Targeting Political Advertising on Television*

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Abstract

We study the targeting of political advertising by congressional candidates on television. Targeting strategies for television differ from targeting strategies for direct mail advertising or get out the vote efforts because candidates cannot target voters individually. Instead, candidates must target television programs with viewers most similar to the desired target voters. Thus, for targeted advertising to have value, the audiences for television programs must differ in meaningful ways and advertising must be effective. In this project, we develop and estimate a model of targeted advertising for U.S. congressional races. We study whether television shows segment potential voters sufficiently to allow for effective targeting and we consider the effect of television advertising- whether it persuades individuals to vote for a particular candidate or mobilizes them to vote in general. Our results suggest the function of television advertising is primarily to persuade. Moreover, we find that there is sufficient variation in the distribution of viewer characteristics across television programs to allow for effective targeting. The most effective targeting strategies therefore involve both parties adopting similar strategies of advertising primarily on programs with audiences containing many swing voters that are likely to vote. While we uncover specific ways in which actual candidate strategies differ from this benchmark, actual candidate behavior is largely consistent with this strategy indicating that candidates seem to accurately believe that the function of television advertising is to persuade voters.

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1 Introduction

Television has traditionally been viewed as a broadcast medium where advertising is placed in order to reach as much of the population as possible. As the number of television channels has increased and the concentration of viewers on the three major networks has decreased, it has become more and more difficult to reach even most of the viewers. At the same time, an increase in the number of specialized channels suggests greater potential to target ads to specific groups.

While targeting political advertisements on television has received surprisingly little attention,[1] targeting through mail, phone, and internet has become a standard tool in modern political campaigns (Malchow, 2008). A number of studies demonstrate that direct mail, grassroots, and get-out-the-vote (GOTV) efforts lead to statistically and practically significant effects, particularly for mobilizing voters to turn out (e.g., Gerber and Green, 2000). Yet the total expenditures spent on such direct targeting activities represents only a small fraction of the expenditures spent on television advertising. For example, in the 2008 Presidential campaign, expenditures on direct targeting efforts were less than 10% of broadcast media expenditures and broadcast media costs were the single largest expenditure category out of the $1.3 billion campaign expenditures in 2008 (www.opensecrets.org). Given such large expenditures and the decreasing concentration of audiences, the value of television advertising is increasingly dependent on the ability to target effectively.

A candidate may target voters based on their likelihood of turning out to vote and/or their likelihood of voting for the candidate. Effective targeting strategies depend on whether advertising is effective in mobilizing individuals to vote or persuading them to vote for a particular party. If advertising primarily persuades, then candidates should target swing voters who are likely to turn out (Lindbeck and Weibull, 1987). If advertising primarily mobilizes, then candidates should target core supporters who have an intermediate likelihood of voting (Nichter, 2008).

In television advertising, however, candidates cannot directly target individuals. While GOTV and direct mail efforts target individuals or households, television advertisements target the audiences of television programs. This complicates the targeting decision. Some shows have viewers

[1] See Ridout et al. (2010) for a recent exception.

that are very diverse and some viewers watch a diverse set of shows. Since television advertising is indirect, it is unclear how effectively television advertising can be targeted, if at all. Thus, in order for targeting television ads to be effective, not only must the ads affect voters in the way campaigns believe them to (to mobilize or persuade), but also television programs need to have audiences that are sufficiently differentiated.

In this study we disentangle three key questions about targeting television ads- whether advertising effects support targeting for mobilization or persuasion, whether television program audiences differ sufficiently to enable targeting, and how consistent actual candidate behavior is with the most effective targeting behavior. To answer these questions, we analyze congressional races in the 2004 election, integrating a new combination of data sources and developing a new two-stage estimation approach.

We employ data from the National Annenberg Election Study for information on voting behavior, the Wisconsin Advertising Project for information on candidate strategies, the aggregate election outcomes for matching actual voting patterns, and the Simmons National Consumer Survey for television program viewership. Incorporating this last dataset is new. This dataset contains the viewership for television programs on which over 95% of the political ads were shown. This viewership data includes information on all the key demographics as well as political ideology, party identification, and voter registration. This dataset enables two key elements in our empirical strategy. First, it allows us to extend existing research that demonstrates the importance of exposure in correctly estimating the effect of advertising (Freedman and Goldstein, 1999; Goldstein and Freedman, 2002; Freedman, Franz and Goldstein, 2004). With this data, we are able to identify much larger variation in the actual exposure to programs and candidate advertising than previous efforts. Second, this data enables us to determine whether television programs are sufficiently differentiated to enable targeting efforts on persuasion and mobilization.

With these datasets, we estimate a model of targeted advertising for U.S. congressional races that has two key components. First, we estimate a model of individual exposure to television programs. We develop a minimum distance estimator that allows us to estimate show specific parameters for a large number of shows using aggregate data. The outputs of this model provide

individual level predictions for exposure to candidate advertising. Second, we estimate the effect of advertising exposure on voter turnout and candidate choice. This estimator uses a combination of micro-level and aggregate voter data and controls for endogeneity in the estimates of advertising effects. The identification of advertising effects comes from variation in individual exposures to ads within a media market in a congressional district.

Our results suggest that television advertising is effective in persuading voters in congressional races. This result is consistent with the findings of Gerber et al. (2007) for Gubernatorial races and Huber and Arceneaux (2007) for Presidential races. Further, we find that, without proper econometric controls, we would find a positive turnout effect. Once controlling for fixed effects at the level of campaign advertising decisions (i.e., for a media market in a congressional district), the turnout effect is no longer significant. Lacking econometric controls may be one possible explanation for why Freedman, Franz and Goldstein (2004) and Shachar (2009) find significant turnout effects in Presidential races. Our result of no turnout effect in congressional races is consistent with the evidence on turnout effects in Presidential races as reported by Ashworth and Clinton (2007), Krasno and Green (2008), and Huber and Arceneaux (2007). Thus, we add to the literature on advertising effects by providing evidence on congressional races and by providing a potential explanation for the inconsistent results on these effects in Presidential races.

We find that the variation in television program audiences is sufficient to allow for effective targeting. Since our estimates indicate persuasion is the primary role of advertising, optimal targeting strategies involve both parties adopting similar strategies of advertising. Specifically, both parties should advertise primarily on programs that have many likely swing voters among their viewers. We find that actual candidate strategies are largely consistent with this benchmark indicating that candidates seem to accurately believe that the function of television advertising is to persuade voters.

Nonetheless, we uncover specific ways in which actual candidate strategies differ from this benchmark. We find that congressional candidates spend little on dramas, news magazines, and cable news shows, despite the fact that advertising on these shows would be particularly effective. This is partially explained by the fact that many such shows air on prime time- reaching a prime

time viewer is approximately three times as expensive as reaching an early morning or daytime viewer. However, a number of cost-effective daytime and early morning cable dramas, cable news shows, and news magazines exist, where the candidates advertise little. We find that while the candidates spend large amounts on news programs that run on all four major networks, spending on NBC news is much more cost effective than spending on Fox news. Together, these results suggest that the candidates employ heuristics that approximate optimal behavior, but miss subtle distinctions that our data is able to uncover.

2 Relationship with Literature

One key strategy that candidates have to increase their likelihood of winning an election is to target their efforts towards the citizens most affected by these activities. The exact targeting strategy will depend on whether advertising is being using to persuade or to mobilize. Whether persuasion or mobilization effects exist for television advertising is an empirical question, one that has received a great deal of attention in the literature. For example, Gerber et al. (2007) test the persuasive effects of television advertising using a field experiment during the 2006 Texas gubernatorial election. They randomly assigned 18 media markets to receive varying levels of advertising exposure and measure the resulting evaluations of the candidates and voting intentions. Their results indicate that advertising has a strong persuasive effect, but one that decays quickly over time.

Unlike Gerber et al. (2007), most of the recent research has used secondary data and correlational studies. Such studies have been revolutionized by The Wisconsin Advertising Project (WAP), which provides data on the exact advertisements shown for Presidential, Senate, House, and Gubernatorial candidates for the 100 largest media markets in the United States. This data allows researchers to identify the effect of ads employing a range of empirical strategies. Freedman, Franz and Goldstein (2004) use the WAP data along with self-reported measures of television viewing for a few shows. Such measures are available in the 2000 American National Election Study and they allow Freedman et al. to calculate individual level estimates of advertising exposures. With these estimates, they find that exposure to campaign advertising has a large positive effect on voter turnout. In contrast, Krasno and Green (2008) exploit variation in ad exposure within states

induced by media market boundaries and find that advertising does not have an effect on voter turnout. Huber and Arceneaux (2007) integrate the WAP data with survey data to test whether advertising has a persuading or mobilizing effect in Presidential elections. Their approach relies on media markets that overlapped battleground and non-battleground states and they find that advertising has a persuasive effect, but does not mobilize citizens to vote. Hill et al. (2007) find evidence that advertising has a persuasive effect in presidential elections, but also argue that the effect decays very quickly.[2]

Our setting and empirical strategy differs from that of existing studies. Most of these studies focus on Presidential races, where arguably each election has a single observed strategy. In contrast, we study congressional races where each race has its own strategy. We control for the campaign effects and use variation within a congressional district in how much each citizen watches particular television programs (and hence the advertisements shown on those programs) to identify the effect of advertisements. Using this approach, we provide new evidence on the persuasive and mobilizing effects of advertising.

In contrast to what progress has been made in understanding the relative effectiveness of various types of political advertising, much less progress has been made in understanding the strategies that the candidates take.[3] A few exceptions are worth mentioning. Hillygus and Shields (2008) studied direct mail targeting strategies in Presidential elections and found that candidates use wedge issues to persuade weak partisans of the opposing party. Spiliotes and Vavreck (2002) studied the content of television advertisements and found that Democratic and Republican candidates emphasize different issues. Fletcher and Slutsky (Forthcoming) developed a model of targeting political advertising across multiple districts. They argue that the parties will target the media markets that contain the most persuadable voters and use the WAP data to provide evidence that parties do in fact use this strategy. Shachar (2009) developed a model in which Presidential

[2]A number of studies have also studied whether the effect of advertising may differ by advertising tone. However, the results are mixed as some studies suggest that negative ads lead to lower turnout (Ansolabehere and Iyengar, 1997), others suggest it leads to higher turnout (Goldstein and Freedman, 2002; Freedman, Franz and Goldstein, 2004) and still others suggest there is no effect of negative ads on turnout (Clinton and Lapinski, 2004).

[3]By contrast, the research on candidate positioning has integrated the study of voting behavior and candidate behavior at least since the work of Erikson and Romero (1990). See also Adams and Merrill (2003), Moon (2004), Adams, Merrill and Grofman (2005), Schofield and Sened (2006), and Peress (forthcoming).

campaigns target advertising and grassroots contact to states and estimates it empirically to show targeted campaign activities account for the relationship between closeness of the election and voter turnout. Ridout et al. (2010) argue that Democratic and Republican presidential candidates target different genres with their television advertisements. We extend this literature by examining targeting in terms of the television programs candidates use. While the number of television programs is huge, we utilize data on television show demographics and political attitudes to reduce this dimensionality to two- how likely the viewers are to vote and how like the viewers are to vote for a Republican. Using this much simpler map, we examine the match between what candidates do and what our estimates of advertising effects would suggest to be optimal.

3 Data

We collected data from four sources. First, we obtained data on television program viewer characteristics from the 2004 Simmons National Consumer survey. Second, we obtained a sample of potential voters from the 2004 National Annenberg Election Study. Third, we obtained data on television advertising from the 2004 Wisconsin Advertising Project. Fourth, we collected additional congressional district and media market-level data, including advertising costs.

3.1 Program Viewership Data

Candidates would like to target television programs based on viewer characteristics. What characteristics are available depends on the data source used by the campaign. We would like to collect data on voter characteristics that are at least as good as the data that the candidates have available to them. Such data allows us to reproduce the best possible inputs to targeting decisions that candidates could have had.

The Simmons National Consumer Survey meets this requirement– it provides us with a large sample of American adults ($N = 24,868$) and provides more detailed information than what is available from other sources such as Nielson. In particular, the Simmons survey contains a host of demographic variables and, more importantly, items that directly tap voting behavior including the respondent's self-reported party identification, political ideology, and voter registration status.

These latter survey items are critical to generating accurate predictions and imputed data like that available from other vendors cannot perform as well.

In addition, the Simmons data allows us to approximate the contextual knowledge available to political consultants (e.g., for example as consultants have argued, in the Simmons data, we find that *Hannity and Colmes*'s viewers are indeed more conservative, *The Oprah Winfrey Show*'s viewers are indeed more liberal, and news viewers are indeed more likely to be registered voters). Even so, some variables that would be useful for targeting are not available from the Simmons data. For example, whether the respondent voted in the previous election is useful in predicting an individual's future voting behavior. However, the campaigns are also unable to link such voting data to show viewership, so lack of access to such data should not lessen our ability to recover the best information campaigns' could have had.

One limitation of the Simmons data is that we are not able to obtain individual level data. Instead, licensing restricts access to a single computer terminal in a library and only cross tabulations are available. Fortunately, it is possible to estimate an individual level model from these cross tabulations using a minimum distance estimator (Newey and McFadden, 1994). We extracted cross tabulations of show viewership and various demographic characteristics for over 700 programs in the Simmons data. These tabulations provide the aggregate average portion of individuals with a given set of demographic characteristic that view a program on a single occasion.

3.2 Voter and Potential Voter Data

We employ two components of the 2004 National Annenberg Election Study (NAES) in our analysis. The rolling cross section (RCS) component contains a very large sample of potential voters. The RCS component surveys 81,423 respondents in evenly spaced interviews starting a year before the election and ending about three months afterwards. The sample size is large enough to allow us to accurately estimate the distribution of demographic characteristics within each congressional district. The RCS component, however, does not provide for us a sample of voting behavior. We rely on the election panel component of the NAES for estimating our model of voting behavior. The election panel component provides the turnout and candidate choice decisions for 8,665 respondents.

Observing voting behavior and viewing behavior in separate surveys complicates the analysis (see Section 4). Nonetheless, there are some advantages to our approach. In particular, if we measured both voting behavior and viewership from the same survey, we would be worried that measurement error in reported viewership would be correlated with actually voting behavior (Vavreck, 2007). Given that reported viewership and voting behavior come from different sources, such correlation is not possible in our study.

3.3 Advertising Data

Our ad spending data is from the 2004 Wisconsin Advertising Project (WAP). The data cover the 100 largest media markets in the United States, which include about 80% of the U.S. population. Both network and cable ads are included in the data. In addition, the data provides us with a detailed coding of the ads including what time and day they aired, where they aired, who aired them, and on what program they aired. In our analysis, we focus on the general election campaign and consider all ads run between Labor Day and Election Day.

3.4 Additional Race Level Data

In addition, we collected congressional district and media market level aggregate data. As we describe later, we would like to control for unobserved district-level characteristics, but the election panel of the NAES sample (that provides individual level voting data) is not large enough to accurately estimate fixed effects for each media market within each congressional district. Instead, we estimate these fixed effects from aggregate level data on voter turnout and congressional voting using a procedure suggested by Berry (1994).

More specifically, we would like to obtain voter turnout rates and congressional voting rates for the units that are constructed from intersecting congressional districts and media markets. We purchased proprietary data to obtain the proportion of voters voting for the Republican congressional candidate. To obtain an estimate of voter turnout, we collected census data on the voting age population by county and congressional district. We then aggregated from counties to media markets. Finally, we defined congressional turnout as the total number of congressional votes in

the district divided by the voting age population.

We also collected data on the cost of ads. Television ad prices are negotiated between ad buyers and television stations or cable providers on a case by case basis. However, a starting point of these negotiations are cost estimates published by SQAD Inc. These estimates report the average cost per rating point[4] of running ads for each media market and each day part. These estimates may not perfectly reflect the costs the campaigns actually pay for ads, but after talking with ad buyers, we believe these estimates accurately reflect the costs the campaigns believe they will pay at the time they make their advertising decisions.

3.5 Defining the Sample

We were not able to use all congressional districts in our final sample. We excluded from our analysis a number of congressional districts because of missing data. First, the 2004 WAP data only covered the 100 largest media markets in the United States. As a result, we excluded any congressional districts that intersected with unobserved media markets. Second, the 2004 NAES did not sample in Alaska and Hawaii. Hence, we excluded all districts in those states. Finally, we excluded races where the losing major party candidate received less than 20% of the two party vote share. While this shrinks our sample size, we dropped these congressional districts to guard against any biases arising from potentially different motivations candidates and voters have in races that are uncompetitive. Our final sample consists of 219 congressional districts, 36 of which are served by multiple media markets.

3.6 Summary Statistics

In Figure 1, we present scatter plots of the television programs in our data set, according to the percent of registered voters and the percentage of conservative minus the percentage of liberal identifiers among their viewers. The political characteristics of program audiences exhibit considerable variation. The percent of registered voters ranges from 46% for *Run of the House* (WB) to 89% for *Meet the Press* (NBC). Net conservative identifiers ranges from -25% for *Now with Bill Moyers*

[4] A rating point is defined as a percentage point of the population who watch a program.

(PBS) to 40% for *Sue Thomas FB:Eye* (PAX).

Table 1 presents summary statistics for the media markets and day parts in our sample. We see that media markets differ quite a bit in the cost per thousand viewers. Within each day part, the most expensive media market typically charges about four times as much per viewer as the cheapest media market. These differences are partly due to the size of the media market and the affluence of households in the market.

We also find substantial differences between the day parts. Early morning ads cost between 18% and 57% as much as prime time ads. This difference likely arises from the greater proportion of older and female viewers for early morning and daytime programs and the belief among commercial advertisers that reaching these viewers is less valuable. From the perspective of political campaigns, old and female votes count just as much as young and male votes, making early morning advertising particularly attractive for political candidates. We note that actual ad spending patterns are consistent with this- the candidates purchase many ads during the early morning and purchase few ads during prime time.

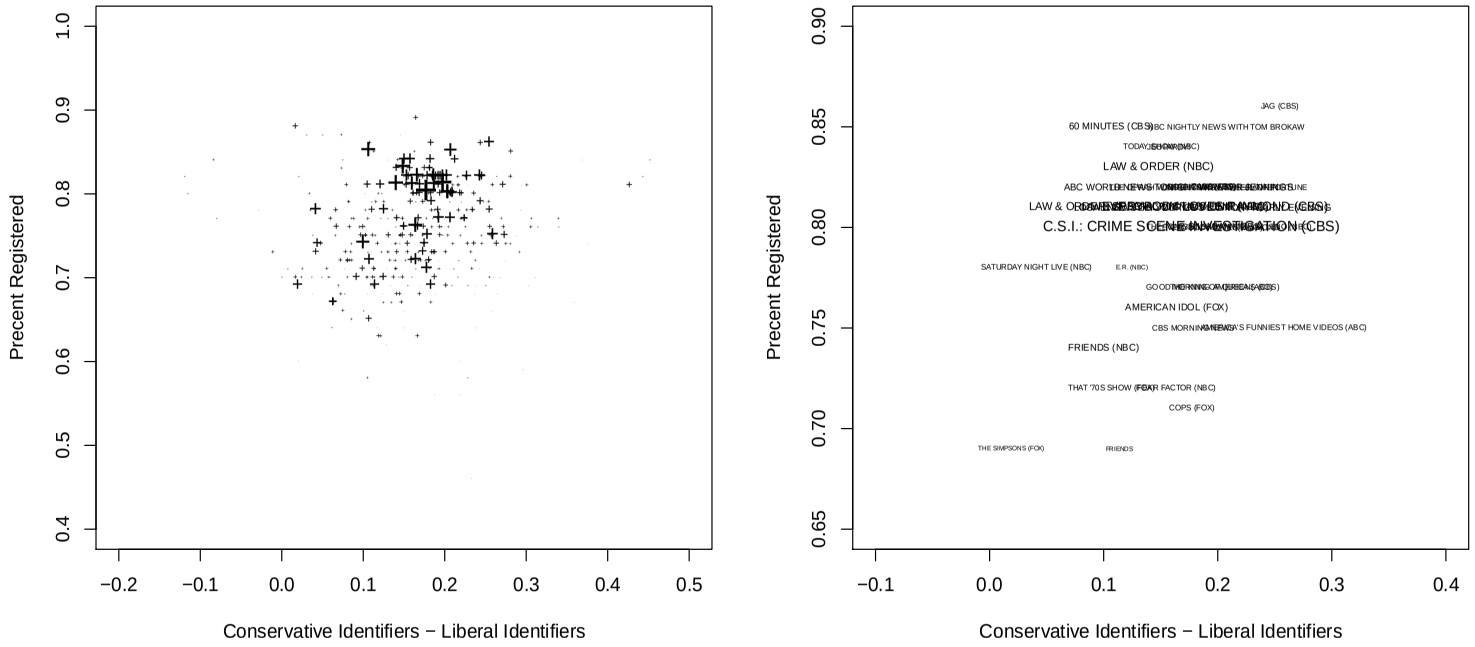

Figure 1: Characteristics of the Average Viewer – In the left panel, plus signs indicate the characteristics of the average viewer of the show. The size of the plus sign is proportional to the rating of the show. In the right panel, only shows that are seen by more than 10% of the population in a given viewing are included. The size of the text is proportional to the rating of the show.

		Early Morning (12:30pm-9am)	**Day Time** (9am-4pm)	**Early Fringe** (4pm-6pm)	**Early News** (6pm-7pm)	**Prime Access** (7pm-8pm)	**Prime Time** (8pm-11pm)	**Late News** (11pm-11:30pm)	**Late Fringe** (11:30pm-12:30pm)
Cost per Rating Point (in dollars)	*Avg.*	112	115	150	170	218	399	256	174
	Sd.	139	139	189	197	281	596	301	214
	Min.	26	28	35	34	44	77	55	41
	Max.	990	878	1247	1177	1835	3677	1866	1465
Cost per Thousand Viewers (in dollars)	*Avg.*	6.0	6.3	8.0	9.2	11.3	18.7	13.8	9.7
	Sd.	1.8	1.5	2.0	2.1	2.7	5.4	3.1	2.5
	Min	3.2	3.8	4.5	6.0	6.3	11.1	8.7	5.1
	Max	11.2	12.1	15.9	15.8	21.2	39.7	22.3	16.3
Congressional Ads	*Dem.*	14033	12092	3247	8694	6398	3495	5461	2139
	Rep.	16317	15067	2859	11317	6802	3635	7754	2156
	Tot.	30350	27159	6106	20011	13200	7130	13215	4295

Table 1: Summary Statistics for Day Parts.

4 Estimation Procedure

In our model there are J elections (e.g., congressional districts with competitive races), indexed by j, each featuring a Democratic and Republican candidate, and no major third party challenger. In each race, there are M_j media markets, indexed by m. Within each media market, the Democratic and Republican candidates are able to run ads on up to P different television programs, indexed by p. We let $a_{D,m,p}$ denote the number of ads run on media market m and program p by Democratic candidates and we let $a_{R,m,p}$ denote the number of ads run on media market m and program p by Republican candidates. Advertising by the candidates can potentially influence the voting behavior (turnout and candidate choice) of individuals. To consider this effect, we develop a model of individual exposure to ads and a model of how voter behavior depends on exposure to ads.

4.1 Estimation of the Exposure Function

For each program p and viewing occasion c, individual n chooses between $w_{n,p,c} = 1$ (watch program p on occasion c) and $w_{n,p,c} = 0$ (don't watch program p on occasion c). We assume that the distribution of $w_{n,p,c}$ depends on a vector of individual characteristics x_n. We further assume a logistic model for $w_{n,p,c}|x_n$,

$$\Pr(w_{n,p,c} = 1|x_n) = \Lambda(\gamma_p' x_n)$$

where $\Lambda(z) = \frac{e^z}{1+e^z}$ denotes the logistic cdf and where γ_p is a vector of parameters to be estimated. We assume that viewing decisions $w_{n,p,c}$ and $w_{n,p',c'}$ are independent conditional on x_n for $(p, c) \neq (p', c')$.

Our model of program viewing is an individual level model, while our data contains aggregate-level cross-tabulations. Accounting for this difference in levels requires us to use multiple data sets and develop a minimum distance estimator. In our application, we rely on cross tabulations of show viewership and demographic characteristics and estimate a logistic model that includes a dummy variable for each characteristic without interactions. We estimate the show viewership model separately for each program, so each program has its own parameter vector characterizing viewership.

We include as exogenous variables a program intercept and dummy variables for the following characteristics: gender, race, age, education, marital status, employment status, income, previous service in the armed forces, region, voter registration, party identification, and ideology. This represents the full set of demographic and political variables available in the Simmons data that are identically available in the NAES. The identical items allow us to employ these two data sets in conjunction. Further details are given in the computational appendix.

4.2 Estimation of the Effectiveness of Advertising

Individuals also make voting decisions, y_n. Individuals choose between $y_n = 0$ (not voting), $y_n = 1$ (voting for the Democratic candidate), and $y_n = 2$ (voting for the Republican candidate).

We are concerned about a number of potential endogeneity biases due to unobserved characteristics in the media market or congressional district. The unobserved characteristics could be any unobserved tendency of the area to more likely turnout or vote Republican. In particular, these characteristics might reflect some (known to campaigns) tendency such as past higher (or lower) voting percentages or Republican leanings. Further, this could reflect other actions taken by the campaigns that we do not observe such as GOTV efforts.

These unobserved characteristics could lead to problematic biases in our estimates if they are correlated with the observed advertising levels. If advertising is primarily persuasive, national and state level candidates (i.e., candidates for President, Governor, and the Senate) will target high turnout districts with larger numbers of advertisements in order to capitalize on the higher turnout and collect the most votes from the district. This will induce a positive unobserved correlation between advertising and turnout that will bias our estimates of the mobilizing effect of advertising upward. A similar argument can be made for congressional candidates targeting media markets within the congressional district. With persuasive effects another source of bias may arise due to trade-offs between different campaign expenditures. Since GOTV efforts mobilize voters (Gerber and Green, 2000), the incentive to spend on GOTV efforts increases as the portion of core supporters increases. Hence, in districts with higher proportions of core supporters the relative incentive to spend on television advertising is lower, which could bias our estimates of the persuasive effect of

advertising downward.

Alternatively, if the effect of advertising is primarily to mobilize, national and state level candidates will target districts with large portions of core supporters to air more ads. This will induce an inverted U relationship between Republican vote shares and advertising that could bias our estimates in favor of finding evidence for persuasion effects. Again a similar argument can be made for congressional candidates targeting media markets within the congressional district.

In both cases the endogeneity bias due to unobserved characteristics will lead us precisely to the wrong conclusion if we do not account for congressional district and media market-level differences in the prior likelihood of turning out and voting for Republican candidates. If advertising in fact has a persuasive effect, we may find a mobilization effect when none exists and may underestimate the strength of the persuasion effect. If advertising in fact has a mobilization effect, we may find a persuasion effect when none exists. For this reason, we include fixed effects in both the turnout and candidate choice equations- for each media market within a congressional district- to control for these potential biases. These fixed effects have the added advantage that we do not have to worry about specific variables to include as congressional district and media market level controls.[5]

These fixed effects mean that we identify the advertising effects by variation in individual level exposure within a media market in a congressional district. Thus, our identification strategy builds on the new television viewing data we bring to this problem; without it, including such fixed effects would not be possible.

The individual voting tendencies are represented by the latent variables, t_n^* and v_n^*. We assume that,

$$t_n^* = \xi_{j,m}^t + \beta_t' x_n + \rho_t(e_{n,D} + e_{n,R}) + \varepsilon_n^t$$

$$v_n^* = \xi_{j,m}^v + \beta_v' x_n + \rho_v(e_{n,R} - e_{n,D}) + \varepsilon_n^v$$

Here, x_n denotes the demographic characteristics of individual n, β_t and β_v specify the effect of these characteristics, $e_{D,n}$ and $e_{D,n}$ denote the exposure of individual n to ads by the Democratic

[5]Such controls include the incumbent party, the quality of the challenger (Lublin, 1994), money spent on GOTV efforts, the number of presidential visits, etc. Such a relationship will already be captured by the fixed effects.

and Republican candidates and ρ_t and ρ_v determine the effects of advertising exposure on the turnout and voting decisions of individuals. We assume that ε_n^t and ε_n^v are independent normally distributed shocks and we include fixed effects, $\xi_{j,m}^t$ and $\xi_{j,m}^v$, that are common to all individuals in media market m within congressional district j.

Based on prior literature, we expect advertising to increase a candidate's vote share (hence, we would expect $\rho_v \geq 0$). However, advertising may have a mobilizing or demobilizing effect, so we don't necessarily have an expectation for the sign of ρ_t. By employing this specification, we are assuming that exposure to ads by the Democratic and Republican candidates cancel for the persuasion effect and sum for the turnout effect.[6]

We assume that an individual turns out if $t_n^* < 0$ and that conditional on turning out, the individual votes for the Republican candidate if $v_n^* < 0$. We group conditioning variables $z_n = (j, m, x_n, e_n)$ and parameters $\theta = (\beta_t, \beta_v, \rho_t, \rho_v, \xi_{j,m}^t, \xi_{j,m}^v)$. Based on this, we can characterize the distribution of $y_n|z_n$ using,

$$\Pr(y_n = 0|z_n;\theta) = 1 - \Phi(\xi_{j,m}^t + \beta_t' x_n + \rho_t(e_{n,D} + e_{n,R}))$$

$$\Pr(y_n = 1|z_n;\theta) = \Phi(\xi_{j,m}^t + \beta_t' x_n + \rho_t(e_{n,D} + e_{n,R}))(1 - \Phi(\xi_{j,m}^v + \beta_v' x_n + \rho_v(e_{n,R} - e_{n,D}))$$

$$\Pr(y_n = 2|z_n;\theta) = \Phi(\xi_{j,m}^t + \beta_t' x_n + \rho_t(e_{n,D} + e_{n,R}))\Phi(\xi_{j,m}^v + \beta_v' x_n + \rho_v(e_{n,R} - e_{n,D}))$$

We can use these probabilities to form the log-likelihood function,

$$l(\theta) = \sum_{n=1}^{N} 1\{y_n = 0\} \log \Pr(y_n = 0|z_n;\theta) \tag{1}$$

$$+1\{y_n = 1\} \log \Pr(y_n = 1|z_n;\theta) + 1\{y_n = 2\} \log \Pr(y_n = 2|z_n;\theta)$$

We use the NAES election panel to estimate the likelihood in (1). While this model has a standard nested probit model form, the unobserved characteristics, $\xi_{j,m}^t$ and $\xi_{j,m}^v$, complicate the estimation.

[6] We investigated alternative forms by estimating a model with $t_n^* = \xi_{j,m}^t + \beta_t' x_n + \rho_t(e_{n,D} + e_{n,R})^{\alpha_t} + \varepsilon_n^t$ and $v_n^* = \xi_{j,m}^v + \beta_v' x_n + \rho_v((e_{n,R})^{\alpha_v} - (e_{n,D})^{\alpha_v}) + \varepsilon_n^v$ and found that the point estimates of α_t and α_v were close to 1 and statistically indistinguishable from 1, providing evidence in support of the specification we employ.

Within each congressional district, in the election panel sample (where we get the voting data) we observe relatively few individuals. Hence, to avoid potential small sample bias, we estimate the unobserved characteristics using aggregate data. In the aggregate data, for each congressional district j and media market m, we observe the voter turnout rate $s^t_{j,m}$ and the Republican vote share $s^v_{j,m}$. Rather than optimizing over the fixed effects $\xi^t_{j,m}$ and $\xi^v_{j,m}$, for each value (β, ρ) at which we evaluate the log-likelihood function, we select the fixed effects to equate the turnout and Republican voting shares predicted by the model to those observed in the data. Further details are given in the computational appendix.

4.3 Multiple Imputation

An additional complication with the formulation above is that we do not actually observe $e_{n,D}$ and $e_{n,R}$. Instead, we have an estimate of the distribution of $w_{n,p,c}$ conditional on x_n which allows us to simulate $e_{n,D}$ and $e_{n,R}$. Specifically, $w_{n,p,c}$ is related to x_n by the model, $\Pr(w_{n,p,c} = 1|x_n) = \Lambda(\gamma_p' x_n)$, where γ_p is a parameter characterizing the viewing decisions for program p, which was estimated in Section 4.1. We simulate $w_{n,p,c}$ using independent draws from the $Bernoulli(\Lambda(\hat{\gamma}_p' x_n))$ distribution. We then calculate exposure for each individual in the election panel using,

$$e_{n,D} = \sum_{p=1}^{P} \sum_{c=1}^{a_{D,m,p}} w_{n,p,c}, \qquad e_{n,R} = \sum_{p=1}^{P} \sum_{c=1}^{a_{R,m,p}} w_{n,p,c}$$

We follow the multiple imputation literature (Rubin, 1987; Schafer, 1997; King et al., 2001) and estimate the model based on 5 draws for $e_{n,D}$ and $e_{n,R}$. Repeating this process five times allows us to properly account for the uncertainty in the imputation model and also produces estimates that are more efficient than one would obtain with a single draw (Schafer, 1997).[7] We then preform the entire constrained maximum likelihood estimation on the 5 replicated data sets. As Rubin (1987) suggests, we report point estimates based on the average values of β and ρ and we report

[7] We depart from much of the existing literature in that we do not apply a multivariate normal model for the data and do not apply the EM algorithm to estimate the model for the missing data. The multivariate normal model is not appropriate for our case because watching a particular program is a binary variable. The EM algorithm is used to approximate the maximum likelihood estimator in situations where directly maximizing the likelihood function would be intractable. The fact that we do not observe individual level data means we must depart from conventional practice. Instead, we estimate the imputation model using a minimum distance estimator, as described in Section 4.1.

standard errors based on the formula derived in Rubin (1987). This formula provides an upper bound on the asymptotic confidence interval which accounts for uncertainty due to sampling error in the imputation model, imputation error, and sampling error in the second-stage estimation procedure.[8] Our use of multiple imputation here closely resembles the use of multiple imputation in Gelman and Little (1997) and Lax and Phillips (2009) in that we employ multiple imputation to fill in values in one survey based on a relationship estimated from a separate survey with partially overlapping covariates.

5 Estimation Results

In Table 2, we report estimates of the effect of television advertising on voter turnout and candidate choice. We first report results without fixed effects. In column (1), we find that ads increase turnout and that advantages in advertising exposure lead to greater vote shares. Consistent with expectations and the literature (Wolfinger and Rosenstone, 1980), registered, more educated, and older voters are more likely to vote and blacks are less likely to vote. Similarly, blacks and younger voters tend to vote more Democratic, while liberal voters more likely vote Democratic and conservative voters more likely vote Republican.

The results reported in column (1) do not account for endogeneity in ad spending. As discussed in section 4.2, we expect biases as a result of the unobserved characteristics. For example, if candidates believe that ads are persuasive, they may target their ad spending towards media markets with many likely voters. If this were the case, we would spuriously conclude that ad spending increases turnout when in fact it does not. Moreover, if ads are persuasive, the persuasive effects are likely to be underestimated due to trade-offs involved in the allocation of expenditures to advertising versus other campaign efforts. Alternatively, if candidates believe that ad spending mobilizes voters, they will target their ad spending towards media markets where they expect to do well. If this were the case, we would spuriously conclude that ad spending persuades voters when in fact it does not. In order to deal with these problems, we include fixed effects for each media market

[8] A exact calculation is possible based on the formula derived in Wang and Robins (1998), but applying this formula is much more involved in our case.

within each congressional district separately for the turnout and Republican voting equations.

We report the results controlling for fixed effects in column (2). We find that ads no longer have a statistically significant effect on turnout. Further, we find that ads are successful in persuading voters and that the exposure coefficient is approximately two times larger. These results are consistent with the biases we expect when not controlling for unobserved characteristics under a true persuasive effect. This also implies that the estimates in column (1) suffers from endogeneity bias. Without controlling for fixed effects, one would falsely conclude that advertising has a mobilizing effect on voters.

	(1)	(2)
Turnout:		
Total Ad Exposures	0.115*	0.054
	(0.056)	(0.163)
Registered	1.473***	1.516***
	(0.068)	(0.072)
Black	-0.278**	-0.265*
	(0.096)	(0.108)
Education	0.202***	0.193***
	(0.018)	(0.019)
Age	0.141***	0.146***
	(0.018)	(0.020)
Female	-0.020	0.007
	(0.051)	(0.055)
Voting:		
Advantage in Ad Exposures	0.741**	1.315*
	(0.240)	(0.663)
Ideology	0.822***	0.798***
	(0.033)	(0.033)
Black	-0.939***	-0.929***
	(0.144)	(0.141)
Education	0.005	0.006
	(0.018)	(0.018)
Age	-0.088***	-0.099***
	(0.018)	(0.018)
Female	-0.090+	-0.060
	(0.051)	(0.052)
Fixed Effects?	No	Yes
N	3,436	3,436

Table 2: Main Estimation Results – One star indicates statistical significance at the 5% level. Two stars indicates statistical significance at the 1% level. Three stars indicates statistical significance at the 0.1% level. A plus sign indicates statistical significance at the 10% level.

The magnitude of the advertising effect on candidate choice, however, is moderate. We illustrate by calculating the average effect of a uniform increase in advertising exposure. We hold all variables at observed values and use the estimated parameter values to predict a baseline turnout and

Scenario	Turnout	Rep. Vote Share
Baseline	54.5%	49.2%
Dem. Exposure Increased (One Sd.)	54.6%	47.4%
Rep. Exposure Increased (One Sd.)	54.6%	50.9%
Dem. Exp. Increased - Dem. Exp. Decreased	-0.2%	-3.5%
Rep. Exp. Increased - Rep. Exp. Decreased	-0.2%	3.5%

Table 3: Marginal Effects of Advertising Exposure.

Republican vote share.[9] We then increase and decrease Democratic exposure for every observation by one standard deviation (45 ad exposures) and observe the effect on turnout and Republican vote share. We perform the same calculation for Republican candidates. The results are reported in Table 3. We find that for both parties, a change in exposure from one standard deviation below the baseline to one standard deviation above leads to an increase in that party's vote share of 3.5%. While not a huge effect, it is substantial enough to swing a close election. For example, in 2004 this would have reversed a number of election outcomes including the defeats of incumbents Christopher Shays, Max Burns, Philip Crane, and Baron Hill.

To summarize, after controlling for candidate strategies and voter exposure, we find that persuasion effects dominate mobilization effects and that mobilization effects are either minor or do not exist at all. In contrast persuasion effects appear to be moderate, but potentially contest winning in close elections. Further, we find that without controlling for fixed effects, one would falsely conclude that television advertising has a mobilization effect.

6 The Strategy Space and Targeting Opportunities

In this section, we explore what options candidates have to target their advertising on television. Our framework allows us to succinctly present the strategic opportunity to target hundreds of television programs. In our analysis, we account for not only aggregate show tendencies, but also variation in viewer characteristics within each show across multiple key attributes. As a result, our framework allows us to do far more than simple descriptive analyses like those presented in Figure

[9]By construction this baseline matches aggregate data since we constrained it to during estimation. We note that this baseline represents an average rate for voters residing in the 219 congressional districts in our sample. The turnout rate in our sample of congressional districts will be higher than the turnout rate in the excluded districts because we have excluded uncompetitive congressional races from the analysis.

1. We develop a series of maps and measures that allow us to evaluate heuristic strategies and identify the most effective programs to target.

Central to our approach is mapping individuals and (by considering all individuals that watch a program) television shows into two critical dimensions– the predicted voter turnout rate and the predicted Republican support rate (as opposed to Democratic support rate). Each individual in the NAES rolling cross section sample is characterized by a vector of demographic and political variables x_n^{rcs}. Based on this value, we can set ad exposures to zero and compute the probability each individual votes using $T_n^* = \Phi(\xi_{j,m}^t + \hat{\beta}_t' x_n^{rcs})$ and prefers the Republican candidate using $V_n^* = \Phi(\xi_{j,m}^v + \hat{\beta}_v' x_n^{rcs})$. We then allocate individuals to programs by drawing for each individual whether this individual watches a given airing of program p using $w_{n,p} \sim Bernouli(\Lambda(\hat{\gamma}_p' x_n^{rcs}))$. By considering all individuals that view the program, we estimate the joint distribution of voting tendencies for the program audience, $(T_n^*, V_n^* | w_{n,p} = 1)$.

In Figure 2, we report this distribution for viewers of three programs with distinctive audiences- *Steve Harvey's Big Time* (WB), *60 Minutes* (CBS), and *Cavuto on Business* (Fox News). We plot contour lines for the 20% and 50% quantiles using a bivariate kernel density estimator. The graph depicts the variation within the audience of a show as well as the general voting tendencies of an audience. Although the show viewer profiles overlap, clear differences are apparent. Most viewers of *Steve Harvey's Big Time* heavily prefer Democratic candidates and are relatively unlikely to vote, most viewers of *60 Minutes* prefer Democratic candidates and are likely to vote, and most viewers of *Cavuto on Business* prefer Republican candidates and are likely to vote.

We use the distribution $(T_n^*, V_n^* | w_{n,p})$ to depict the position and rating of all television shows on a single map. Specifically, we calculate the average voting tendency of the viewers of each show as

$$\bar{T}_{n,p}^* = \frac{\sum_{n=1}^{N^{rcs}} w_{n,p} T_n^*}{\sum_{n=1}^{N^{rcs}} w_{n,p}}, \qquad \bar{V}_{n,p}^* = \frac{\sum_{n=1}^{N^{rcs}} w_{n,p} V_n^*}{\sum_{n=1}^{N^{rcs}} w_{n,p}}$$

We report these estimates in Figure 3, which plots the locations of television shows in this predicted turnout/candidate choice space. There are a large number of shows with a middle of the road audience that vary greatly in their propensity to turnout, but far more shows lean Democratic

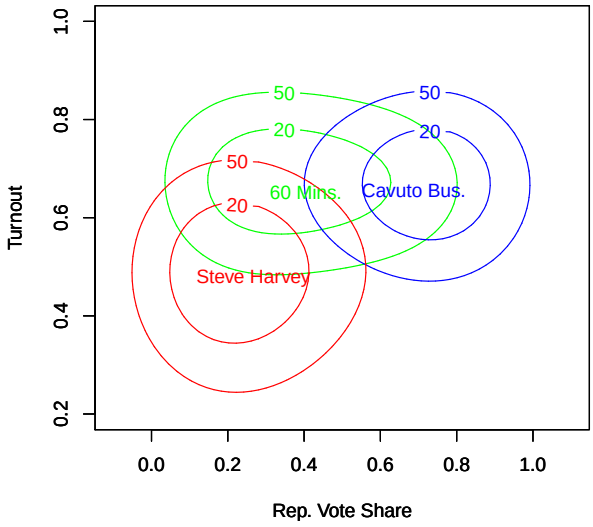

Figure 2: Distribution of Voting Behavior for Three Shows.

than Republican. Both of these tendencies in Figure 3 (which are based on predictions from the model) are qualitatively similar to the results in Figure 1 (which are based on the raw political characteristics). This provides some face validity to our model predictions. However, important differences arise because Figure 3 considers the predictive ability of all viewer characteristics. Figure 3 depicts a cluster of shows with low turnout and heavy Democratic leaning that is absent in 1. Even the middle of the road shows differ in important ways. For example, *American Idol* (Fox) and *Friends* (NBC) swap their relative vertical positions between the two figures due to *American Idol*'s larger proportion of black viewers and smaller proportion of college-educated viewers, both of which reduce turnout probabilities.

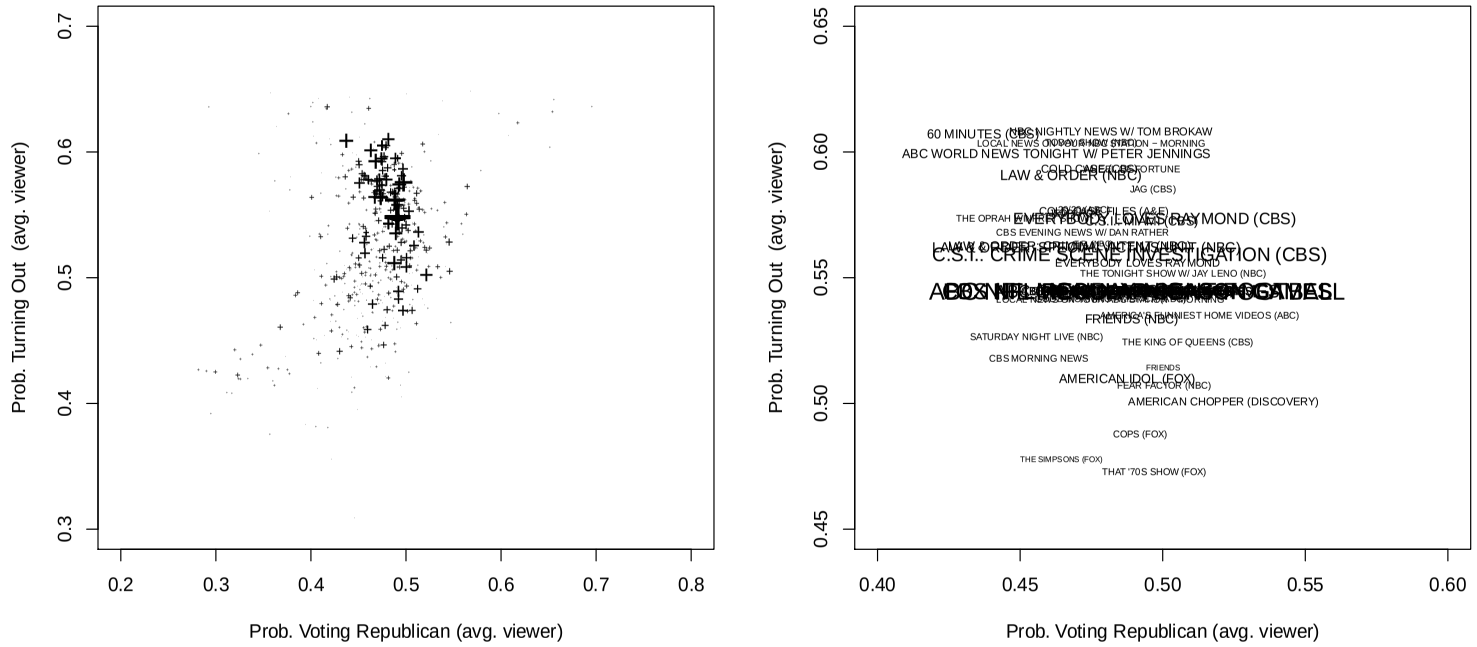

Figure 3: Voting Behavior of the Average Viewer – In the left panel, plus signs indicate the voting behavior of the average viewer of the show. The size of the plus sign is proportional to the rating of the show. In the right panel, only shows that are seen by more than 10% of the population in a given viewing are included. The size of the text is proportional to the rating of the show.

Using this map, we can easily characterize the options candidates have for implementing heuristic mobilization or persuasion strategies. Candidates pursuing a persuasion strategy have many options to target middle of the road individuals with a high likelihood of voting. Democratic candidates pursuing a base mobilization strategy also have options in the lower left cluster of shows. These shows largely appear on UPN and the WB, feature black characters, and relatively young and black audiences. Republicans, however, would have more difficulty practicing a base mobilization strategy– the shows with very conservative audiences already have high voter turnout rates. This makes mobilization efforts less likely to be effective. Of course, given our estimates in the previous section, a targeting strategy based on mobilization is misguided.

7 Candidate Strategies

Using the television program map, we study candidate strategies. In Figure 4 we report the advertising levels for the Democratic and Republican candidates. The figure clearly demonstrates that candidates of both parties target very similar programs since the panels for the two parties are almost impossible to distinguish. Further, the correlation in advertising levels aggregated over congressional districts is 98.1%, suggesting remarkable agreement or perhaps imitation.

Ad spending by both candidates is heavily targeted at programs where voters are evenly divided between the parties and have between a 50 and 60% probability of turning out. A large portion of this spending is targeted towards local news programs, nightly news broadcasts, and a selected set of talk and game shows. The average Democratic ad is run on a program with a 54.9% turnout rate and a 47.5% Republican voting rate. The average Republican ad is run on a program with a 55.4% turnout rate and a 47.7% Republican voting rate. Moreover, both candidates consistently target shows with above average turnout rates (52%). The candidates aired 82.9% of ads on television programs with turnout rates above the mean and more than half of ads on programs in the top quartile of turnout. This behavior is consistent with a belief that advertisements persuade swing voters but not with a belief that ads mobilize base voters. While the lack of Republicans engaging in this strategy can be explained by the lack of opportunity (absence of television programs with Republican leaning individuals that are unlikely to vote), the Democrats have plenty of opportunity

to target for mobilization.

The candidates tend to advertise on shows with moderate to high ratings. However, the number of large empty circles suggest that candidates do not simply target shows with high ratings. The correlation between the number of ads run and the rating of the program is only 22.1% for Democratic ads and 20.5% for Republican ads. Further, a number of targeted programs clearly do not fit a ratings-based heuristic. For example, many highly rated shows, including sports programs, procedural dramas, and reality shows, receive relatively few political ads. Similarly, some news programs, such as *Dateline* and *ABC World News Tonight*, are seen by more viewers than targeted shows, but are largely avoided by the candidates. These network evening news programs generally have Democratic leaning audiences. In contrast, many local news broadcasts have smaller audiences, yet receive a disproportionately large number of ads. These local news broadcasts have consistently centrist audiences. Hence, we find not only that audience size cannot fully account for candidates' targeting decisions, but also that the discrepancies in behavior from a purely audience size hypothesis are explained well by our hypothesis.

Of course, the cost of an ad differs throughout the day. Figure 5 depicts the candidates' actions by day part. Early morning, daytime, and early news receive the most advertisements. Prime time receives very few ads, late news receives a moderate number of ads, and prime access receives somewhat less. In general these patterns match the relative costs of shows in the day parts. Within early morning, daytime, early news, and late news, the candidates target news programs with relatively high voter turnout rates (with the exception of *Good Day Live*). In particular, the early news ads are heavily concentrated on three major networks' local news programs. In contrast, the programs that candidates target during daytime, which offers cheap airtime but few news shows, vary the most in terms of turnout and candidate choice probabilities.

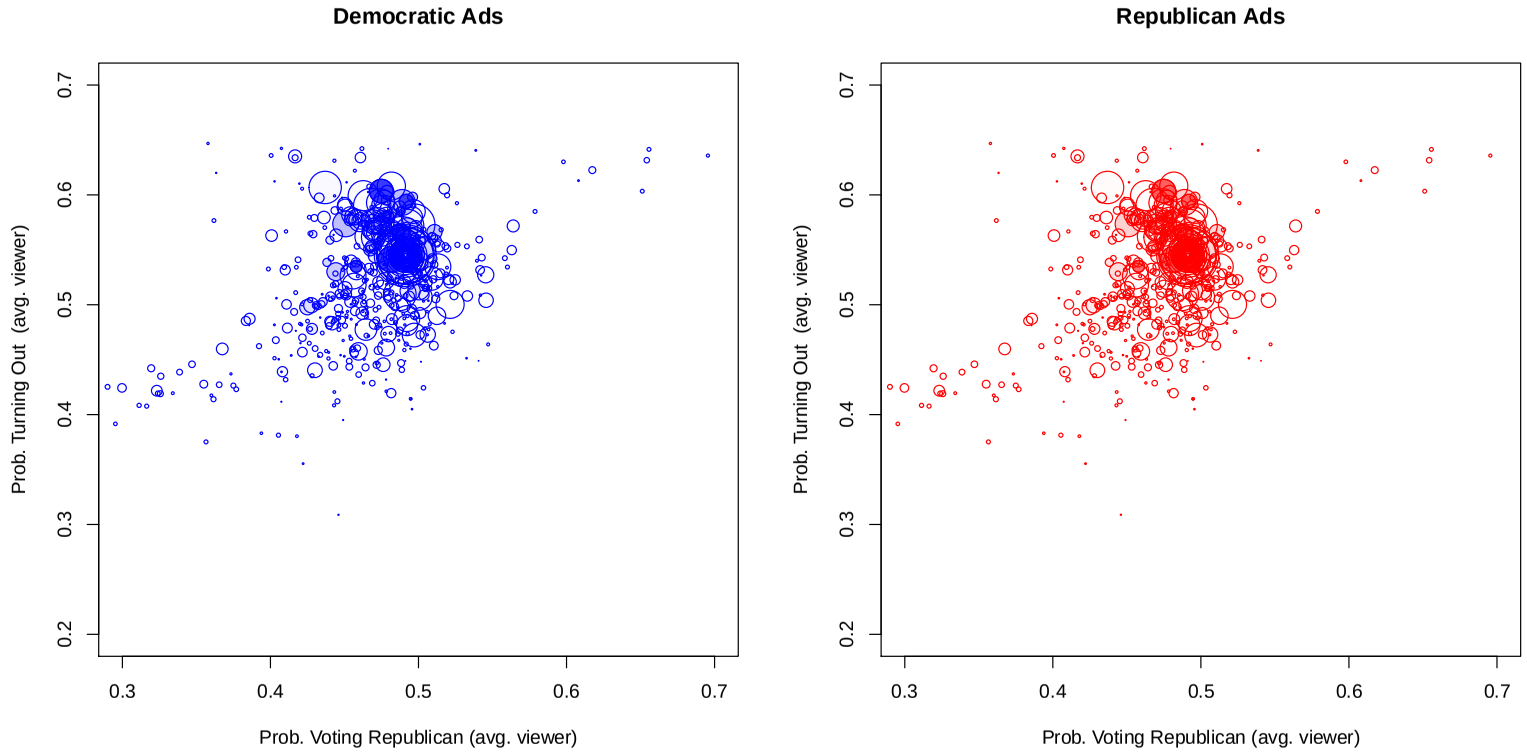

Figure 4: Advertising in Congressional Elections for Democratic and Republican Candidates – Each circle represents a program with the center its spatial location and the size proportional to the size of the program audience. Circles shaded darkly contain more ads than circles shaded lightly with the shade proportional to the number of ads.

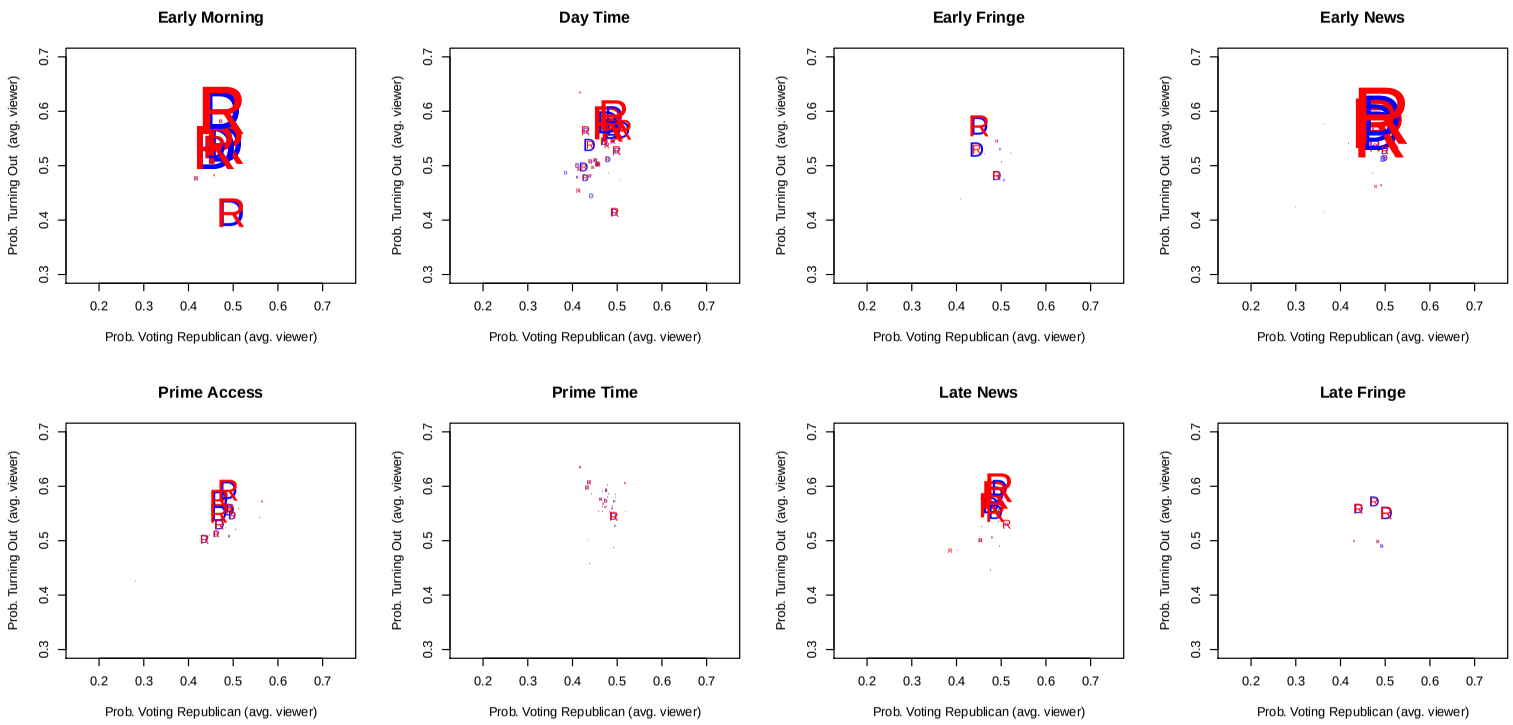

Figure 5: Advertising in Congressional Elections by Day Part – Blue D's indicate ads by Democratic candidates and Red R's indicate ads by Republican candidates. The size of the letters is proportional to the number of ads.

Beyond the news programs, candidates air ads on a selection of talk shows, sports programs, and soap operas. Because of the lower turnout for this selection, these ads are likely less effective than other available options. Similarly, both parties spend heavily on *Good Day Live* (FOX), but we estimate it to have a very low turnout rate.[10] Thus, it appears that candidates may be using heuristics that are broadly consistent with a persuasion strategy and account for costs, but they miss some important subtleties. In the next section we closely examine the nature of subtleties they miss and characterize the best programs to target.

7.1 Ad Effectiveness and Cost-Effectiveness by Program

In this subsection, we evaluate the effectiveness of advertising on a program. Running political ads on some programs is more effective than on other programs. With persuasion effects, shows with audiences that have high average turnout probabilities will, all else equal, be more effective targets than those with low averages. However, average program tendencies could ignore important variation within an audience. In order to fully capture the effect of an ad, we account for each individual's response. Further, we incorporate advertising costs to evaluate the net benefit of running an ad. Without the combination of a model of show viewership and a model that relates viewer characteristics to voting behavior this full accounting would not be possible.

To measure ad effectiveness by television program, we calculate the impact of each candidate purchasing an additional 3 gross ratings points– i.e., we increase the number of ads regardless of the cost.[11] To investigate cost-effectiveness by television program, we consider the impact of each candidate spending an additional fixed amount. We set this amount to what it would cost a candidate to buy 3 gross rating points on an early morning program. These ad effectiveness and cost-effectiveness measures succinctly report the benefit and net benefit of advertising on a program.[12]

[10] We note that this estimate is not an artifact of our modeling procedure, but is present in the raw data. We find that only 56% of *Good Day Live* viewers report being registered (the average program in our sample has 75% registered voters among its' viewers).

[11] A gross ratings point is a measure of advertising exposure which corresponds to a number of viewings equal to the size of the population. For example, one gross ratings point would correspond to 10% of the population seeing an ad 10 times, or 5% of the population seeing an ad 20 times.

[12] See Imai and Strauss (forthcoming) for an analysis of the optimal targeting of GOTV.

In Tables 4, 5, and 6, we report respectively the most and least effective shows, the most and least cost-effective shows, and the shows where the candidates ran the most ads. In each table, we report the day part, show rating, average turnout probability, average Republican vote share, and total ads shown. We also report the increase in respective vote share for a 3 point GRP increase in ads on that show, and for a fixed increase in spending. All of these quantities are aggregated over congressional districts.

Figure 6 summarizes much of the information in the three tables by depicting total candidate ads and average cost effectiveness for programs by day part. The large empty circles represent missed opportunities for candidates and the dark small circles represent ads aired on relatively cost-ineffective programs. Looking across day parts, on average early morning and day time have the most cost effective shows while prime time and late news have the least effective shows. These differences arise directly from the costs reported in Table 1. Looking within a day part, say early fringe, the more cost-effective shows, not surprisingly, have higher turnout. However, the probability of voting Republican appears to shift cost-effectiveness very little in comparison.

From Table 4 we can see that of the 20 most effective shows only 3 have average turnout rates less than 60%, whereas all of the 20 least effective shows have average turnout rates below 40%. In contrast, the average probability of voting Republican has a larger range in the top twenty shows than the bottom twenty, though the average tendency is more moderate.

Ads run on the most effective show (*West Wing* on NBC) are about 4 times more effective than ads run on the least effective show (*Living Single* on USA). Among the most effective shows are cable news shows, dramas such as *Joan of Arcadia* and *Navy: NCIS*, nightly news shows, and news magazines. NBC news shows (both local and national) are more profitable than news broadcasts by the other networks because the viewers turn out at higher rates. Cable news broadcasts are even more effective than NBC news broadcasts. The least effective shows largely have young and black audiences. These shows feature both low turnout and heavily Democratic voting, with the exception of WB's *The Help*, a sitcom designed to appeal to working class white viewers that leans Republican.

The most cost-effective shows consist largely of news programs, but also include *Dr. Phil*, *The*

View, as well as *Biography*, *City Confidential*, and *Cold Case Files* on A&E. The least cost-effective shows consist of prime time shows with low voter turnout rates. As compared to the least cost-effective show (*Run of the House*), the most cost-effective show (*Meet the Press*) is twelve times more cost-effective. The effectiveness accounts for a factor of four while the day part average cost differences from Table 1 account for a factor of three to four. Thus, these two sources of variation in costs are roughly equal in determining cost effectiveness.

In Table 6, we report the 25 shows with the most ads aired by congressional candidates. At the top of the list are early evening local news, early morning local news, and early morning national news shows. The candidates advertise heavily on news show broadcasts on all four major networks, but ads on NBC news are far more cost effective. In addition, the candidates spend a large amount of money on the early evening news, though far more cost-effective shows are available. These include early morning news programs, day time news programs, and shows such as *Meet the Press*, *Biography* (A&E), *This Week w/ George Stephanopoulos*, *The Chris Matthews Show*, and *Cold Case Files* (A&E). One potential explanation for this behavior is that ads on news programs or during the late news day part could generate a greater viewer response than other ads. We tested these hypotheses in our model of voting behavior and found no statistical support. These results are not entirely conclusive because the standard errors are large. The general pattern, however, suggests that even within news shows candidates appear to miss important subtleties in effectiveness and cost-effectiveness.

Beyond new shows, congressional candidates spend heavily on *Wheel of Fortune*, the *Oprah Winfrey Show*, *Jeopardy!*, *Dr. Phil*, *Entertainment Tonight*, *The Tonight Show with Jay Leno*, and *Judge Judy*. We find that while *Dr. Phil* is a very good option, *Wheel of Fortune*, *Jeopardy!*, and *Entertainment Tonight* are about half as cost-effective, largely due to the relatively high cost of broadcasting during prime access.

	Show	Day Part	Rating	Turnout	Rep. Share	Total Ads	Dem. Eff.	Rep. Eff.	Dem. Cost Eff.	Rep. Cost Eff.
1	WEST WING (NBC)	PRIME	6.0%	63.5%	41.7%	213	0.16%	0.15%	3.9	4.0
2	STREET SIGNS (CNBC)	DAY	0.3%	64.2%	48.0%	0	0.16%	0.14%	9.9	11.2
3	HARDBALL W/ MATTHEWS (MSNBC)	LN	1.8%	64.2%	46.2%	0	0.15%	0.15%	4.9	4.9
4	NEWSNIGHT W/ BROWN (CNN)	PRIME	1.0%	64.7%	35.8%	0	0.15%	0.16%	3.2	3.8
5	CLOSING BELL (CNBC)	EF	0.7%	64.6%	50.1%	0	0.16%	0.15%	8.0	7.6
6	THIS WEEK W/ STEPHANOPOULOS (ABC)	DAY	2.8%	63.4%	41.7%	190	0.15%	0.15%	10.5	12.9
7	WOLF BLITZER REPORTS (CNN)	EF	1.7%	63.6%	40.0%	0	0.15%	0.15%	8.1	9.5
8	NAVY NCIS (CBS)	PRIME	4.9%	60.6%	51.7%	188	0.14%	0.15%	3.5	3.5
9	NBC LOCAL NEWS - LATE EVENING	LN	4.6%	59.8%	49.6%	2502	0.15%	0.14%	5.1	5.2
10	CAVUTO ON BUSINESS (FOX NEWS)	EF	3.2%	62.3%	61.7%	0	0.15%	0.14%	10.2	7.7
11	MEET THE PRESS (NBC)	EM	4.9%	63.4%	46.1%	200	0.15%	0.14%	11.8	12.5
12	JOAN OF ARCADIA (CBS)	PRIME	6.5%	60.2%	47.9%	96	0.14%	0.15%	3.5	3.5
13	LOU DOBBS TONIGHT (CNN)	EN	1.0%	64.2%	40.7%	0	0.14%	0.14%	6.2	8.4
14	NBC LOCAL NEWS - MORNING	EM	11.0%	60.3%	47.5%	4828	0.14%	0.14%	11.6	12.0
15	BIOGRAPHY (A&E)	EM	3.5%	55.4%	47.2%	0	0.14%	0.14%	10.3	11.5
16	SCARBOROUGH COUNTRY (MSNBC)	PRIME	0.8%	64.1%	53.9%	0	0.14%	0.14%	3.8	3.2
17	60 MINUTES (CBS)	PRIME	15.0%	60.7%	43.7%	433	0.14%	0.14%	3.5	3.5
18	NBC NIGHTLY NEWS W/ BROKAW	EN	13.0%	60.8%	48.2%	70	0.14%	0.14%	7.7	7.7
19	FRASIER (NBC)	PRIME	7.1%	58.0%	45.7%	0	0.14%	0.14%	3.5	3.4
20	CROSSFIRE (CNN)	EF	1.5%	63.1%	44.3%	0	0.13%	0.15%	7.6	7.7
...										
544	RICKI LAKE	DAY	2.2%	42.3%	37.7%	0	0.06%	0.05%	3.9	5.3
545	BET COMICVIEW (BET)	EM	3.6%	42.8%	35.5%	0	0.06%	0.05%	4.4	5.2
546	THE PARKERS (UPN)	PA	5.0%	42.2%	32.3%	0	0.05%	0.06%	2.5	2.5
547	BET MOVIE OF THE WEEK (BET)	PA	2.8%	41.9%	32.6%	0	0.06%	0.05%	2.2	2.6
548	JAMIE FOXX	EF	2.6%	42.7%	36.5%	0	0.06%	0.05%	2.9	3.9
549	STEVE HARVEY	EN	3.3%	44.2%	31.9%	0	0.05%	0.05%	2.7	3.2
550	WAYANS BROTHERS	PRIME	1.3%	41.7%	36.0%	0	0.05%	0.05%	1.2	1.4
551	MARTIN	EN	2.4%	41.4%	36.2%	0	0.05%	0.05%	2.5	2.7
552	THE PARKERS	EN	4.0%	42.4%	30.0%	0	0.05%	0.05%	2.7	3.2
553	SOUL FOOD (BET)	PRIME	2.3%	42.6%	37.5%	0	0.06%	0.05%	1.2	1.4
554	RAP CITY (BET)	EF	1.3%	38.0%	41.8%	0	0.05%	0.05%	2.6	2.8
555	ACCESS GRANTED (BET)	DAY	1.9%	37.5%	35.6%	0	0.05%	0.05%	3.8	4.2
556	ROCK ME BABY (UPN)	PRIME	0.8%	35.5%	42.2%	0	0.05%	0.06%	1.1	1.1
557	THE MULLETS (UPN)	PRIME	0.5%	39.5%	44.9%	0	0.05%	0.05%	1.1	0.9
558	THE HUGHLEYS	EF	2.9%	43.5%	32.6%	0	0.05%	0.05%	3.0	3.3
559	LIVIN' LARGE	LN	0.7%	45.0%	40.6%	0	0.05%	0.04%	1.6	2.0
560	106 & PARK (BET)	DAY	1.9%	38.1%	40.5%	0	0.05%	0.05%	3.5	3.9
561	THE HELP (WB)	PRIME	0.4%	44.9%	54.1%	0	0.05%	0.05%	1.2	1.2
562	RUN OF THE HOUSE (WB)	PRIME	0.6%	30.9%	44.6%	0	0.05%	0.04%	0.9	0.9
563	LIVING SINGLE (USA)	LN	1.2%	38.3%	39.4%	0	0.04%	0.05%	1.5	1.6

Table 4: Shows Where Advertising Is Most and Least Effective.

	Show	Day Part	Rating	Turnout	Rep. Share	Total Ads	Dem. Eff.	Rep. Eff.	Dem. Cost Eff.	Rep. Cost Eff.
1	MEET THE PRESS (NBC)	EM	4.9%	63.4%	46.1%	200	0.15%	0.14%	11.8	12.5
2	TODAY SHOW (NBC)	EM	11.0%	60.3%	47.5%	4526	0.14%	0.14%	11.8	12.1
3	NBC LOCAL NEWS - MORNING	EM	11.0%	60.3%	47.5%	4828	0.14%	0.14%	11.6	12.0
4	THIS WEEK W/ STEPHANOPOULOS (ABC)	DAY	2.8%	63.4%	41.7%	190	0.15%	0.15%	10.5	12.9
5	BIOGRAPHY (A&E)	EM	3.5%	55.4%	47.2%	0	0.14%	0.14%	10.3	11.5
6	NBC LOCAL NEWS - AFTERNOON	DAY	6.6%	59.4%	49.2%	2668	0.13%	0.14%	10.6	10.9
7	ABC LOCAL NEWS - AFTERNOON	DAY	8.0%	56.6%	48.8%	2348	0.12%	0.13%	10.6	10.6
8	STREET SIGNS (CNBC)	DAY	0.3%	64.2%	48.0%	0	0.16%	0.14%	9.9	11.2
9	EARLY TODAY (NBC)	DAY	7.4%	57.1%	47.0%	27	0.13%	0.13%	10.1	10.7
10	DR. PHIL	DAY	10.0%	57.6%	47.9%	2026	0.13%	0.13%	10.1	10.6
11	COLD CASE FILES (A&E)	DAY	13.0%	55.0%	49.4%	0	0.12%	0.12%	10.1	10.3
12	SATURDAY TODAY (NBC)	DAY	2.8%	60.7%	46.7%	412	0.14%	0.13%	10.0	10.4
13	THE VIEW (ABC)	DAY	3.4%	58.0%	47.9%	828	0.12%	0.13%	9.7	10.5
14	CBS LOCAL NEWS - AFTERNOON	DAY	5.8%	54.1%	48.2%	3154	0.12%	0.12%	10.1	10.0
15	GOOD MORNING AMERICA (ABC)	EM	12.0%	54.1%	48.2%	4154	0.12%	0.12%	9.8	10.0
16	ABC LOCAL NEWS - MORNING	EM	12.0%	58.2%	47.1%	4260	0.12%	0.12%	9.9	9.7
17	SUNDAY TODAY (NBC)	EM	2.6%	55.5%	48.0%	388	0.13%	0.13%	9.7	9.9
18	THE CHRIS MATTHEWS SHOW	DAY	2.4%	56.3%	44.4%	181	0.14%	0.13%	9.6	10.0
19	CITY CONFIDENTIAL (A&E)	DAY	5.9%	54.5%	49.1%	0	0.12%	0.12%	9.0	10.6
20	FIGURE SKATING	DAY	15.5%	54.5%	49.1%	27	0.12%	0.12%	9.7	9.7
...										
543	WONDERFALLS (FOX)	PRIME	0.7%	45.3%	45.8%	0	0.07%	0.07%	1.9	1.4
544	CRACKING UP (FOX)	PRIME	0.9%	45.7%	43.9%	0	0.06%	0.07%	1.6	1.6
545	WWE SMACKDOWN! (UPN)	PRIME	4.3%	42.0%	48.2%	15	0.07%	0.07%	1.6	1.6
546	BEVERLY HILLS 90210 (FX)	PRIME	0.6%	46.5%	42.0%	0	0.07%	0.08%	1.4	1.7
547	LIVING SINGLE (USA)	LN	1.2%	38.3%	39.4%	3	0.04%	0.05%	1.5	1.6
548	UPN'S THE PLAYER	PRIME	0.5%	41.2%	40.7%	0	0.06%	0.06%	1.6	1.5
549	THE BIG HOUSE (ABC)	PRIME	0.7%	40.5%	49.6%	0	0.06%	0.06%	1.6	1.5
550	SECRET ADVENTURES OF JULES VERNE	PRIME	0.7%	45.1%	53.2%	0	0.07%	0.07%	1.7	1.4
551	STEVE HARVEY'S BIG TIME (WB)	PRIME	3.1%	44.6%	34.7%	9	0.06%	0.06%	1.5	1.6
552	MEET MY FOLKS (NBC)	PRIME	1.0%	46.7%	44.9%	0	0.08%	0.08%	1.5	1.5
553	ALL ABOUT THE ANDERSONS (WB)	PRIME	1.3%	42.0%	33.4%	0	0.06%	0.06%	1.3	1.7
554	REMARKABLE JOURNEY	PRIME	0.3%	44.9%	49.1%	1	0.06%	0.06%	1.5	1.4
555	HALF & HALF (UPN)	PRIME	2.2%	42.5%	29.0%	7	0.07%	0.06%	1.4	1.4
556	SPY TV (NBC)	PRIME	0.8%	43.9%	40.7%	0	0.06%	0.06%	1.5	1.3
557	SOUL FOOD (BET)	PRIME	2.3%	42.6%	37.5%	0	0.06%	0.05%	1.2	1.4
558	WAYANS BROTHERS	PRIME	1.3%	41.7%	36.0%	0	0.05%	0.05%	1.2	1.4
559	THE HELP (WB)	PRIME	0.4%	44.9%	54.1%	0	0.05%	0.05%	1.2	1.2
560	ROCK ME BABY (UPN)	PRIME	0.8%	35.5%	42.2%	0	0.05%	0.06%	1.1	1.1
561	THE MULLETS (UPN)	PRIME	0.5%	39.5%	44.9%	0	0.05%	0.05%	1.1	0.9
562	RUN OF THE HOUSE (WB)	PRIME	0.6%	30.9%	44.6%	0	0.05%	0.04%	0.9	0.9

Table 5: Shows where Advertising is Most and Least Cost-Effective.

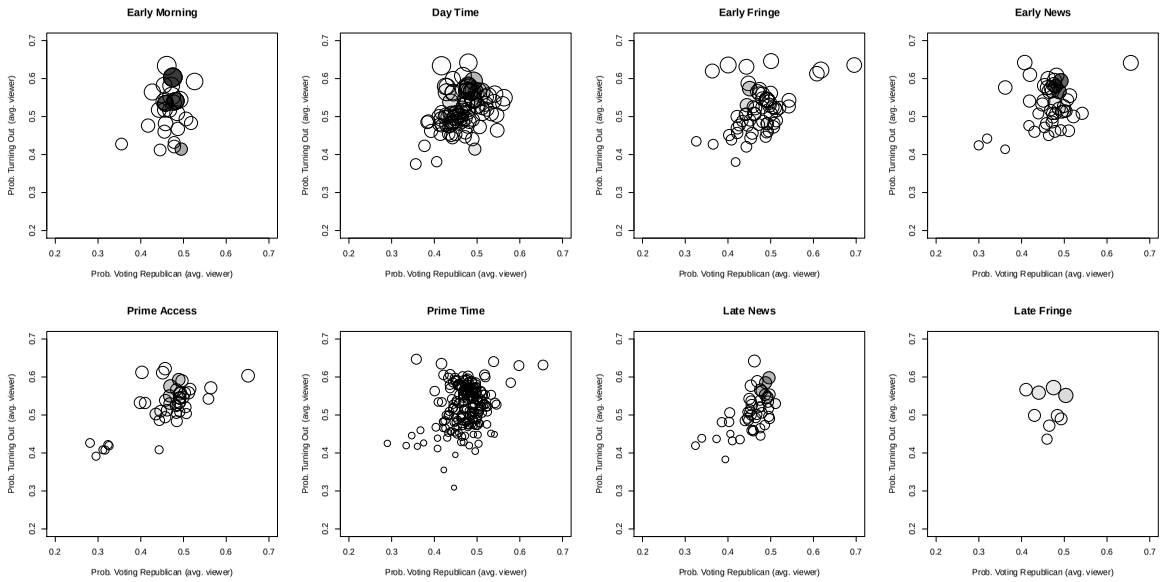

Figure 6: Advertising and Cost Effective in Congressional Elections by Day Part – The size of each circle is proportional to the cost-effectiveness of the show (averaged for Democratic and Republican candidates). Circles shaded darkly contain more ads than circles shaded lightly with the shade proportional to the number of ads.

	Show	Day Part	Rating	Turnout	Rep. Share	Total Ads	Dem. Eff.	Rep. Eff.	Dem. Cost Eff.	Rep. Cost Eff.
1	NBC LOCAL NEWS - EARLY EVENING	EN	6.6%	59.4%	49.2%	5542	0.14%	0.13%	7.3	7.4
2	ABC LOCAL NEWS - EARLY EVENING	EN	8.0%	56.6%	48.8%	5254	0.13%	0.13%	6.9	7.3
3	CBS LOCAL NEWS - MORNING	EM	5.5%	53.5%	45.8%	4938	0.11%	0.11%	8.6	8.9
4	CBS LOCAL NEWS - EARLY EVENING	EN	5.8%	58.0%	47.9%	4937	0.12%	0.12%	6.7	6.3
5	NBC LOCAL NEWS - MORNING	EM	11.0%	60.3%	47.5%	4828	0.14%	0.14%	11.6	12.0
6	TODAY SHOW (NBC)	EM	11.0%	60.3%	47.5%	4526	0.14%	0.14%	11.8	12.1
7	ABC LOCAL NEWS - MORNING	EM	12.0%	54.1%	48.2%	4260	0.12%	0.12%	9.9	9.7
8	GOOD MORNING AMERICA (ABC)	EM	12.0%	54.1%	48.2%	4154	0.12%	0.12%	9.8	10.0
9	CBS LOCAL NEWS - AFTERNOON	DAY	5.8%	58.0%	47.9%	3154	0.12%	0.12%	10.1	10.0
10	FOX LOCAL NEWS - MORNING	EM	1.2%	41.4%	49.5%	3132	0.06%	0.06%	5.4	5.1
11	NBC LOCAL NEWS - AFTERNOON	DAY	6.6%	59.4%	49.2%	2668	0.13%	0.14%	10.6	10.9
12	CBS LOCAL NEWS - LATE EVENING	LN	3.9%	58.5%	48.8%	2541	0.13%	0.13%	5.0	5.2
13	THE EARLY SHOW (CBS)	EM	5.5%	53.5%	45.8%	2515	0.11%	0.11%	8.4	8.6
14	NBC LOCAL NEWS - LATE EVENING	LN	4.6%	59.8%	49.6%	2502	0.15%	0.14%	5.1	5.2
15	ABC LOCAL NEWS - AFTERNOON	DAY	8.0%	56.6%	48.8%	2348	0.12%	0.13%	10.6	10.6
16	ABC LOCAL NEWS - LATE EVENING	LN	4.6%	56.6%	47.6%	2348	0.12%	0.13%	4.9	5.1
17	WHEEL OF FORTUNE	PA	12.0%	59.3%	48.9%	2190	0.12%	0.12%	5.4	5.4
18	THE OPRAH WINFREY SHOW	EF	12.0%	57.4%	45.1%	2174	0.12%	0.12%	7.3	7.4
19	LIVE WITH REGIS AND KELLY	DAY	7.0%	56.6%	51.1%	2116	0.12%	0.12%	9.9	9.4
20	JEOPARDY!	PA	11.0%	57.6%	46.9%	2060	0.13%	0.13%	5.9	6.1
21	DR. PHIL	DAY	10.0%	56.9%	49.2%	2026	0.13%	0.13%	10.1	10.6
22	FOX LOCAL NEWS - LATE EVENING	LN	3.9%	55.3%	48.7%	1963	0.12%	0.13%	4.6	4.4
23	ENTERTAINMENT TONIGHT	PA	6.1%	55.1%	46.7%	1934	0.12%	0.12%	5.1	5.3
24	THE TONIGHT SHOW W/ JAY LENO (NBC)	LF	11.0%	55.1%	50.4%	1393	0.13%	0.13%	7.0	7.0
25	JUDGE JUDY	EF	8.3%	53.0%	44.4%	1358	0.09%	0.10%	6.0	6.2

Table 6: Shows where the Most Ads were Run.

The results in this subsection indicate that candidates use appropriate heuristics to target their ads, but sometimes miss subtle distinctions. Viewers of NBC news programs are more likely to turn out and are more persuadable, but congressional candidates do not seem to appreciate this fact. In addition, the candidates heavily target early evening and late news programs, which are less cost-effective. Finally, there are certain classes of shows which the candidates avoid, but which our results suggest would be good options– documentary style cable shows, Sunday news programs, and cable news shows. Our results demonstrate missed opportunities, specific options, and a method for evaluating shows that fully accounts for individual-level response.

7.2 Alternative Explanations and Future Research

We next consider some potential alternative explanations for the differences we find between candidate strategies and what our model suggests. First, we have assumed that all shows in our sample are available to the candidates. Congressional candidates may find it relatively easy to purchase ads on local news shows, but more difficult to purchase ads on shows with national audiences. This problem may be exacerbated in media markets heavily targeted by presidential candidates. Cable advertising may pose practical problems for congressional candidates because these channels may not offer the technology to target local media markets (or at least, did not offer this technology in 2004). Such constraints would limit the observed ad placements to a limited set of shows.

The constraints on behavior can also be political. It may be politically infeasible for Democratic candidates to run ads on shows with largely Republican audiences, or vice versa. For example, Democratic candidates may fear losing support among their "base" if they run ads on programs such as *Cavuto on Business* and *Hannity and Colmes* because such a practice might suggest to base voters that the candidates support the editorial stances of commentators on the *Fox News Channel*. Given the degree to which CBS news has been vilified by conservative candidates, Republican candidates may face similar negative response if they placed ads on these types of shows.

An alternative set of explanations instead postulate that the campaigns are not sufficiently sophisticated to appreciate some of the subtleties we have uncovered. Campaigns may not have the background to fully take advantage of these subtleties, instead relying on contextual knowledge

and heuristics. They may not fully appreciate the link between advertising effects and strategy or since advertising effects are difficult to estimate, they may hold incorrect beliefs about the nature of advertising effects.

Moreover, they may not have access to the necessary data to make more informed decisions. Although the Simmons National Consumer survey is potentially available to the candidates, the candidates may not buy this information (though we know of some campaigns that have used the Simmons data). The campaigns may rely solely on viewer demographics provided by Nielson and may lack access to the political variables we employ in our analysis. Without access to information on voter registration, ideology, and party identification of program viewers, our ability to predict their voting behavior would be more limited. Candidates, facing this limitation, may not be able to uncover differences within categories of programs (such as the large difference in turnout rates we found between viewers of *The Today Show* and *Good Day Live*).

8 Conclusions

In this paper, we studied targeted television advertising strategies in congressional elections. We found three major results. First, we found that television advertising persuades voters, but does not mobilize them. Second, we found that television programs have sufficient differentiation to allow the candidates to engage in targeted campaigning. Third, we found that candidates of both parties target their ads towards swing voters with a high likelihood of voting. This finding is consistent with the notion that candidates (or their campaign strategists) believe that the function of television advertising is primarily to persuade. Overall, the results suggested that the candidates practice persuasion strategies in their television advertising and largely avoid base mobilization strategies. Whether this behavior is purposeful or accidental is harder to establish. We established that candidates do not simply target shows with large audiences, and do not simply target all news programs. Moreover, we find that strategies differ from these very simple heuristics in ways that are well explained by targeting for persuasion. Instead, the candidates seem to employ a targeting heuristic, where candidates place ads on the types of shows that are expected to have high turnout rates among their viewers. These heuristics, however, lead candidates to miss subtle audience

differences and not always advertise on the most cost-effective shows.

We note that our method can provide more detail than we could possibly present in this paper. For example, we can investigate the strategies of candidates within each congressional district separately and we can estimate the cost effectiveness of shows within each congressional district. Space limitations restrict us from reporting such results here, but our results clearly indicate that candidates could increase the cost-effectiveness of their ad targeting by using such information.

We believe that the techniques we developed here will be useful for studying targeted campaigns more generally. We provide an approach that combines survey and observational data at the individual and aggregate levels. Our approach uses this data to apply a two stage estimation process. In a first stage we estimate exposure to television programs and predict individual level exposure to ads. In the second stage, we use these more precise exposure predictions to estimate advertising response while simultaneously controlling for district specific shocks in campaign strategies. We have documented the importance of both aspects of this method for understanding targeted advertising.

9 Computational Appendix

9.1 Estimation of the Exposure Function

Define $x_{n,i}$ as one arbitrary characteristic i from those contained in x_n. The Simmons data provides estimates of the form $\widehat{\Pr}(w_{n,p,c} = 1|x_{n,i} = q)$. For example, this could be the percentage of very liberal viewers in the Simmons sample that watched *60 Minutes* on a given viewing occasion. We would like to compare these to their theoretical counterparts, which are given by,

$$\Pr(w_{n,p,c} = 1|x_{n,i} = q) = \frac{\sum_{x:x_i=q} \Pr(x)\Lambda(\gamma_p' x)}{\sum_{x:x_i=q} \Pr(x)}$$

Here, $\Pr(x)$ denotes the probability mass function of the demographic characteristics. This distribution is not directly observed in our television viewership data, but we observe a large sample of x in the NAES rolling cross section. Specifically, let x_n^{rcs} denote the demographic characteristics of an individual observed in the rolling cross section sample of the NAES and let N^{rcs} denote the sample size of the rolling cross section. We use the empirical distribution to obtain an estimate of

the (population) distribution of x. That is, we can estimate,

$$\widehat{\Pr}(x) = \tfrac{1}{N^{rcs}} \sum_{n=1}^{N^{rcs}} 1\{x_n^{rcs} = x\}$$

We use this to obtain the desired estimate of the model predicted probabilities. Specifically, we estimate the probability that an individual with characteristic x_i at a value q watches program p on occasion c,

$$\Pr(w_{n,p,c} = 1 | x_i = q) \approx \frac{\frac{1}{N^{rcs}} \sum_{x:x_i=q} \sum_{n=1}^{N^{rcs}} 1\{x_n^{rcs} = x\} \Lambda(\gamma_p' x)}{\frac{1}{N^{rcs}} \sum_{x:x_i=q} \sum_{n=1}^{N^{rcs}} 1\{x_n^{rcs} = x\}}$$

Based on this, we can form the following moment conditions,

$$\widehat{h}_{p,i,q}(\gamma_p) = \widehat{\Pr}(w_{n,p,c} = 1 | x_i = q) - \frac{\frac{1}{N^{rcs}} \sum_{x:x_i=q} \sum_{n=1}^{N^{rcs}} 1\{x_n^{rcs} = x\} \Lambda(\gamma_p' x)}{\frac{1}{N^{rcs}} \sum_{x:x_i=q} \sum_{n=1}^{N^{rcs}} 1\{x_n^{rcs} = x\}}$$

Here $\widehat{\Pr}(w_{n,p,c} = 1 | x_i = q)$ is observed in the Simmons data, i denotes the variable being conditioned on, and q denotes a value that the variable takes.

For each i, we select moments based on all the values q that x_i can take.[13] This corresponds to using the proportion of each subgroup that watches each show as moments in our estimation. Let $\widehat{h}_p(\gamma_p)$ denote the vector of moments for program p. By choosing these moments, we have that $\widehat{h}_p(\gamma_p) \xrightarrow{prob.} 0$ if and only if $\gamma_p = \gamma_{p,0}$ (where $\gamma_{p,0}$ denotes the true parameter vector characterizing the data generating process for one program), so the moments will define a minimum distance estimator. We therefore have an exactly identified minimum distance estimator and we estimate $\gamma_{p,0}$ by solving the nonlinear system $\widehat{h}_p(\gamma_p) = 0$.

9.2 Estimation of the Effectiveness of Advertising

Based on the model we aggregate over individuals to get the turnout and Republican shares by

$$s_{j,m}^t(\theta) = \tfrac{1}{N_{j,m}^{rcs}} \sum_{n \in \mathcal{N}_{j,m}^{rcs}} \Phi(\xi_{j,m}^t + \beta_t' x_n^{rcs} + \rho_t(e_{n,D}^{rcs} + e_{n,R}^{rcs}))$$

[13] For example, if x_i denotes gender, then x_i can take on the values 1 (for females) and 0 (for males).

$$s^v_{j,m}(\theta) = \frac{\frac{1}{N^{rcs}_{j,m}} \sum_{n \in \mathcal{N}^{rcs}_{j,m}} \Phi(\xi^t_{j,m} + \beta'_t x^{rcs}_n + \rho_t(e^{rcs}_{n,D} + e^{rcs}_{n,R}))\Phi(\xi^v_{j,m} + \beta'_v x^{rcs}_n + \rho_v(e^{rcs}_{n,R} - e^{rcs}_{n,D}))}{s^t_{j,m}(\theta)}$$

where $\mathcal{N}^{rcs}_{j,m}$ denotes the indices of individuals that reside in the jth congressional district and the mth media market and $N^{rcs}_{j,m} = |\mathcal{N}^{rcs}_{j,m}|$.

Our estimation therefore maximizes the log-likelihood function,

$$l(\theta) = \sum_{n=1}^{N} 1\{y^{ep}_n = 0\} \log \Pr(y^{ep}_n = 0 | z^{ep}_n; \theta)$$

$$+1\{y^{ep}_n = 1\} \log \Pr(y^{ep}_n = 1 | z^{ep}_n; \theta) + 1\{y^{ep}_n = 2\} \log \Pr(y^{ep}_n = 2 | z^{ep}_n; \theta)$$

subject to the constraints,

$$s^t_{j,m} - s^t_{j,m}(\theta) = 0 \tag{2}$$

$$s^v_{j,m} - s^v_{j,m}(\theta) = 0 \tag{3}$$

In our implementation, we apply a nested fixed point approach (Berry, 1994; Berry, Levinsohn and Pakes, 1995). Each time we evaluate the likelihood at (β, ρ), we find the vector of fixed effects that are consistent with the constraints. For each j and m, we first solve (2) for $\xi^t_{j,m}$ using a one-dimensional solver and then solve (3) for $\xi^v_{j,m}$ again using a one-dimensional solver.

Our estimation problem is related to the estimation problems of Petrin (2002) and Berry, Levinsohn and Pakes (2004) in that we observe a combination of micro and macro level data and we want to invert aggregate data to recover unobserved characteristics (shocks). In Petrin (2002) and Berry, Levinsohn and Pakes (2004) the primary data to estimate the parameters of interest comes from aggregate level moments, so it is simpler for them to combine the two types of data by constructing aggregate level moments from the micro data. However, in our application, the primary data to estimate the parameters of interest is available at the individual level, so we form

the likelihood of an individual observation and constrain the unobserved characteristics to match the aggregate level data. Hence, we apply constrained maximum likelihood estimation.

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