis of our categorization of advertising into Sundays and non-Sundays (termed "weekdays" for simplicity).

[43] When we tested for the effect of the capacity constraint on the demand for inserts in this model, we find the effect to be non-significant (Table A.4). We therefore set $\partial q_2/\partial R$ for weekday/Sunday advertising to zero in this robustness analysis.

the market level to construct a fourth inside option. The assumption here is that the single copy sales at different counties are proportional to their respective subscription levels.

We present the results from this alternative readership model in Table 14. We then reestimated the readership and advertising demand models using these data on single copy sales. With these new estimates we recomputed the relative magnitudes of the two explanations. As in earlier analyses, we find that the optimal subscription (advertising) prices increase (decrease) during the period of our analysis. We present the results on the relative extent to which decline in readers' preferences and advertising subsidy played a role in driving up subscription prices in column (3) of Table 13. We see that the decline in readers' preferences and in advertising subsidy explain 12.48% and 87.52% of the price increases respectively, suggesting that our results are robust to the inclusion/exclusion of single-copy sales as a choice option for the reader.[44]

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 the advertiser demand for the print newspaper, and tie them to a model of the newspaper's pricing decision.

Our results suggest that decline in advertising subsidy was a big reason for 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

[44]While these results are based on aggregate (sub-market level) data, they are comparable with our results using micro-moments as our micro-moments are used only to identify heterogeneity, while the means are recovered using aggregate data.

usage in order to offset anticipated losses from a new rule that capped the fees that banks could charge merchants.[45] 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 in order to serve only the loyal readers of its most popular option, possibly in an attempt at coping with the large revenue decline it has witnessed over the last five years. This indicates that newspapers may be becoming a more niche product serving a smaller readership base. Further, this result is also suggestive of a change in the mainstream information dissemination role played by newspapers in the society (Weibull, 1992). However, a shift in newspapers' traditionally advertising-supported revenue structures towards a more "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 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) estimat-

[45] https://consumerist.com/2014/03/07/bank-of-americas-new-debit-card-charges-5month-for-something-that-is-free-on-all-accounts/

ing the optimal advertising markups at the advertiser segment (Local vs. 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' willingness-to-pay for access to higher willingness-to-pay 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.[46] 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 multi-newspaper 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.

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

Appendix 1

Readership re-weighting to account for differential advertising contribution of the Weekday/Sunday newspapers

We consider the case where the Sunday version of the newspaper contributes 75% of the newspaper's total advertising revenues (the industry benchmark). Let ϖ and $\ddot{s}$ denote the per-reader advertising contribution of the Weekday (including Saturday) and Sunday newspaper respectively. If the Sunday edition is responsible for 75% of total advertising revenues, we have

$$\frac{(R_{Daily} + R_{Wknd} + R_{Sun})\ddot{s}}{R_{Daily}(6\varpi + \ddot{s}) + R_{Wknd}(2\varpi + \ddot{s}) + R_{Sun}\ddot{s}} = \frac{3}{4}$$

This can be used to compute an expression for $\varpi/\ddot{s}$, which can further be used to reweight readership according to the expression: $R_t = R_{Daily} * [6\,(\varpi/\ddot{s}) + 1] + R_{Wknd} * [2(\varpi/\ddot{s}) + 1] + R_{Sun}$ in the advertising demand model to account for the differential advertising contribution of the Sunday newspaper.

Appendix 2

Does newspaper advertising influence subscription decisions?

To try to answer this question with our data, we estimated the readership model allowing the levels of advertising (proxied by total advertising quantity) to influence consumer utility. We found that its effect is negative, small and statistically insignificant (last column in Table A.1). However, readers' subscription decisions may be influenced differentially by the three advertising types: Display ads, Inserts, and Classifieds. To explore this possibility we estimated alternative model specifications where we allowed the three advertising types to influence readers' decisions individually.[47] We found that the coefficients on the advertising terms were insignificant in all cases. We found no difference in the result based on whether or not we allowed the advertising effect to vary by option (Table A.2), or allowed these coefficients to be heterogeneous.[48] Further, as we described in the Estimation section, in our empirical specification for readership demand, we specify year-fixed effects to flexibly capture the temporal evolution of readers' preferences. Therefore, the insignificant effect of advertising on readership just suggests that the within year variation in advertising might not have an effect on readership. A concern is that these year fixed effects may also be capturing the significant influence of year-on-year changes in advertising on subscription decisions. To assess the validity of this concern, we also estimated alternative model specifications for readership demand with advertising included as a covariate, but without year fixed effects. We found that the advertising coefficients were statistically insignificant even after excluding the year fixed effects. We provide these results in Table A.2. This helps us place more faith in our assumption that newspaper subscription decisions are not influenced by advertising levels.

[47] Given the high temporal correlation (0.55-0.85) between the three types of advertising, we could not estimate a model that allowed for the simultaneous influence of all three advertising quantities.

[48] These results can be obtained from the authors on request.

Does advertising influence readers' subscription decisions?

Parameter	**Display**		**Inserts**		**Classifieds**		**Total Advertising**	
	Est.	SE	Est.	SE	Est.	SE	Est.	SE
Pref (M-Thurs)	2.30***	0.26	2.28**	0.25	2.29**	0.26	2.29**	0.26
Pref (Fri,Sat)	-1.77***	0.12	-1.77**	0.11	-1.77**	0.12	-1.77**	0.12
Pref (Sun)	-6.67***	0.50	-6.68**	0.50	-6.76**	0.56	-6.67**	0.50
core market price	-0.05*	0.02	-0.05*	0.02	-0.05*	0.02	-0.05*	0.02
outside core market price	-0.02	0.01	-0.02	0.01	-0.02	0.01	-0.02	0.01
# of news pgs	0.44**	0.16	0.45**	0.15	0.45**	0.15	0.45**	0.15
C1-Income	0.64**	0.07	0.64**	0.07	0.64**	0.07	8.98**	0.07
C2-Income	0.46**	0.08	0.46**	0.08	0.46**	0.08	5.58**	0.08
C3-Income	0.29**	0.09	0.29**	0.09	0.29**	0.09	3.36**	0.09
C4-Income	0.58**	0.08	0.58**	0.08	0.58**	0.08	7.73**	0.08
C5-Income	0.13^{+}	0.08	0.13^{+}	0.08	0.13^{+}	0.08	1.61**	0.08
core market Y2007	-0.30**	0.06	-0.30**	0.06	-0.29**	0.06	-0.30**	0.06
core market Y2008	-0.48**	0.08	-0.48**	0.07	-0.45**	0.11	-0.48**	0.07
core market Y2009	-0.16^{+}	0.09	-0.16*	0.07	-0.12	0.12	-0.17*	0.08
core market Y2010	-0.16	0.10	-0.16*	0.08	-0.11	0.12	-0.17^{+}	0.09
core market Y2011	-0.29*	0.11	-0.29**	0.08	-0.23^{+}	0.14	-0.29**	0.10
Outside core market Y2007	-0.17**	0.05	-0.17**	0.05	-0.17**	0.05	-0.17**	0.05
Outside core market Y2008	-0.30**	0.07	-0.30**	0.06	-0.27**	0.10	-0.30**	0.07
Outside core market Y2009	-0.02	0.08	-0.02	0.06	0.02	0.12	-0.02	0.07
Outside core market Y2010	0.04	0.10	0.04	0.07	0.09	0.12	0.04	0.08
Outside core market Y2011	0.03	0.10	0.03	0.08	0.08	0.14	0.03	0.09
Display Advertising	-0.03	0.14						
Inserts			-0.05	0.10				
Classifieds Advertising					0.64	2.02		
Total Advertising							-0.21	0.59

** p<0.01, *p<0.05, $^{+}$ p<0.1

Table A.1: Appendix - Alternative specifications for the readership model (1)

	Allowing for different effects of advertising for Daily, Weekend and Sunday options		**Effect of advertising excluding year dummies and demographic controls**							
	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE
Pref (M-Thurs)	0.63	1.29	0.62	1.03	0.54	1.03	0.64	1.01	0.59	1.03
Pref (Fri,Sat)	-2.72**	0.64	-2.52**	0.47	-2.56**	0.47	-2.50**	0.46	-2.54**	0.47
Pref (Sun)	-6.01**	1.22	-5.77**	0.90	-5.72**	0.90	-5.95**	0.94	-5.74**	0.90
core market price	0.18*	0.06	0.16**	0.05	0.16**	0.05	0.17**	0.06	0.16**	0.05
Outside core market price	0.03	0.05	0.02	0.05	0.02	0.05	0.03	0.05	0.02	0.05
# of news pgs	1.50	0.98	1.42*	0.64	1.48**	0.64	1.37*	0.62	1.45**	0.64
Display Advertising			-0.10	0.32						
Inserts					-0.27	0.37				
Classifieds Advertising							1.16	2.71		
Total Advertising									-0.81	1.72
Total Advertising-Daily	-0.82	7.75								
Total Advertising-Weekend	2.51	3.87								
Total Advertising-Sunday	-0.06	3.19								

** p<0.01, *p<0.05, + p<0.1

Table A.2: Appendix - Alternative specifications for the readership model (2)

Appendix 3

Simulation

To whether the actual variation in our data is sufficient to recover the parameters of interest, we perform a simulation exercise. In line with Liu et al. (2010), we first generate demand shocks by regressing log sales on our instruments. Using these demand shocks, we use the data generating process to simulate the dependent variable (market shares). In order to keep the simulation exercise straightforward, we consider a simple random normal heterogeneity distribution only on the intercept, and first simulate the individual choices. We aggregated these data to mimic the sub-market level data that we use in our estimation. Next we estimate the demand parameters using these

simulated data, employing the same instruments used to generate the demand shocks earlier, with the objective of recovering the mean utility parameters. We repeat the above process 100 times, using the same draws to synthesize all 100 datasets. We report the means and standard deviations across these 100 trials, and the Mean Absolute Deviation (MAD) of our recovered estimates from these 100 datasets for each model in Table A.3. Our recovered parameters are similar to the initial values used in the simulation in all cases. We consider four cases: (a) model estimated using data on one option (only the Daily option), (b) model estimated overall market-level data on all three subscription options, (c) model estimated on sub-market (county) level data and three subscription options, and (d) model as in (c) where we allow for correlations between the option specific intercepts.[49]

A substantive finding here is that recoverability improves with the availability/use of greater number of markets and options. For example, a model estimated on county level data with three inside options has lower MAD than one that uses market data and a single choice option. The results suggest that we are able to recover the key mean utility parameters, i.e., year fixed effects as well as sensitivity to price and the number of news pages, reasonably well, in addition to the parameters governing the heterogeneity distribution over the subscription options. These results give us some confidence that we can recover both the mean utility parameters as well as the heterogeneity distribution using the variation in our data.

[49]We present the parameters corresponding to the lower-triangular matrix that captures the correlation between the option specific intercepts in the table.

	Agg data; 1 option (Daily option)				**Agg data; 3 options**				**Cty data; 3 options**				**Cty data; 3 options; estimated covariance**			
	Case a				Case b				Case c				Case d			
Parameter	True	Sim Mean	SD	MAD	True	Sim Mean	SD	MAD	True	Sim Mean	SD	MAD	True	Sim Mean	SD	MAD
SD Intercept - B1	1.30	0.104	0.087	1.318	1.30	0.542	0.215	0.817	1.30	0.286	0.235	1.247				
SD Intercept - B2					0.20	0.469	0.375	0.529	0.20	0.418	0.340	0.567				
SD Intercept - B3					1.37	0.491	0.244	1.167	1.37	0.470	0.318	1.370				
Intercept - B1	-2.55	-1.983	0.084	0.567	-2.55	-2.094	0.086	0.456	-2.55	-2.012	0.102	0.538	-2.55	-2.319	0.109	0.234
Intercept - B2					-4.44	-4.658	0.216	0.218	-4.44	-4.619	0.195	0.180	-4.44	-4.416	0.105	0.086
Intercept - B3					-3.33	-2.719	0.099	0.611	-3.33	-2.739	0.148	0.591	-3.33	-3.358	0.084	0.054
p_core market	-0.06	-0.054	0.007	0.008	-0.06	-0.054	0.001	0.006	-0.06	-0.055	0.004	0.006	-0.06	-0.058	0.001	0.002
p_outside core market	-0.07	-0.062	0.007	0.008	-0.07	-0.064	0.001	0.006	-0.07	-0.064	0.003	0.006	-0.07	-0.068	0.002	0.002
Core market Y2007	-0.04	-0.034	0.024	0.194	-0.04	-0.037	0.006	0.006	-0.04	-0.039	0.021	0.017	-0.04	-0.041	0.006	0.005
Core market Y2008	-0.16	-0.142	0.027	0.292	-0.16	-0.157	0.009	0.007	-0.16	-0.154	0.022	0.018	-0.16	-0.160	0.007	0.006
Core market Y2009	-0.01	-0.003	0.048	0.273	-0.01	-0.018	0.008	0.010	-0.01	-0.013	0.030	0.024	-0.01	-0.013	0.008	0.006
Core market Y2010	-0.08	-0.069	0.058	0.094	-0.08	-0.086	0.011	0.010	-0.08	-0.087	0.034	0.028	-0.08	-0.082	0.010	0.008
Core market Y2011	-0.13	-0.114	0.060	0.081	-0.13	-0.138	0.011	0.011	-0.13	-0.121	0.040	0.033	-0.13	-0.131	0.009	0.007
Outside core market Y2007	-0.14	-0.126	0.023	0.486	-0.14	-0.132	0.006	0.008	-0.14	-0.138	0.019	0.015	-0.14	-0.140	0.008	0.006
Outside core market Y2008	-0.25	-0.226	0.030	0.186	-0.25	-0.243	0.009	0.009	-0.25	-0.238	0.019	0.018	-0.25	-0.250	0.009	0.007
Outside core market Y2009	0.15	0.132	0.049	0.292	0.15	0.131	0.008	0.019	0.15	0.136	0.020	0.020	0.15	0.144	0.010	0.009
Outside core market Y2010	0.300	0.267	0.063	0.277	0.3	0.272	0.011	0.028	0.3	0.273	0.027	0.032	0.3	0.292	0.012	0.013
Outside core market Y2011	0.320	0.283	0.064	0.363	0.32	0.287	0.011	0.033	0.32	0.291	0.024	0.032	0.32	0.312	0.011	0.012

Est (Ltt)		
True	Sim Mean	SD
1.000	0.551	0.640
-0.500	-0.679	0.200
1.000	0.821	0.200
0.000	-0.070	0.111
-0.667	-0.737	0.111
1.000	0.930	0.111

Table A.3: Appendix - Simulation: Assessing parameter recoverability

Appendix 4

Considering Differential Responsiveness of Advertising to Weekday and Sunday Readership

In this section, we present the detailed estimates of the demand for advertising, estimated on data broken down by weekdays and Sundays. The estimates verify the robustness of our results from the baseline advertising demand model (the elasticities as well as the temporal trends in advertiser intrinsic attractiveness are similar across the two specifications).

Parameter	Est	SE
Ad type specific intercepts for Wkday	√	
Ad type specific intercepts for Sunday	√	
CPM_Wkday	-0.96**	0.14
Effect of Readership for Inserts_Wkday	1.24	1.27
Y2007_Wkday_display	-0.07	0.11
Y2008_Wkday_display	-0.37**	0.10
Y2009_Wkday_display	-0.46**	0.16
Y2010_Wkday_display	-0.41**	0.15
Y2007_Wkday_inserts	-0.18	0.11
Y2008_Wkday_inserts	-0.08	0.10
Y2009_Wkday_inserts	-0.01	0.42
Y2010_Wkday_inserts	0.14	0.65
Y2007_Wkday_classifieds	-0.19**	0.02
Y2008_Wkday_classifieds	-0.68**	0.04
Y2009_Wkday_classifieds	-1.22**	0.09
Y2010_Wkday_classifieds	-1.31**	0.11
Quarter fixed effects for each type for Wkday advertising	√	
CPM_Sun	-1.03**	0.25
Effect of Readership for Inserts_Sun	0.39	0.73
Y2007_Sun_display	-0.11*	0.05
Y2008_Sun_display	-0.27**	0.04
Y2009_Sun_display	-0.54**	0.06
Y2010_Sun_display	-0.56**	0.07
Y2007_Sun_inserts	-0.10*	0.04
Y2008_Sun_inserts	-0.13	0.12
Y2009_Sun_inserts	-0.31	0.29
Y2010_Sun_inserts	-0.42	0.45
Y2007_Sun_classifieds	-0.18**	0.05
Y2008_Sun_classifieds	-0.59**	0.06
Y2009_Sun_classifieds	-1.88**	0.17
Y2010_Sun_classifieds	-2.11**	0.20
Quarter fixed effects for each ad type for Sun advtg.	√	

** p<0.01, * p<0.05, + p<0.1

Table A.4: Advertising model estimated on Weekday/Sunday advertising data

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Tables and Figures

(A) Readership				
	Avg. subscription share (aggregate data) (% of households subscribing to the newspaper)		Avg. subs. price (inflation adjusted) ($/month)	
option	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%

Table 1: Descriptive Statistics

% increase in inflation-adjusted prices between 2006-2011		
option	Within Core market	Outside Core market
Daily	77.22%	77.45%
Weekend	52.73%	52.52%
Sun only	37.74%	43.70%

Table 2: Subscription price increases for each option

option	Based on aggregate data		Based on individual data	
	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 3: Average market share of each option, conditional on subscribing to the newspaper

	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%

Table 4: Avg. year-on-year % decay rate in circulation shares (between 2006-2011) within/outside the Core market

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

Table 5: CPM for each Advertising Option

CPM for display and classifieds is computed by dividing the corresponding ad rate (in $ per col. inches) by the number of readers (in thousands); those for inserts are in cost per thousand inserts.

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

Table 6: Relative contribution of reader and advertiser side of the newspaper market

Year	% contribution of Sunday advtg.
2006	74
2007	74
2008	75
2009	70
2010 (first 6 months)	70

Table 7: Sunday advertising contribution

(A) Readership Model

Endogenous variable→	Subscription Prices				# 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	

** p<0.01, *p<0.05, $^{+}$ p<0.1

Table 8: First stage regressions of endogenous variables on instruments

Parameter	Est.	SE		
Option specific intercepts	√			
Core market price	-0.07**	0.01		
Outside core market price	-0.05**	0.01		
# of news pgs	0.18**	0.06	Est (Ltt)	SE
Core market Y2007	-0.01	0.04	1.32**	0.01
Core market Y2008	-0.10*	0.05	0.18**	0.01
Core market Y2009	0.06^{+}	0.04	0.17**	0.02
Core market Y2010	-0.01	0.03	0.30**	0.00
Core market Y2011	-0.06^{+}	0.04	0.28**	0.00
Outside core market Y2007	-0.14**	0.02	0.30**	0.02
Outside core market Y2008	-0.29**	0.04		
Outside core market Y2009	0.04	0.03		
Outside core market Y2010	0.11**	0.03		
Outside core market Y2011	0.12**	0.04		
County fixed effects, Cty Income	√			

** p<0.01, * p<0.05, + p<0.1

Table 9: Readership demand – with news pages and a common temporal trend across options

Parameter	Est.	SE	Est (Ltt)	SE
Option specific intercepts	√			
price	-0.03**	0.00		
Core market Y2007 - b1	-0.10**	0.02		
Core market Y2008 - b1	-0.23**	0.02		
Core market Y2009 - b1	-0.28**	0.02		
Core market Y2010 - b1	-0.35**	0.02		
Core market Y2011 - b1	-0.51**	0.02		
Outside core market Y2007 - b1	-0.05**	0.01		
Outside core market Y2008 - b1	-0.16**	0.02		
Outside core market Y2009 - b1	-0.07**	0.01		
Outside core market Y2010 - b1	-0.02	0.02		
Outside core market Y2011 - b1	-0.09**	0.02		
Core market Y2007 - b2	0.06**	0.02	0.07**	0.01
Core market Y2008 - b2	-0.05*	0.02	0.04**	0.01
Core market Y2009 - b2	-0.08**	0.02	0.04**	0.01
Core market Y2010 - b2	-0.21**	0.02	0.10**	0.01
Core market Y2011 - b2	-0.23**	0.02	0.09**	0.01
Outside core market Y2007 - b2	-0.11**	0.01	0.09**	0.01
Outside core market Y2008 - b2	-0.28**	0.01		
Outside core market Y2009 - b2	-0.10**	0.01		
Outside core market Y2010 - b2	-0.19**	0.01		
Outside core market Y2011 - b2	-0.24**	0.01		
Core market Y2007 - b3	0.00	0.03		
Core market Y2008 - b3	-0.16**	0.02		
Core market Y2009 - b3	0.00	0.03		
Core market Y2010 - b3	-0.07**	0.02		
Core market Y2011 - b3	-0.11**	0.02		
Outside core market Y2007 - b3	-0.20**	0.02		
Outside core market Y2008 - b3	-0.46**	0.03		
Outside core market Y2009 - b3	-0.05*	0.02		
Outside core market Y2010 - b3	0.15**	0.02		
Outside core market Y2011 - b3	0.28**	0.03		
County fixed effects, Cty Income	√			

** p<0.01, * p<0.05, + p<0.1

Table 10: Readership demand - without news pages, with option specific year fixed effects and a common price coefficient

Parameter	Model a - National newspaper readership instrument		Model b - Search propensity instruments	
	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 fixed effects for each ad type	√		√	

** p<0.01, * p<0.05, + p<0.1

Table 11: Advertising model results

	National Newspaper Readership Instrument		Search Propensity Instruments	
	Reader model: With news pages, common yr fixed ef	Reader model: Common price coef and option-year fixed ef	Reader model: With news pages, common yr fixed ef	Reader model: Common price coef and option-year fixed ef
Decline in readers' preferences	10.13%	20.70%	8.18%	18.01%
Decline in advertising	89.87%	79.30%	91.82%	81.99%
of which:				
display contributes	47.63%	41.59%	49.72%	44.92%
inserts contributes	3.36%	3.40%	0 %	0 %
classifieds contributes	38.88%	34.31%	42.10%	37.07%

Table 12: Pricing results

Explanation	Considering the best case scenario where all exiting print readers migrate to the online newspaper	Using the advertising model estimated on Weekday/Sunday advertising data	Readership Model with single copy as the fourth inside option
	(1)	(2)	(3)
Decline in Readers' Preferences	3.01%	44.35%	12.48%
Decline in Advertising Subsidy	91.31%	55.65%	87.52%
Gain in Online Advertising Revenues	5.70%	N/A	N/A

Table 13: Robustness Checks

Parameter	Est.	SE
SD - Daily Subs	1.07**	0.16
SD - Weekend Subs	0.52	2.72
SD - Sun Subs	1.20**	0.32
SD - Single Copy	0.97	1.30
Daily Subs	-5.48**	0.60
Weekend Subs	-7.70**	1.65
Sun Subs	-6.56**	0.67
Single Copy	-6.02**	1.27
Core market - Subs price	-0.06**	0.01
Core market - Single Copy price	-0.21*	0.08
Outside core market - Subs price	-0.03**	0.01
Outside core market - Single Copy price	0.21**	0.08
News pages	0.29**	0.07
Core market Y2007	-0.30**	0.05
Core market Y2008	-0.49**	0.06
Core market Y2009	-0.19**	0.04
Core market Y2010	-0.17**	0.04
Core market Y2011	-0.32**	0.05
Outside core market Y2007	-0.12*	0.05
Outside core market Y2008	-0.22**	0.06
Outside core market Y2009	0.03	0.06
Outside core market Y2010	0.02	0.07
Outside core market Y2011	-0.02	0.06
Cty Income	$\surd$	

** p<0.01, * p<0.05, + p<0.1

Table 14: Readership Model using aggregate sub-market level data, with single copy as the fourth inside option

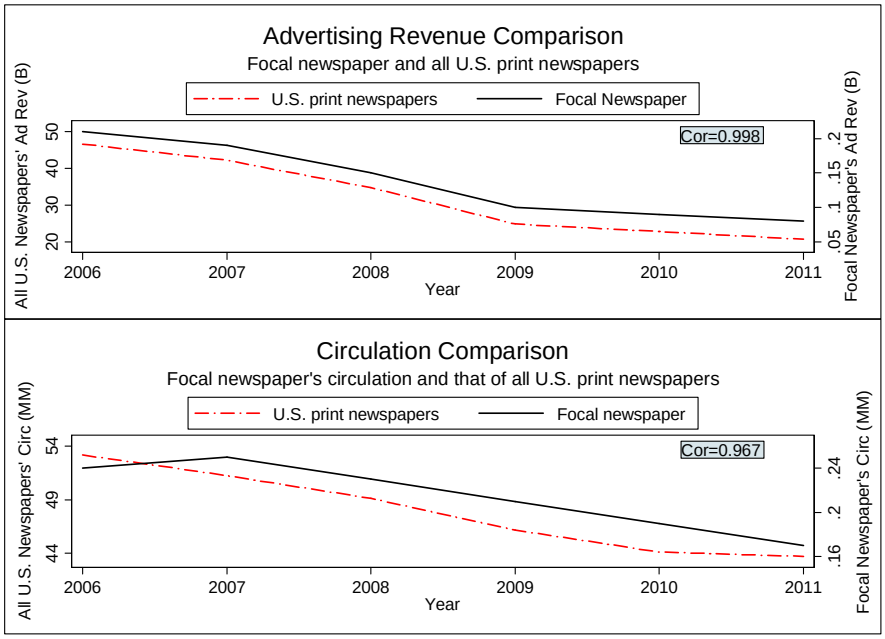

Figure 1: Comparison of Readership and Advertising Revenue trends of the Focal newspaper with those of the U.S newspaper industry

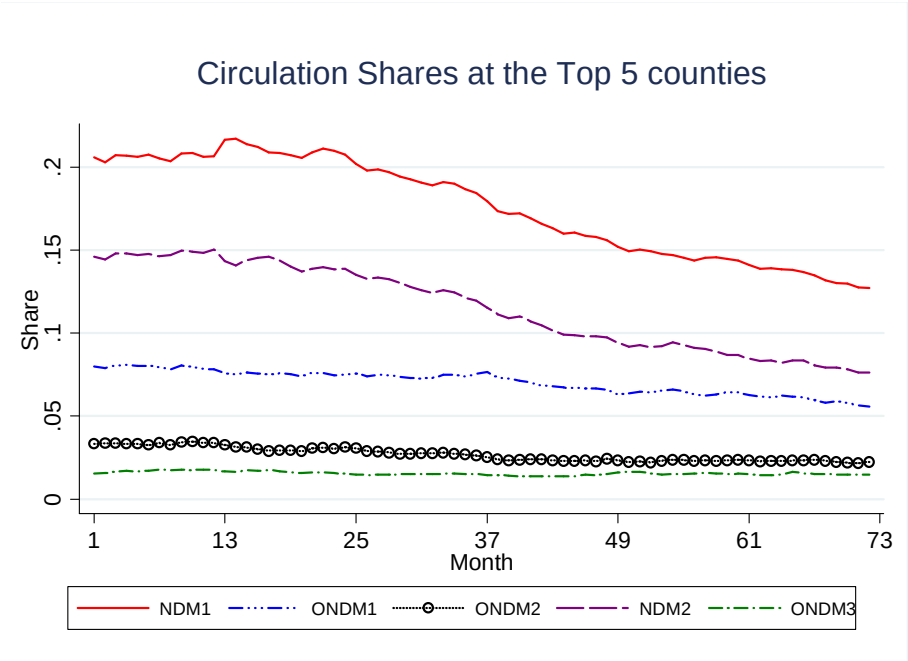

Figure 2: County circulation shares
Month 1 corresponds to Jan 2006 and 72 to Dec 2011.

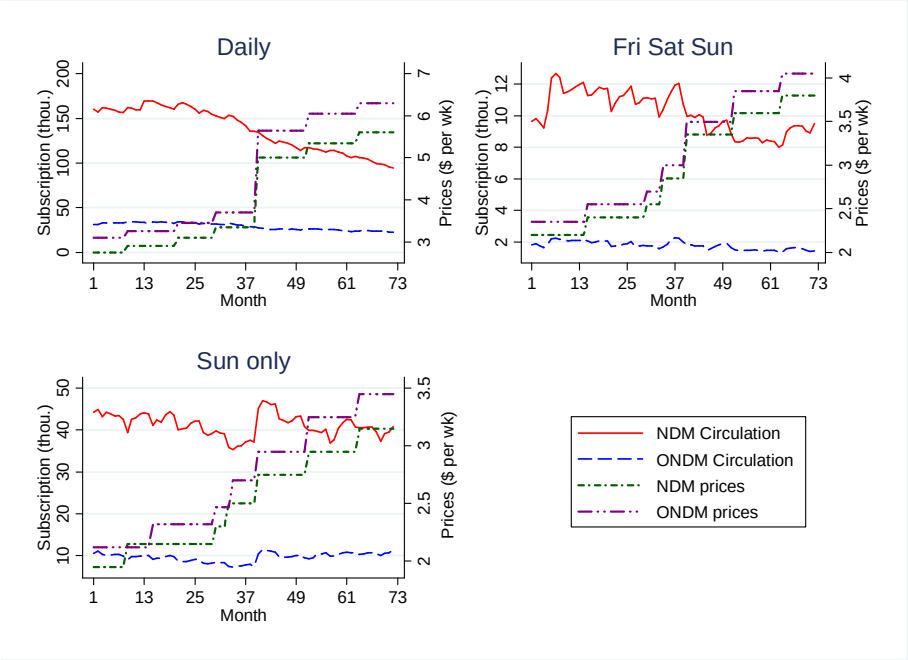

Figure 3: Temporal pattern of subscriptions within and outside the newspaper's core market. Month 1 corresponds to Jan 2006 and 72 to Dec 2011.

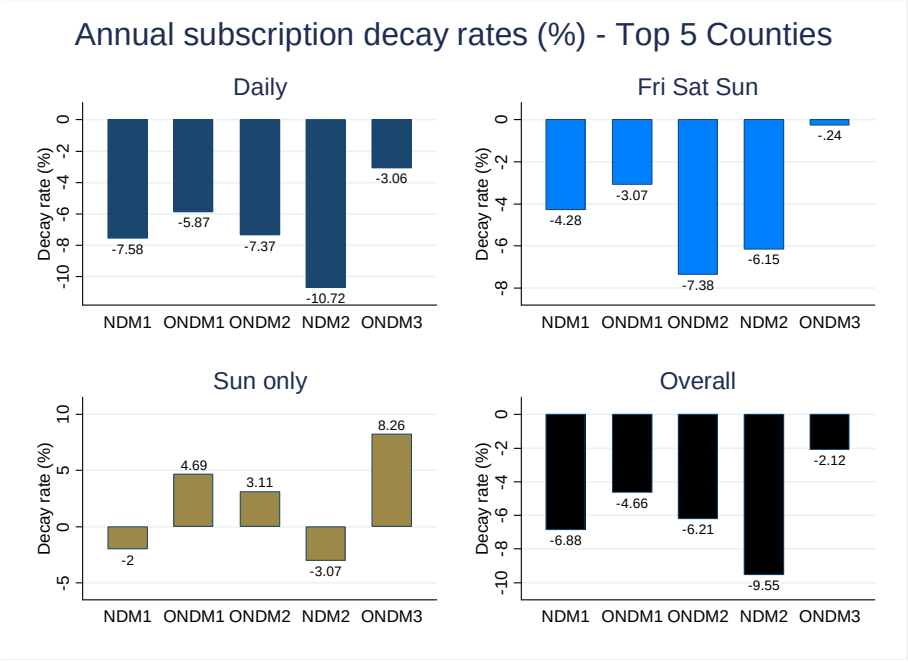

Figure 4: Plots of the average year-on-year % decay rates in circulation shares across counties within and outside the core market (between 2006-2011).

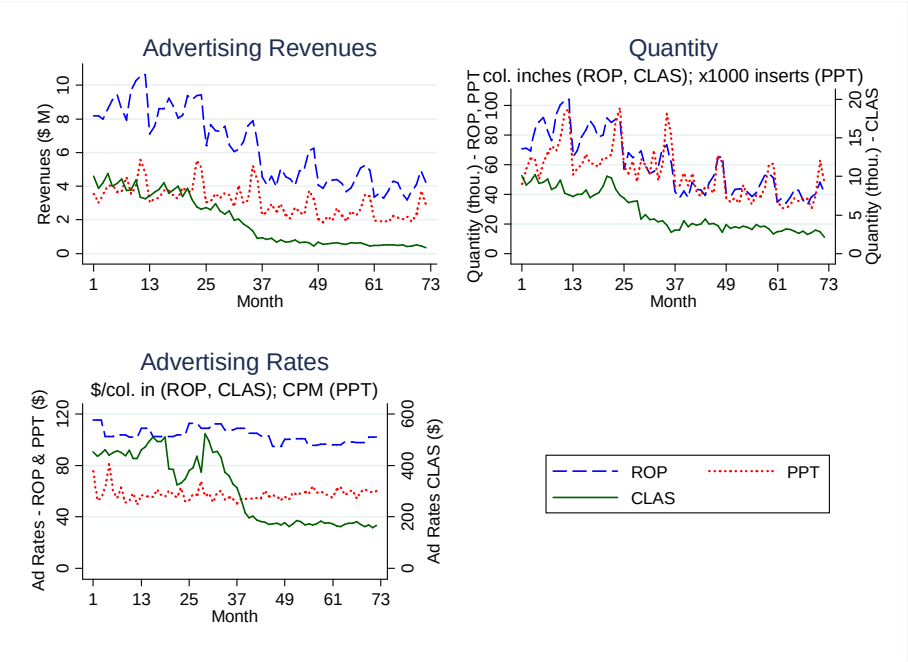

Figure 5: Advertising at the focal newspaper
Month 1 corresponds to Jan 2006 and 72 to Dec 2011.

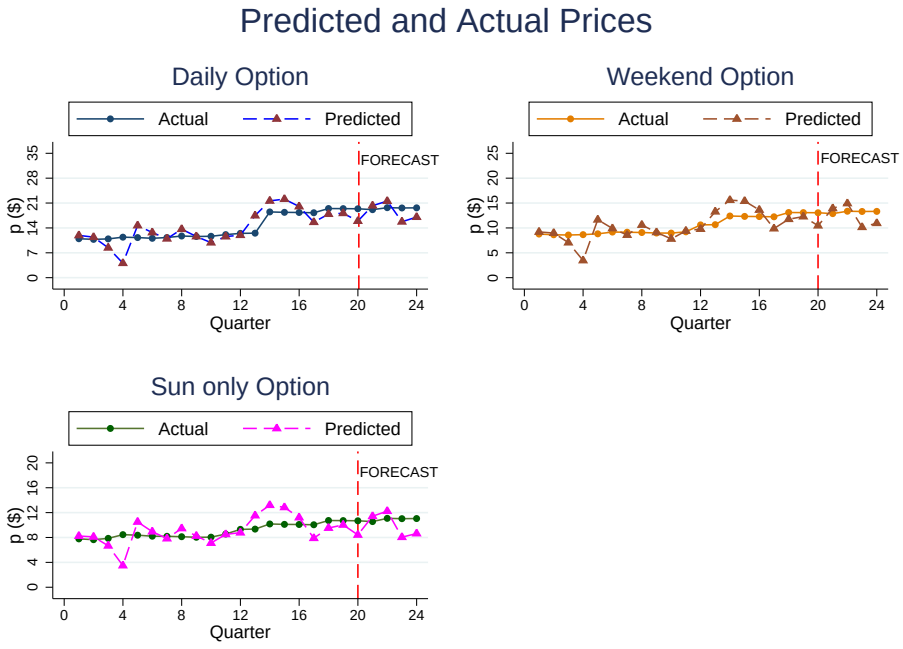

Figure 6: Holdout sample validation for 2011 prices

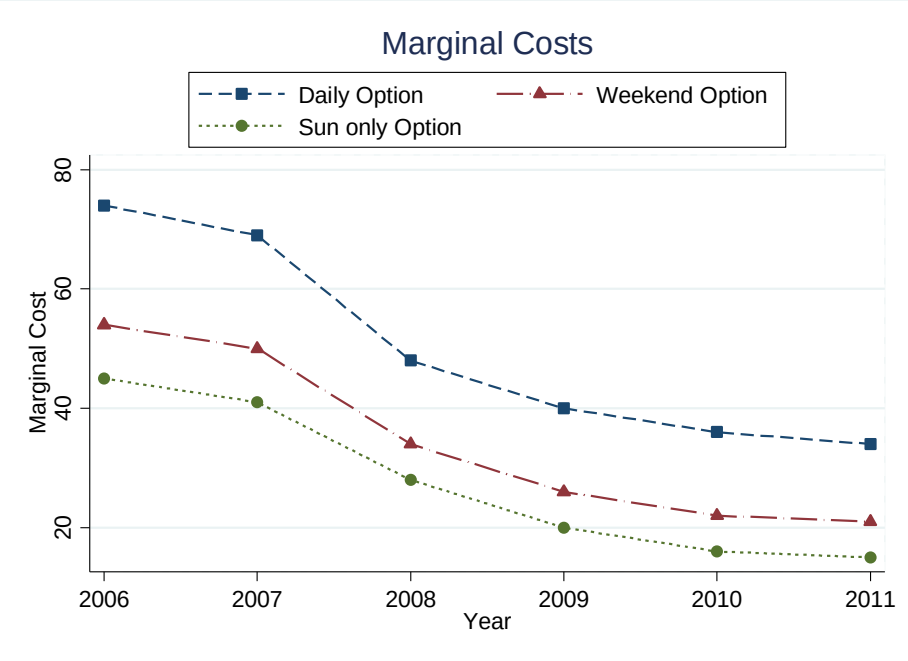

Figure 7: Marginal Costs

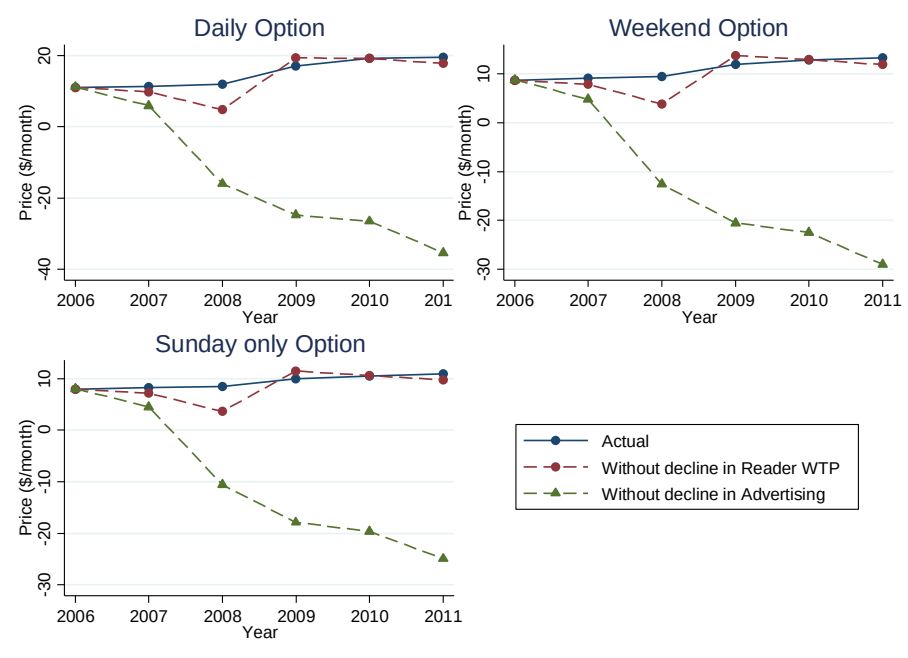

Figure 8: Counterfactual Prices