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Advertising competition in presidential elections

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Abstract Presidential candidates purchase advertising based on each state's potential to tip the election. The structure of the Electoral College concentrates spending in battleground states, such that a majority of voters are ignored. We estimate an equilibrium model of multimarket advertising competition between candidates that allows for endogenously determined budgets. In a Direct Vote counterfactual, we find advertising would be spread more evenly across states, but total spending levels can either decrease or increase depending on the contestability of the popular vote. Spending would increase by 13 % in the extremely narrow 2000 election, but would decrease by 54 % in 2004. These results suggest that the Electoral College greatly increases advertising spending in typical elections.

Keywords Advertising · Politics · Empirical game · Presidential election · Electoral college · Direct vote · Resource allocation · Contest

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1 Introduction

In the general election for president, candidates strategically allocate their resources to states most likely to tip the election outcome. Battleground states, where competition is especially intense, arise under the Electoral College because most states use a winner-take-all rule to assign all their electoral votes to the candidate who receives a plurality of the state's popular vote.[1] A consequence of this election mechanism is that candidates direct the majority of their campaigns' attention—advertising, candidate visits, get-out-the-vote activities, supporter mobilization, and funding—towards swaying a minority of voters in these states. In contrast, candidates pay scant attention to the majority of the electorate who reside in more polarized states with foregone outcomes.

Among the marketing instruments at a campaign's disposal, TV advertising has both grown in prevalence and importance over the past few decades. In the 2012 presidential election, nearly $2 billion (NPR 2012) was spent on TV advertising, representing the largest component of campaign media expenditure (TVB 2013). Most expect this sum to be eclipsed in the 2016 election cycle. Figure 1 illustrates how candidate TV advertising in 2000 was highly concentrated in states with votes close to the zero margin, suggesting the candidates anticipated these narrow margins and strategically directed advertising funds toward them. To the extent the advertising messages, and the policies they represent, are chosen with these battleground state voters in mind, the preferences of voters in non-battleground states are being underrepresented in the election process.[2]

Given these concerns, numerous proposals for reform have been made (Congressional Research Service 2009). The most oft-proposed alternative to the Electoral College is a Direct Vote that eliminates the state-level contests and counts each vote equally in a national contest. A Direct Vote equalizes the relevance of marginal voters in determining the election outcome, whereas in the Electoral College marginal votes are only valuable in states with closely divided voter preferences (i.e., battleground states near the zero margin). Our goal is to quantify how a Direct Vote changes the intensity of advertising competition and the degree to which advertising is more evenly distributed across markets.

[1] The two exceptions are Maine and Nebraska, which have used a congressional district method since 1972 and 1996, respectively. Maine's votes have never been split across candidates, whereas Nebraska's were split for the first and only time in 2008 when Barack Obama won the state's 2nd district.

[2] The Electoral College might directly distort a candidate's policies (or promises, in the case of challengers) to favor voters in battleground states. The winner-take-all rule makes a smaller coalition of voters necessary to win the election, and a politician might be more responsive to these pivotal voters' preferences through targeted policies instead of broader economic programs. For instance, such incentives help explain the timing of financial support bestowed upon Florida's Everglades by Presidents Bill Clinton in 1996, George W. Bush in 2004, and Barak Obama in 2012—all announced within months of the general election. Similar reasoning applies to the bipartisan support for corn (ethanol) subsidies in Iowa (Oppel 2011). Empirical studies lend further credence to the view that candidates adopt policies that disproportionately favor battleground states (Garrett and Sobel 2003; Berry et al. 2010; Reeves 2011).

To this end, we estimate an equilibrium model of multimarket competition between presidential candidates to evaluate counterfactual outcomes in a Direct Vote. Candidates simultaneously choose advertising levels across markets in order to shift voters' decisions on Election Day. Since candidates must set advertising levels before voters cast their ballots, candidates face uncertainty in setting advertising and must form beliefs over voters' eventual choices. We model voters' decisions using a simple aggregate market share model that depends on advertising, controls such as demographic and economic indicators, and market-specific demand shocks. Candidates do not perfectly observe these shocks, which are realized on Election Day when voters vote but after candidates set advertising. Candidates form rational expectations and strategically set advertising levels to equate the local marginal benefits of advertising to local advertising prices.

Our empirical strategy follows a structural approach to recover voter preferences, the degree of candidate uncertainty about voting outcomes, and the potential financial support for the candidates. Using data from the 2000 and 2004 elections, we form moments in a GMM specification based on the first-order conditions (FOCs) of candidates' advertising decisions. To identify candidate uncertainty over voting outcomes, we rely on joint variation in advertising and candidates' expected vote margins. A candidate's willingness to spend money in states with large ex-post voting margins indicates significant uncertainty over voting outcomes. Otherwise, candidates have little incentive to advertise in states they are predicted to win or lose. The second set of parameters we estimate guide each candidate's overall spending level without the need to impose an exogenous budget. This approach permits aggregate spending to adjust accordingly as the marginal benefits to advertising change in a counterfactual, whereas previous work assumed a fixed budget (Strömberg 2008; Shachar 2009).

We use the estimated model to evaluate Direct Vote counterfactuals in 2000 and 2004. Under this alternative mechanism, we find that all states receive positive advertising in both election years. The distribution of advertising is more evenly distributed, with the standard deviation of exposures across markets dropping by 66 % in 2000 and 89 % in 2004. The notable difference between 2000 and 2004 is that while battleground state advertising dropped dramatically in both years, in the 2000 election there is a larger offsetting increase in non-battleground spending. In 2004, non-battleground state advertising is basically unchanged when moving from the Electoral College to the Direct Vote. Thus total advertising expenditures in a Direct Vote increase by 13 % in 2000, but fall by 54 % in 2004 due to the sharp reduction in battleground state spending.

This contrasting result between the two elections illustrates the interplay between voting margins in specific states and the national outcome. Non-battleground states only attract more advertising funds in a Direct Vote if the national voting margin is sufficiently narrow to raise the value of those marginal votes. Otherwise, candidates cannot justify additional spending in those states. The (observed) popular vote margin in 2000 was one half of a percent, the narrowest margin since Kennedy-Nixon in 1960, which helped motivate candidates to double non-battleground spending in the Direct

Vote. Although much wider by comparison, the 2.5 % margin in 2004 was smaller than every other election since the 2 % margin in 1976 (except 2000). This suggests that decreased spending in the Direct Vote could be the norm given the historical distribution of popular vote margins.

The diminished importance of advertising in 2004, and perhaps in other less contestable elections, highlights how other dimensions of candidates' strategies may gain importance in a Direct Vote. Our analysis holds fixed candidates' policy positions and other campaign strategies. In a less contested Direct Vote, these choices would likely change, although a Direct Vote might still reduce the role of financing in most elections.

A second set of counterfactuals examine the sources of variation that generate advertising in the Direct Vote: candidates' funding levels, differences in advertising prices across markets, and variation in voter preferences. Perhaps surprisingly, we find that candidate funding and advertising prices explain most of the resulting advertising variation. Eliminating these asymmetries results in a nearly uniform distribution of advertising across states despite the rich underlying variation in voter preferences.

Our work contributes to several literatures. Early studies in political science primarily sought to explain observed resource allocations in the Electoral College (Friedman 1958; Brams and Davis 1974; Owen 1975; Colantoni et al. 1975). Related work considers how candidates allocate resources under more general conditions and in other forms of elections (Snyder 1989; Persson and Tabellini 1999; Lizzeri and Persico 2001). Our paper is distinct due to its empirical orientation, whereas these prior works are purely theoretical.

An important recent exception is Strömberg (2008), who examines empirically the interaction between a state's competitiveness and candidates' state visit decisions in the Electoral College. We, too, illustrate that the sharp influence of geographic variation in voter preferences on candidates' strategies is a consequence of the Electoral College. Furthermore, we show that candidates' strategies in a Direct Vote would primarily reflect two aspects of competition absent in Strömberg (2008)'s analysis: geographic variation in the costs of reaching voters (via advertising prices) and asymmetries in candidates' fundraising abilities.

Our paper's empirical strategy utilizes recent advances in industrial organization that integrate equilibrium concepts with econometric models. Although Strömberg (2008) recovers voter preferences and candidate uncertainty, he only utilizes variation in vote shares—candidates' choices are not explicitly leveraged in the econometric analysis. In contrast, we recover the parameters that guide candidate behavior using moments derived from their decision problems and evaluated at the observed advertising choices. Thus we apply an empirical games approach to elections in a manner similar to Bresnahan and Reiss (1991)'s study of firm entry, Berry et al. (1995)'s analysis of static pricing in differentiated products, and Ackerberg et al. (2006)'s estimation of production functions (see Ackerberg et al. 2007 for a general review). In Appendix A, we show that our empirical model of elections could be applied to a more general econometric model of competition in contests (Tullock 1980; Dixit 1987).[3]

The analysis of presidential elections also contributes to the economics of advertising. Much of the existing literature focuses on the mechanism behind advertising's influence on choice (see Bagwell 2007 for an overview), and a growing body of work examines the intersection between marketing and politics (Gordon et al. 2012). Structural econometric approaches often estimate the informative component of advertising (Ackerberg 2003; Goeree 2008), which may imply a welfare benefit from advertising.[4] We abstract away from such mechanisms to focus on competition in advertising. The focus of work on advertising competition to date has been on intertemporal allocation and long-run effects (Doraszelski and Markovich 2007). These issues are likely relevant in presidential campaigns, however the primary strategic dimension for candidates is geographic—in which markets and how much to spend. Thus, we extend the econometrics of advertising to the context of presidential elections, where the stakes are arguably more important than in many other applications.

2 Model

We develop a model of strategic interaction between presidential candidates in the general election. The game has two stages. First, candidates campaign in election t using advertising to influence voters' preferences. This campaign activity occurs in a single period as candidates $j = 1, \ldots, J$ form rational expectations about voter preferences and simultaneously choose advertising levels A_{tmj} across M media markets. A market is composed of a collection of counties $c \in C_m$, with each county populated by N_c voters. Advertising decisions are made at the market level, such that advertising is the same across counties within a market, $A_{tcj} = A_{tmj}, \forall c \in C_m$. In our application, we set $J = 2$ and ignore minor party candidates for simplicity.

Second, Election Day signifies the conclusion of campaigning. Voters treat candidates like products in a differentiated goods market: voters perfectly observe the demand shocks ξ_{tcj} and candidates' advertising choices, and then choose the candidate who yields the highest utility or opts not to vote. After voting outcomes across all

[3]The Electoral College is a nested contest where the final outcome depends on the weighted sum of binary outcomes across state-level contests. In this literature's terminology, the contest success function determines a player's probability of success as a function of all players' efforts (Skaperdas 1996). We construct an empirical contest success function using our estimates of voters' preferences and the structure of the candidates' game. To econometrically analyze such a contest, we present a computational approach to calculate the marginal effect of an agent's effort (e.g., funds directed towards advertising, R&D, lobbying, etc.). To the best of our knowledge, our work is among the first to estimate an empirical contest model. Appendix A provides more details.

[4]Although rich data exist to describe the informativeness and/or persuasiveness of political ads, the lack of an appropriate instrument makes it hard to identify their relative effects.

counties are realized, one candidate is deemed the winner. Following this approach necessarily assumes that voters do not consider the probability that their vote could be pivotal in deciding the election. This assumption seems reasonable given the extremely small probability that a voter will be pivotal in such a large election.

The model differs in an important way from standard equilibrium models of differentiated products in the industrial organization literature (e.g., Berry et al. 1995). Typically firms set prices to clear the market while observing the demand shocks ξ that influence consumers' decisions. In our setting, candidates must choose advertising levels before votes are cast and without perfect knowledge of ξ_{tcj}. As a result, candidates form beliefs over the demand shocks at the time of their advertising decisions.

2.1 Voters

A voter who resides in county $c \in C_m$ receives the following indirect utility for party j:

$$\begin{aligned} u_{itcj} &= \beta_{tj} + g\left(A_{tmj};\alpha\right) + \phi' X_{tc} + \gamma_{mj} + \xi_{tcj} + \varepsilon_{itcj} \\ &= \delta_{tcj} + \varepsilon_{itcj} \end{aligned} \tag{1}$$

where δ_{tcj} is the mean utility of the candidate. β_{tj} is the average national preference for a party in election t. We set $g(A_{tmj};\alpha) = \alpha \log\left(1 + A_{tmj}\right)$ to permit advertising to exhibit diminishing marginal effects.[5] X_{tc} is a vector of observables at the county or market level that shift voters' decisions to turnout or their decisions to vote for a particular candidate. γ_{mj} is a market-party fixed effect that captures the mean time-invariant preference for a party in a given market (e.g., Democrats consistently attract votes in Boston and similarly for Republicans in Dallas). ξ_{tcj} is an election-county-party demand shock that voters observe on Election Day but which is unobserved by candidates when they choose advertising. ε_{itcj} captures idiosyncratic variation in utility. If a voter does not turnout for the election, she selects the outside good and receives a utility of $u_{itc0} = \varepsilon_{itc0}$.

Assuming that $\left\{\varepsilon_{itcj}\right\}_j$ are i.i.d. extreme-valued shocks, integrating over them implies county-level vote shares of the form:

$$s_{tcj}(A, X, \xi; \theta^v) = \frac{\exp\left(\beta_{tj} + g\left(A_{tmj};\alpha\right) + \phi' X_{tc} + \gamma_{mj} + \xi_{tcj}\right)}{1 + \sum\limits_{k\in\{1,\ldots,J\}} \exp\left(\beta_{tk} + g\left(A_{tmk};\alpha\right) + \phi' X_{tc} + \gamma_{mk} + \xi_{tck}\right)} \tag{2}$$

where $\theta^v = \{\beta, \alpha, \phi, \gamma\}$ is the vector of voter parameters. Gordon and Hartmann (2013) explore a number of flexible specifications for voter demand, including

[5] Robustness checks with alternative forms do not indicate our results are sensitive to this particular assumption.

one with heterogeneous advertising preferences. However, since they do not find significant heterogeneity, we focus on the model above with homogeneous preferences.[6]

2.2 Candidates

We begin by discussing the details of the election mechanism, how candidates form beliefs over voting outcomes, and then present a candidate's objective function for advertising. We suppress the t subscript when possible since our model treats each election independently.

2.2.1 Election mechanism in the electoral college

The election mechanism dictates how individual-level votes are aggregated to select a winner. The Electoral College effectively tallies votes at the state level, in the form of electoral votes, to determine the winner of the general election. In general, the candidate who receives a plurality of a state's vote wins all of the state's electoral votes.

We observe county-level vote shares $s_{cj}(\cdot)$ across a collection of counties in M markets and S states. Since a state can contain multiple markets, let M_s be the set of markets that overlap state s and denote C_{ms} as the group of counties in market m and state s. A candidate's state-level vote count is

$$v_{sj}(A, X, \xi; \theta^v) = \sum_{m \in M_s} \sum_{c \in C_{ms}} N_c s_{cj}(A, X, \xi; \theta^v) .$$

Whether a candidate wins the state's electoral votes is given by

$$d_{sj}(A, X, \xi; \theta^v) = 1 \cdot \left\{ v_{sj}(A, X, \xi; \theta^v) > v_{sk}(A, X, \xi; \theta^v), \forall k \neq j \right\} \qquad (3)$$

A candidate wins the general election by obtaining a majority of the votes in the Electoral College,

$$d_j \left(A, X, \xi; \theta^v\right) = 1 \cdot \left\{ \sum_{s=1}^{S} d_{sj}(A, X, \xi; \theta^v) \cdot E_s \geq \bar{E} \right\} \qquad (4)$$

where E_s is the state's electoral votes and $\bar{E} = 270$ is the minimum number required for a majority.

Note that the function $d_j\ (A, X, \xi; \theta^v)$ completely encapsulates the rules of the election system. In Section 5 we show how to trivially modify $d_j(\cdot)$ to implement the Direct Vote counterfactual.

[6]Linking individual-level voter data to TV exposures is difficult but could potentially provide the means to recover heterogeneity in advertising responsiveness. Lovett and Peress (2015) combine multiple data sets to study the targeting of political TV advertising by presidential candidates.

2.2.2 Beliefs

The previous section specifies how votes are tallied on Election Day based on the realized values of the demand shocks ξ, which voters observe. However, as we discussed earlier, candidates choose advertising levels without perfectly observing these shocks. Prior to making their decisions, candidates gather information through campaign research and other sources about potential demand shocks in each county. This information allows candidates to form beliefs according to

$$\boldsymbol{\xi}_{cj} = \bar{\xi}_{cj} + \boldsymbol{\eta}_{mj}, \qquad \boldsymbol{\eta}_{mj} \sim N(0, \sigma^2)\,, \tag{5}$$

where $\bar{\xi}_{cj}$ is the expectation of the shock and σ represents candidates' ex-ante uncertainty. The bolded variables, $\boldsymbol{\xi}_{cj}$ and $\boldsymbol{\eta}_{mj}$, indicate that they are random variables from the candidates' perspectives. The shock $\boldsymbol{\eta}_{mj}$ enters at the market level, as opposed to the county, to be consistent with the level of candidates' advertising choices.[7]

The $\boldsymbol{\eta}_{mj}$ represent all unknown factors at the time candidates set advertising that will become known to voters on Election Day. Uncertainty over voting outcomes is an inherent feature of political contests: unexpected gaffes, surprising news stories, and the weather all contribute to candidates' uncertainty over voters' preferences on Election Day. For example, Gomez et al. (2007) find that rain differentially suppresses the turnout of one party. Since the market-party fixed effects absorb time-invariant unobservables, the realized value ξ_{cj} captures election-candidate-specific deviations, such as whether it actually rained in a county on Election Day.

2.2.3 Advertising decisions

Candidates choose advertising levels $A_j = \left[A_{1j}, \ldots, A_{mj}, \ldots, A_{Mj}\right]'$ based on the local marginal costs and benefits of advertising. The marginal cost of advertising is simply the local price of advertising faced by the candidate, ω_{mj}. To characterize the marginal benefit of advertising, consider the probability a candidate wins the election, which can be expressed as:

$$\begin{aligned}\mathbb{E}\left[d_j\left(A, X, \boldsymbol{\xi}; \theta^v\right)\right] &= \int_\eta d_j\left(A, X, \boldsymbol{\xi}; \theta^v\right) dF(\eta; \sigma)\\ &= \int_\eta d_j\left(A, X, \bar{\xi} + \eta; \theta^v\right) dF(\eta; \sigma)\,,\end{aligned}$$

where the expectation is taken over all markets and candidates. For now we suppress including σ as an argument on the left-hand side. The marginal effect of advertising in market m on the probability of winning the election is the derivative of $\mathbb{E}\left[d_j\left(A, X, \boldsymbol{\xi}; \theta^v\right)\right]$ with respect to advertising. Note that this quantity depends on

[7] We could generalize the specification of the shocks to allow for correlations across markets at the expense of an increased computational burden in estimation.

the specific election mechanism, voters' preferences, and candidates' uncertainty. A candidate's first-order conditions (FOCs) for advertising must satisfy

$$R_j \frac{\partial \mathbb{E}\left[d_j\left(A, X, \boldsymbol{\xi}; \theta^v\right)\right]}{\partial A_{mj}} \leq \omega_{mj}, \quad \text{for } m = 1, \ldots, M, \tag{6}$$

where R_j is a structural parameter that translates the probability of winning into dollar terms, placing both sides of the condition in equivalent units. Thus, the FOCs balance the value of an increase in the candidate's probability of winning the election relative to the marginal cost of one unit of advertising.

Below we show that R_j has a natural interpretation when a candidate's objective function is specified in a form consistent with work on either candidate resource allocation or contest theory. Both approaches yield advertising FOCs consistent with Eq. 6. We are agnostic as to the precise interpretation of R_j beyond its ability to reasonably guide advertising in different election regimes, as manifested in the particular form of $d_j(\cdot)$.

Competition with a budget constraint Suppose each candidate sets advertising to maximize his probability of winning subject to a budget constraint.[8] As in Strömberg (2008) and Shachar (2009), we do not specify an explicit model of budget formation. Unlike these papers, however, we do not assume the budget is exogenous. Instead the observed budgets in our model arise from the optimal allocation of resources among a pool of potential donors. Consider a candidate's constrained objective function:

$$\begin{aligned} \max_{A_j} \quad & \mathbb{E}\left[d_j\left(A, X, \boldsymbol{\xi}; \theta^v\right)\right] \\ \text{s.t.} \quad & \sum_{m=1}^{M} \omega_{mj} A_{mj} \leq B_j \end{aligned} \tag{7}$$

where B_j is the budget. Both the Lagrangian $\mathscr{L}_j(B)$ and its multiplier $\lambda_j(B)$ depend on all the budget levels $B = [B_1, \ldots, B_J]$ in the election due to the strategic interaction between candidates. At a solution, the associated FOC is

$$\frac{\partial \mathscr{L}_j(B)}{\partial A_{mj}} : \quad \frac{\partial \mathbb{E}\left[d_j\left(A, X, \boldsymbol{\xi}; \theta^v\right)\right]}{\partial A_{mj}} = \lambda_j(B)\, \omega_{mj} \quad \text{for } m = 1, \ldots, M. \tag{8}$$

Inspecting this FOC makes evident its equivalence with the FOC in Eq. 6. Suppose there exists a pool of representative donors each faced with the decision of whether to

[8] We refer to candidates using male pronouns throughout the paper because we analyze past elections and, at the time of this writing, the United States has yet to have a female candidate in the general election for president. Hopefully this changes in the future and potentially leads to a broader movement toward gender-neurtral pronouns (Petrow 2014).

allocate funds to the candidate's campaign or to an outside opportunity. Our assumed optimal allocation of donor resources implies that in equilibrium,

$$\lambda_j\left(B^*\right) = \frac{MU_I}{R_j}, \quad \text{for } j = 1, \ldots, J.$$

Normalizing the marginal utility of income MU_I to one, $1/R_j$ represents donors' opportunity cost of investing in the campaign relative to the utility they expect from the candidate winning. In equilibrium, donors contribute funds until the shadow price of an additional dollar, λ_j, is equal to $1/R_j$, yielding the set of optimal budgets $B^* = \left[B_1^*, \ldots, B_J^*\right]$. We assume aggregate campaign contributions are small relative to the broader philanthropic fundraising market, such that the return to donors' outside opportunities is invariant to the election mechanism and outcome.[9]

Thus, R_j is a policy-invariant parameter, independent of campaign fundraising, that we refer to as a candidate's financial strength. This specification provides a simple way to conceptualize the endogenous formation of the budget. For example, consider a policy change that alters d_j to some $\tilde{d}_j$. The previously optimal budgets B^* may imply that $\lambda_j\left(B^*; d\right)$ is greater or less than $1/R_j$ because the left-hand side of Eq. 8 changes (i.e., moving to $\tilde{d}_j$ changes the marginal benefit of advertising). Such an imbalance will result in a new set of efficient budgets $\tilde{B}^*$ that equate each $\lambda_j\left(\tilde{B}^*; \tilde{d}\right) = 1/R_j$.[10] Although explicitly modeling a more formal budget formation process is beyond the scope of this paper, this parsimonious specification allows us to relax the exogenous budget imposed in other work.[11]

Competition in a contest Another formulation for a candidate's objective function that is consistent with Eq. 6 draws on contest theory (e.g., Tullock 1980). Such models consider the following unconstrained problem where the candidate balances the value of winning against the total cost of advertising:

$$\max_{A_j} \pi_j\left(A; \theta\right) = R_j \mathbb{E}\left[d_j\left(A, X, \boldsymbol{\xi}; \theta^v\right)\right] - \sum_{m=1}^{M} \omega_{mj} A_{mj}\,, \tag{9}$$

where R_j is the value associated with candidate j winning.

[9] To the extent that the opportunity cost of funds is spending on other party activities or elections, it is possible that alterations to the election mechanism might shift the returns to donors' investments in these related funding opportunities.

[10] We do not consider a donor's expected utility from an election outcome and assume that R_j is invariant to the actual amount of money donated. This implies two features of donor behavior. First, the marginal utility of donor income must be independent of the amount they donate to the campaign. This is reasonable unless policy changes significantly alter the proportion of a donor's lifetime income that is offered to the campaign. Second, the expected utility from the candidate winning cannot be contingent on the amount donated. This assumption may be stronger because of common speculation that large donations earn political favors. Nevertheless, such issues are beyond the scope of the paper.

[11] Although building a complete model of endogenous budget formation is challenging, recent work by Urban and Niebler (2013) investigates the relationship between advertising and individual campaign donations.

Since the second term above is candidate j's total spending, scaling the first term by R_j converts the probability of winning into monetary terms. The key distinction relative to the objective in Eq. 7 is the lack of a budget constraint imposed on the candidate. The contest literature commonly refers to R_j as the "prize" of winning, e.g., Baron (1989) interprets R_j as the candidate's expected stream of benefits associated with winning office and any future election opportunities if successful.[12] In contests, such as elections, lobbying activities, and R&D races, participants expend resources no matter if they win or lose. An important component of such models is the contest success function which determines the probability of winning the prize given each participant's (sunk) effort. In our model, $\mathbb{E}\left[d_j(A, X, \boldsymbol{\xi}; \theta^v)\right]$ plays the equivalent role.

3 Data

Four sources of data are combined for the analysis. First, we use advertising spending by candidate in the top 75 markets, or designated media areas (DMAs), as collected by the Campaign Media Analysis Group (CMAG) and made available through the Wisconsin Advertising Project.[13] These markets account for 78 % of the national population. Second, to instrument for advertising levels in the voter model, we obtain data on the price of advertising across markets. Third, voting outcomes are measured at the county level. Fourth, we include a collection of control variables, drawn from a variety of sources, based on local demographics, economic conditions, and weather conditions on election day.

Table 1 presents descriptive statistics for many of the variables used in the analysis. Below we describe the key features of the data and refer the reader to Gordon and Hartmann (2013) for more details.

3.1 Advertising and instruments

We measure advertising as the average number of exposures a voter observes. The advertising industry commonly refers to this advertising measure as Gross Rating Points (GRPs), which is equal to the percent of the population exposed (reached) multiplied by the number of times each person was exposed (frequency). For example, 1,000 GRPs indicates that, on average, each member of the relevant population was exposed 10 times.

[12] These benefits could include the perceived monetary value of winning the election, the ability to implement policies consistent with the candidate's preferences, or simply the candidate's "hunger" for the office.

[13] The Wisconsin Advertising Project only tracked political advertising in the top 75 media markets in 2000 and the top 100 markets in the 2004 election. We use the 75 markets that are common to both years.

Table 1 Descriptive statistics: variables used in the voter model

	2000		2004	
	Mean	Std. Dev.	Mean	Std. Dev.
Market-Level Variables				
Republicans				
GRPs	5.82	5.59	7.81	10.44
Expenditures	879.84	1,218.73	1,123.76	1,863.43
CPMs	8.07	2.07	7.78	2.21
Democrats				
GRPs	4.78	5.67	9.73	12.81
Expenditures	681.53	1,072.94	1,349.32	2,207.18
CPMs	8.11	2.12	7.73	2.08
Lagged CPM				
Early Morning	4.18	0.95	5.47	1.55
Day Time	4.85	1.11	4.89	1.08
Early Fringe	5.88	1.45	6.67	1.34
Early News	6.26	1.63	7.93	1.73
Prime Access	7.06	1.91	10.41	2.54
Prime Time	12.37	3.47	16.17	4.66
Late News	8.50	2.10	12.26	2.56
Late Fringe	7.18	1.81	8.30	1.94
% Identifying Republican	0.29	0.06	0.33	0.06
% Identifying Democrat	0.30	0.05	0.31	0.06
County-Level Variables				
Republican Votes	23,721	51,787	29,349	63,178
Democrat Votes	25,639	77,929	29,785	89,030
Rain (in.)	0.20	0.27	0.28	0.51
Snow (in.)	0.08	0.40	0.02	0.12
% Aged 25 to 44	0.38	0.05	0.34	0.05
% Aged 45 to 64	0.32	0.03	0.33	0.03
% Aged 65 and up	0.19	0.05	0.19	0.05
Unemployment Rate	4.09	1.56	5.61	1.66
Average Salary (thous.)	24.99	6.63	27.92	6.93
Distance*100 (miles)	9.49	4.11	9.49	4.11

County-level variables have 1,607 observations and market-level variables have 75 observations per year and party. All averages are unweighted. Lagged CPM refers to the one-year lagged cost-per-thousand (CPM) impressions for a particular daypart, reported in dollars. % identification variables come from the pooled NAES surveys

Our advertising data contain detailed information about each political advertisement (see Freedman and Goldstein 1999 for details). Ads are sponsored by either the candidate, the national party, a hybrid candidate-party group, or an independent interest group. We consider all ads supporting a candidate regardless of their sponsor and focus on ads that aired after September 1, the unofficial start of the general election.[14]

[14]Presidential campaign strategies are coordinated across the candidate, national party, and related groups. In theory, laws prohibit independent interest groups from explicit coordination with candidate, however, in practice, the effectiveness of these restrictions is unclear (Garrett and Whitaker 2007). Given this, it is appropriate to treat all advertising funds spent in support of a candidate as if it were controlled by one entity.

The data from CMAG do not contain GRPs. Instead we use CMAG's estimate of an ad's cost divided by an estimate of its cost-per-point (CPP) to impute the ad's GRPs. For each ad, we match it to a CPP for one of eight day parts (time slots) in a market using data from SQAD, a market research firm. The CPP's also serve as the basis on which we calculate ω_{mj} for use in the candidate model. Next we aggregate across all dayparts and sponsors to calculate A_{mj}, the total number of GRPs (exposures) supporting a candidate in a market, which is our focal advertising quantity. Appendix B contains more details on the construction of advertising levels and their prices.

Figure 1 plots state-level GRPs against a state's vote margin and illustrates the strategic allocation of advertising across markets. The winner-take-all rule in the Electoral College creates sharp incentives for candidates to concentrate their advertising in battleground states. In some markets with large vote margins, candidates do not advertise at all. The breadth of advertising across vote margins in Fig. 1 reveals the degree of candidate uncertainty about eventual voting outcomes. Advertising observed in a state with a significant vote margin suggests a candidate might have been better off moving those funds to a state at the (ex-post) margin of zero to potentially shift the state's outcome. Thus, ex-ante uncertainty about outcomes allows our model to rationalize candidate spending in states with large realized vote margins.

Our model of candidate advertising competition posits that candidates choose advertising strategically across markets based on their expectations of the demand shocks ξ_{cj}. Consequently, for the purpose of estimating the voter model, we must address the endogeneity of advertising. A variable naturally excluded from the demand side that enters each candidate's decision problem is the price paid for advertising. The market-party fixed effects, γ_{mj}, absorb time-invariant market-level variation in mean preferences and account for the fact that advertising prices and political preferences tend to be spuriously correlated across markets (e.g., expensive media markets tend to be larger and more liberal). Thus, the instruments are necessary to address any time-varying unobservables that could affect candidate and voter decisions. Given this within-market identification, we require that changes in advertising prices between elections are conditionally independent of voters' preferences. Such changes might arise from local demand shocks to commercial advertisers or from natural variation in TV show ratings (e.g., entry/exit of shows) that should be unrelated to the political climate but will still affect local advertising prices.

However, particular realizations of these unobservable demand shocks could induce a candidate to purchase enough advertising to alter the market clearing price, violating the independence assumption required for a valid instrument. Stories in the popular press confirm the suspicion that large advertisers, such as presidential candidates, can shift a market's advertising prices (Associated Press 2010). To avoid this concern, we use the prior year's advertising price (i.e., 1999 for 2000 and 2003 for 2004) because there are no major political elections in odd-numbered years. Specifically, we use the lagged cost-per-thousand impressions (CPMs) by market-daypart. CPMs express CPPs on a per impression basis and are a more relevant cost metric for an advertiser deciding how many voters to reach. We further interact the lagged CPMs with candidate dummies because candidates purchase advertising in

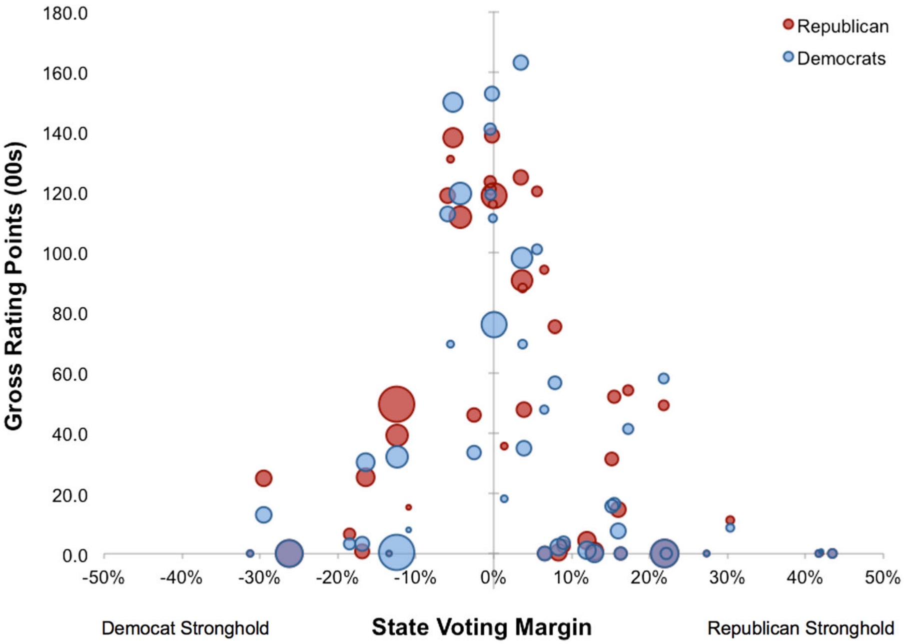


Fig. 1 GRPs by state-level voting margin in 2000 election: horizontal axis is the state-level Republican vote share minus the Democrat vote share. Vertical axis is in hundreds of GRPs, such that one unit indicates one exposure per voter, on average. *Bubbles* are proportional to the state's voting-age population

different mixes of dayparts across markets. The CPMs in Table 1 are a weighted average across dayparts, with weights equal to a candidate's share of advertising in that market-daypart.

It is important to note that errors in our imputed GRPs could arise from errors in CMAG's cost estimates and/or SQAD's CPP estimates. The price an advertiser pays for a slot depends on the terms of purchase, which includes preemption rights and volume discounts for large campaigns. The terms in these contracts potentially differ depending on the type of sponsor purchasing the political ads.[15] We do not observe any of these contractual details and this could lead to measurement errors in our GRP

[15]The price of political advertising in the 60-days prior to the general election is subject to laws which require the station to offer the purchaser the lowest unit rate (LUR). The LUR applies to all the terms of the advertising contract, including the priority or preemption level of the ad. This implies it is possible for a political ad to be preempted by a TV station if another advertiser is willing to pay more for a higher priority ad. If an ad is bumped, the TV station is required to deliver the contracted amount of GRPs within a specific time frame (e.g., 24 hours), allowing them to substitute less desirable slots for the original slot. The LUR is only available to candidates, whereas independent groups must pay the market rate. According to the former president of CMAG, well-financed candidates in competitive races rarely pay the LUR for a preemptible slot because they want to avoid the possibility that their ads will be bumped by another advertiser (such as another candidate).

estimates.[16] Our reliance on instrumental variables should help to avoid any attenuation bias in estimating the voter model. It is possible, however, that if our estimates of candidate's expenditures are inaccurate, this could translate into biased estimates of the candidate parameters R_j. Although we cannot resolve this issue or test for its existence, we do not expect such bias to change the cross-market distribution of advertising, which is our primary emphasis.

3.2 Votes and controls

County-level votes in 2000 and 2004 come from www.polidata.org and www.electiondataservices.com. We restrict the analysis to the 1,607 counties contained in the 75 DMAs for which we observe advertising. When estimating the candidate model and analyzing counterfactual policies, voting behavior is held fixed in counties representing the remaining 22 % of the population. In each county, we observe the total number of votes cast for all candidates and the voting-age population (VAP). The VAP serves as our market size for the county, which we use to calculate voter turnout (i.e., the percentage of voters who choose the inside option to vote for any candidate).[17]

To help explain additional variation in voting outcomes and to account for other potential correlations between unobservables and instruments, in X_{tc} we include the following groups of covariates: (1) variables that measure local political preferences, (2) variables that affect voter turnout but not candidate choice, and (3) demographic and economic variables.

First, data from the National Annenberg Election Surveys (NAES) in 2000 and 2004 measures the percentage of voters in a market who identify as Democrat or Republican. These data capture variation in preferences across parties, and hence candidates, within a market. We include interactions between the Democrat and Republican choice intercepts and the two party identification variables to allow for asymmetric effects across parties. We also include an indicator for whether the incumbent governor's party is the same as the presidential candidate.

Second, we include two types of variables that should solely affect voters' decisions to turnout. Gomez et al. (2007) show that weather can affect turnout in presidential elections, and so we include county-level estimates of rain and snowfall on Election Day in both years. The other variable is a dummy to indicate if a Senate election occurs in the same market and year, because strongly contested Senate races could spur additional turnout for the presidential election.

Third, we add a set of demographic and economic variables for each election year to control for unobserved changes in these conditions which could be correlated with within-market changes in voter preferences and the advertising instruments. We

[16] In 2012, the Federal Communications Commission (FCC) adopted new rules that required major TV broadcast networks in the top 50 markets to make publicly available electronic copies of all political advertising files. This includes the advertising contracts and their terms of purchase. Until this point, obtaining such contracts was extremely difficulty: Hagen and Kolodny (2008) had to visit each station in one market to collect hardcopies of the relevant files.

[17] A more accurate measure of turnout is the voting-eligible population (VEP) because it removes non-citizens and criminals. However, data on the VEP is only available at the state level.

use the county-level percentage of the population in three age-range bins (e.g., 25 to 44) from the Census, the county-level unemployment from the Bureau of Labor Statistics, and the county-level average salary from the County Business Patterns. Interactions between each candidate's choice intercepts and the demographic and economic variables capture differences across parties in voters' responses to these conditions.

4 Estimation

This section applies our model of advertising competition to data from two elections. Estimating the voter model is a straightforward application of work in aggregate discrete choice (Berry 1994), and so this section focuses on our estimation and identification strategy of the candidate parameters $\theta^c = \left\{R_{tj}, \sigma_t\right\}$.

The candidate model is estimated conditional on the estimated parameters and residuals from the voter model. To explain our estimation and identification strategy, it is helpful to summarize the voter model by candidates' advertising choices, the parameter guiding advertising effectiveness, α, yet to be determined shocks, η, and everything else. These remaining factors can be expressed as a vector $\bar{\delta}$ which is the exclusive determinant of candidates' pre-advertising expected vote shares. Specifically, the vector is composed of the county-party specific elements:

$$\bar{\delta}_{cj} = \delta_{cj} - g(A_{mj}; \alpha) + (\bar{\xi}_{cj} - \xi_{cj}),$$

which adjusts δ_{cj} by removing the effect of observed advertising and replaces the realized shock, ξ, with a candidate's beliefs about it using Eq. 5. Note that all the data in X and the voter parameters (β, ϕ, γ) are implicitly included in $\bar{\delta}$. We use this new notation to modify the arguments of the election mechanism,

$$d_j(A, X, \boldsymbol{\xi}; \theta^v) \equiv d_j\left(A, \bar{\delta}, \boldsymbol{\eta}; \alpha\right),$$

because estimating the candidate model relies heavily on calculations involving A and $\boldsymbol{\eta}$ while holding fixed the quantities inside $\bar{\delta}$. Lacking data on candidates' expectations, we assume $\bar{\xi} = \xi$, such that candidates' beliefs are centered on the realized values.[18]

4.1 Estimating the candidate model

To estimate the candidate model, we form moments based on the FOCs of the candidates' decision problem.[19] We decompose the marginal cost into two components: w_{mj}, the observed CPM (summarized in Table 1) and an unobserved component v_{mj}.

[18]It is impossible to recover candidate's expectations of these shocks in the candidate-side estimation because there are at least as many shocks as advertising observations.

[19]We assume the collection of observed advertising choices constitute a pure-strategy equilibrium of the advertising competition game. Although the model may possess multiple equilibria, our estimation strategy does not require us to solve the equilibrium.

This allows us to write a candidate's FOC as:

$$R_j \frac{\partial \mathbb{E}\left[d_j\left(A, \bar{\delta}, \boldsymbol{\eta}; \alpha\right) | \sigma\right]}{\partial A_{mj}} \leq \omega_{mj} = w_{mj} + v_{mj} \,.$$

Candidates observe v_{mj}, but the econometrician does not. This error term forms the basis of our estimation strategy.

Consider first markets with positive advertising, such that a solution to the candidate's FOCs exists and we can recover the econometric unobservable,

$$R_j \frac{\partial \mathbb{E}\left[d_j\left(A, \bar{\delta}, \boldsymbol{\eta}; \alpha\right) | \sigma\right]}{\partial A_{mj}} - w_{mj} = v_{mj} \,. \tag{10}$$

Given a suitable set of instruments z that satisfy $\mathbb{E}[v|z] = 0$, we could form an estimator around this moment. However, the equality above does not hold when observed advertising $A^*_{mj} = 0$. One solution is to drop these observations. Apart from reducing estimation efficiency, the more serious concern is that dropping markets with zero advertising might invalidate the moment condition because $\mathbb{E}[v|z, A > 0] = 0$ does not generally hold (Pakes et al. 2015). For instance, a sufficiently large draw of ν_{mj} could lead a candidate to avoid advertising in a market. If such a "selection on unobservables" were common in our data, dropping markets with zero advertising could be problematic.

The severity of this issue depends on your beliefs about the importance of v_{mj}, which we argue is unlikely to be a problem in our specific context. In our data, the observed marginal costs w_{mj} are SQAD's forecasts for the election season. The v_{mj} represent deviations between these forecasts and candidates' actual advertising costs. The nature of these measurement errors suggests it is unlikely they could shift a candidate's decision to enter or avoid a market. The decision not to advertise in a market is primarily due to demand-side shocks which, through the structure of the Electoral College, reduce the incentives of candidates to advertise in non-battleground states. We recover the demand-side shocks ξ_{cj} using revealed preferences in the voter model. The lack of selection on v_{mj} deviations between forecasted ad prices and candidates' actual advertising costs is reasonable in that candidates likely only observe realizations of v_{mj} *after* committing to advertising in a market.[20]

Based on the discussion above, we assume $\mathbb{E}[v|z, A > 0] = 0$, such that estimation relies on the following moment condition:

$$\mathbb{E}\left[\left(R_j \frac{\partial \mathbb{E}\left[d_j\left(A, \bar{\delta}, \boldsymbol{\eta}; \alpha\right) | \sigma\right]}{\partial A_{mj}} - w_{mj}\right) | z_{mj}, A_{mj} > 0\right] = 0 \,.$$

[20]The unobserved cost shock therefore absorbs any other differences between the observed choices and the model, such as differences across markets in the degree of uncertainty about outcomes. Note that including the structural error v_{mj} on the demand side, such as entering in the marginal effect of advertising, is difficult because the non-linearities in $d_j(\cdot)$ prevent inversion of an additively linear error term.

Let M_j^+ denote the set of markets in which a candidate advertises and set $M^+ = \sum_j M_j^+$. The relevant sample moment is

$$m(\theta) = \frac{1}{M^+} \sum_{j=1}^{J} \sum_{m=1}^{M_j^+} \left[\left(R_j \frac{\partial \mathbb{E}\left[d_j \left(A^*, \bar{\delta}, \boldsymbol{\eta}; \alpha \right) | \sigma \right]}{\partial A_{mj}^*} - w_{mj} \right) \otimes g(z_{mj}) \right],$$

where $g(\cdot)$ is any function and $\otimes$ is the Kronecker product. We discuss the instruments used for z_{mj} in the next subsection.

Calculating the marginal effect of advertising, $\frac{\partial \mathbb{E}\left[d_j(A,\bar{\delta},\boldsymbol{\eta};\alpha)|\sigma\right]}{\partial A_{mj}}$, is challenging because the expectation involves an $M^+ \times J$ dimensional integral in the market-candidate specific shocks $\boldsymbol{\eta}_{mj}$ and $d_j(\cdot)$ is non-differentiable in A_{mj}. Calculating the derivative using Monte Carlo integration $\mathbb{E}\left[d_j(\cdot)\right]$ in conjunction with finite differences will be imprecise because small deviations from a given A_{mj} are unlikely to shift the election outcome in $d_j(\cdot)$. Larger steps around a given A_{mj} could be used, but this increases the bias of the finite difference estimate of the derivative. For a given realization of $\left\{\boldsymbol{\eta}_{mj} : m \in M^+, j \in J\right\}$, the derivative is only non-zero when a small amount of advertising can alter the election outcome, i.e., $d_j(\cdot)$ changes. We develop an approach to calculate the derivative that takes advantage of this tipping point and reduces the effective dimensionality of the integration.

For a particular candidate j and market m in state s, two conditions define a tipping point for $d_j(\cdot)$. First, the number of electoral votes the candidate can gain (lose) in s, E_s, must surpass the candidate's national electoral vote deficit (surplus) outside state s. This condition is necessary because otherwise the election's outcome is invariant to state s's outcome. Second, within s, the candidate's vote advantage within market m must equal the candidate's vote deficit outside the market (i.e., across other markets within the state). That is, the candidate needs to be able to win enough votes in market m in order to tip the entire state and in turn garner enough electoral votes to shift the entire election's outcome. These two conditions define a tipping point in a market and are the basis of our computational strategy.

Appendix A provides more details and illustrates how the method could generalize to other contests or goals that involve multidimensional effort.

4.2 Identification

There are six candidate parameters to identify: an R_j for each party in 2000 and 2004 and a σ for each year.

Identification of candidate uncertainty σ relies on systematic variation in advertising levels across states with varying levels of pre-advertising expected vote margins. Intuitively, if a candidate expects a state to have a large vote margin in the opponent's favor, the candidate would only advertise if the variance of the demand shocks was large enough to generate a reasonable probability of tipping the state. Similarly, a candidate expecting to win a state would only advertise under the belief that a large negative demand shock might flip the state's outcome to favor the opponent. Candidate's pre-advertising expectations are summarized by $\bar{\delta}$. If we could observe $\bar{\delta}$, it would be an ideal instrument to identify σ. Instead we use a pre-advertising measure of expected voting margins published by Cooks Political Report as the instrument.[21] With the further assumption above that candidates expectations are centered at the eventual outcomes, $\bar{\xi} = \xi$, identification of σ can be illustrated through Fig. 1's depiction of candidates' willingness to advertise in ex-post uncontested markets.

Note that σ also influences average spending levels because the incentive to advertise is diminished if candidates' believe outcomes to be nearly random (σ approaching infinity) or known with certainty ($\sigma \approx 0$). However this role is limited because σ only operates through $\partial \mathbb{E}\left[d_j\left(A, \bar{\delta}, \boldsymbol{\eta}; \alpha\right)|\sigma\right]/\partial A_{mj}$ which is bound between zero and one.

The identification of R_j is illustrated in the FOC in Eq. 10, where the parameter guides how much each candidate is willing to advertise. Specifically, the larger is R_j, the more a candidate can advertise and hence reduce the marginal effect of advertising on winning, $\partial \mathbb{E}\left[d_j\left(A, \bar{\delta}, \boldsymbol{\eta}; \alpha\right)|\sigma\right]/\partial A_{mj}$, relative to the dollar-denominated marginal costs of advertising. Candidate intercepts therefore serve as instruments to recover R_j based on candidates' average advertising levels across markets. R_j also serves as a slope coefficient on $\partial \mathbb{E}\left[d_j\left(A, \bar{\delta}, \boldsymbol{\eta}; \alpha\right)|\sigma\right]/\partial A_{mj}$ in the FOC, so it can scale advertising in more or less contested markets, but, unlike σ, it is excluded from influencing $\partial \mathbb{E}\left[d_j\left(A, \bar{\delta}, \boldsymbol{\eta}; \alpha\right)|\sigma\right]/\partial A_{mj}$.

It is useful to contrast our identification strategy with the approach in Strömberg (2008). Whereas we use FOCs from the game to recover candidate parameters, Strömberg (2008) does not estimate any parameters using moments derived from the equilibrium of the game. In his analysis candidates' decisions are uninformative of their uncertainty about election outcomes. Instead the empirical analysis recovers candidate uncertainty as the variances from a time random-effects regression of state-level Democrat vote shares against various observables (e.g., polls, GDP growth, etc.). Uncertainty is therefore identified solely through variation in vote shares. Although this variation may be related to a candidate's uncertainty, such variation would exist even if candidates had perfect foresight regarding voting outcomes.

4.3 Parameter estimates

We begin by presenting estimates from the voter model. The voter parameters $\theta^v = (\beta, \alpha, \phi, \gamma)$ are estimated using 2SLS, and we take those parameters as given when estimating the candidate model. Identification of θ^v follows from standard arguments when estimating aggregate market share models. To identify the advertising coefficient, the instruments are one-year lagged advertising prices per 1,000 voters (CPMs) at the market-daypart level, interacted with year and party dummies.

It is useful to reflect on the sources of variation in the lagged advertising prices to understand their validity as instruments. Advertising prices change in response to changes in the composition and attractiveness of a TV program's audience to commercial advertisers. Although such changes are correlated with audience demographics, commercial advertisers use fundamentally different metrics to determine an audience's value relative to political advertisers, and hence such advertising price variation should serve as a valid instrument.

[21] www.cookpolitical.com

Table 2 presents parameter estimates from the voter model. The advertising coefficient is positive and highly significant, and the average own-advertising elasticity is about 0.03. To help interpret the demand estimates, we compare our advertising

Table 2 Voter model estimates

	Coefficient	Std. Err.
Candidate's Advertising	0.0693**	0.0159
Senate Election	0.0134	0.0098
Gov. Incumbent Same Party	0.0090	0.0106
Rain (in.)	0.0300	0.0293
Rain $\times$ 2004	-0.0201	0.0285
Snow (in.)	-0.0108	0.0072
Snow $\times$ 2004	-0.2210**	0.0606
Distance*100 (miles)	0.0036	0.0025
% $25 \leq$ Age < 44	-0.7317**	0.2186
% $25 \leq$ Age $< 44 \times 2004$	-1.2942**	0.1987
% $25 \leq$ Age $< 44 \times$ Republican	0.9047*	0.3535
% $45 \leq$ Age < 64	3.7490**	0.3345
% $45 \leq$ Age $< 64 \times 2004$	0.3468	0.2247
% $45 \leq$ Age $< 64 \times$ Republican	1.6595**	0.5279
% $65 \leq$ Age	0.1538	0.3771
% $65 \leq$ Age $\times$ 2004	-1.6048**	0.1700
% $65 \leq$ Age $\times$ Republican	1.6091**	0.5254
% Unemployment	0.0019	0.0108
% Unemployment $\times$ 2004	0.0101*	0.0050
% Unemployment $\times$ Republican	-0.1229**	0.0123
Average Salary	0.0161**	0.0020
Average Salary $\times$ 2004	0.0038**	0.0007
Average Salary $\times$ Republican	-0.0195**	0.0024
Fixed Effects		
Party	Y	
Year-Party	Y	
DMA-Party	Y	

Parameter estimates from the two-candidate voter model with 6,428 observations estimated using 2SLS. Robust standard errors clustered by DMA-Party are in parentheses. F-stat of excluded instruments is 88.2. '*' significance at $\alpha = 0.05$ and '**' significance at $\alpha = 0.01$. Some coefficients omitted due to space

Table 3 Candidate model estimates: standard errors in parentheses

Parameters	σ	R_j (\$M)	Observed Spending (\$M)
2000 Bush	0.15 (0.040)	128.6 (11.014)	66.0
2000 Gore		86.1 (3.502)	51.1
2004 Bush	0.307 (0.004)	289.9 (6.400)	84.3
2004 Kerry		264.0 (5.443)	101.2

effects to findings from regular product categories and to those obtained in similar political settings. In consumer goods, our estimate is slightly lower than the median advertising elasticity of 0.05 that Sethuraman et al. (2011) report based on a meta-analysis. The closest study for comparison is Huber and Arceneaux (2007), which examines the 2000 presidential election and reports that an extra 1,000 GRPs of TV advertising increases a candidate's vote share by 2 % to 3 %. Our estimates imply such an increase in advertising yields an extra 1.5 % to the vote share.[22]

Table 3 presents the parameter estimates from the candidate model. Standard errors are calculated using the standard formula for GMM, but we ignore the uncertainty in the first-stage parameter estimates. In 2000, Bush outspent Gore by 29 %, and the corresponding R_j estimates imply that Republicans had a 49 % greater financial strength. In 2004, overall spending increased and Kerry outspent Bush, yet Bush's R_j is slightly higher than Kerry's. Bush's lower spending level may reflect reduced advertising incentives in this less contested election rather than weaker financial support.

Election uncertainty in 2004 is double that in 2000. To explore the degree of candidate uncertainty, we first consider the implications for state outcomes in the 2000 election. Figure 2 presents candidates' beliefs about the likelihood of a Republican victory in each state. The shaded bars represent those states in which each candidate has at least a 10 % chance of winning. Among these, we see well-known battleground states such as Florida, Nevada, New Mexico, Ohio, Pennsylvania, and Wisconsin. The variation in state outcomes translates into a distribution of electoral vote margins depicted in purple for 2000 in Fig. 3. Although the distribution is centered around zero because of the closeness of this election, the standard deviation is about 50 electoral votes, indicating a reasonable degree of uncertainty over the election outcome. The distribution of electoral vote margins for 2004 is depicted in red. The distribution is wider with a standard deviation of 77, but Bush's dominance over Kerry is apparent in the strong rightward shift. Kerry's likelihood of winning was about 16 %, compared to a 46 % chance for Gore to win in the 2000 election.

[22] Gerber et al. (2011) find somewhat larger effects using a randomized experiment in the 2006 Texas gubernatorial campaign.

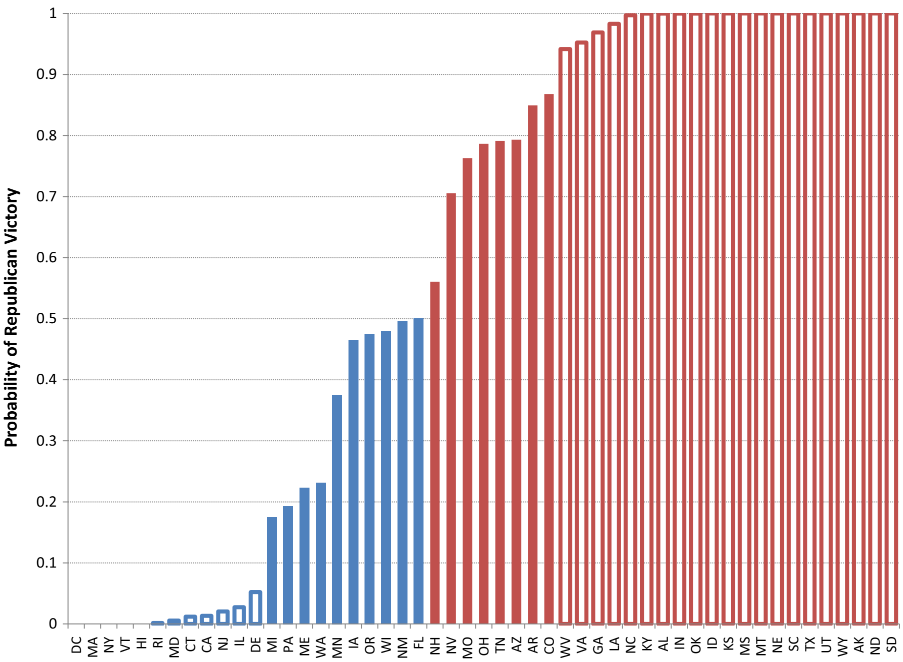


Fig. 2 Candidates' beliefs by state in 2000: *each bar* represents the probability that the Republican candidate will win a majority of a state's popular vote. *Shaded bars* indicate those states in which each candidate has at least a 10 % chance of winning

5 Counterfactuals

We implement a Direct Vote (DV) counterfactual in which the candidate with the most popular votes is deemed the winner. Although other Electoral College reforms

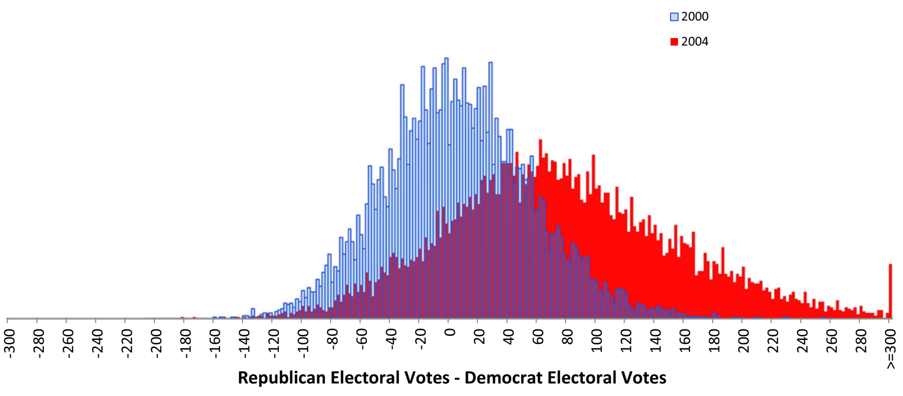


Fig. 3 Candidates' beliefs about the distribution of electoral vote margins. Simulated distribution of electoral vote margins given candidates' estimated beliefs

have been considered, such as the proportional allocation of Electoral College votes, a DV has come the closest to being passed (Congressional Research Service 2009). Conducting such a counterfactual allows us to understand how candidates reallocate their attention (e.g., advertising dollars) under a new electoral process. We begin by specifying how the DV alters the marginal effect of advertising. Then we consider a series of counterfactuals. The first counterfactual only alters the election mechanism by changing $d_j(\cdot)$. Factors such as candidates' other campaign activities (e.g., get-out-the-vote efforts) and voters' preferences over their policy positions are held fixed in the local mean utility net of advertising, defined earlier as $\bar{\delta}$. In addition to changing $d_j(\cdot)$ to be a Direct Vote, we consider additional counterfactuals that remove two factors that affect competition between candidates: asymmetries in the candidates' financial strength and advertising price variation across markets.

5.1 Direct vote model

To implement the Direct Vote, we modify the election mechanism represented by $d_j(\cdot)$. The total number of popular votes a candidate receives is across all markets (and states) is:

$$\tilde{v}_j(A, X, \xi; \theta^v) = \sum_{m \in M} \sum_{c \in C_{ms}} N_c s_{cj}(A, X, \xi; \theta^v) .$$

With $J = 2$, candidate j wins the election if his vote count exceeds the opposing candidate's votes,

$$\tilde{d}_j \left(A, X, \xi; \theta^v\right) = 1 \cdot \left\{\tilde{v}_j(A, X, \xi; \theta^v) > \tilde{v}_k(A, X, \xi; \theta^v)\right\} .$$

The Direct Vote objective function is

$$\tilde{\pi}_j(A; \theta) = R_j \mathbb{E}\left[\tilde{d}_j \left(A, \bar{\delta}, \boldsymbol{\eta}; \alpha\right) |\sigma\right] - \sum_{m=1}^{M} \omega_{mj} A_{mj} , \tag{11}$$

where $\tilde{d}_j$ is once again expressed in terms of the pre-advertising determinant of expected outcomes, $\bar{\delta}$, and the random variable $\boldsymbol{\eta}$. The new FOC for advertising of

$$R_j \frac{\partial \mathbb{E}\left[\tilde{d}_j \left(A, \bar{\delta}, \boldsymbol{\eta}; \alpha\right) |\sigma\right]}{\partial A_{mj}} \leq \omega_{mj} , \quad \text{for } m = 1, \ldots, M. \tag{12}$$

We again rely on our approach to calculating the marginal benefit of advertising discussed more fully in Appendix A. To compute the equilibrium, we solve for the 150 advertising choices that simultaneously set $J \cdot M$ FOC's to zero.[23] Thus, we

[23] In the counterfactuals, we set the supply-side cost residuals v_{mj} to zero because we do not expect these shocks to carry over from the Electoral College to the Direct Vote. As explained in Appendix B, we also remove all other cross-candidate within-market differences in advertising costs, such that $\omega_{mj} = w_m$. Note that these residuals contain both the unobserved cost shocks and any errors in a candidates' estimate of winning the election. Large residuals in some markets tend to be correlated within a state (e.g., the estimated $\hat{v}_{mj}$ are larger for Bush in all California DMAs in 2000), possibly due to a forecast error in the candidate's belief about winning the state. However, since state boundaries are meaningless in a Direct Vote, such errors should not persist in our counterfactual.

Table 4 Comparison of observed and counterfactual results in 2000 and 2004: list of battleground states taken from Cook's Political Report. Votes from third parties are included to calculate voter turnout, although third-party candidates are not explicitly included in the model

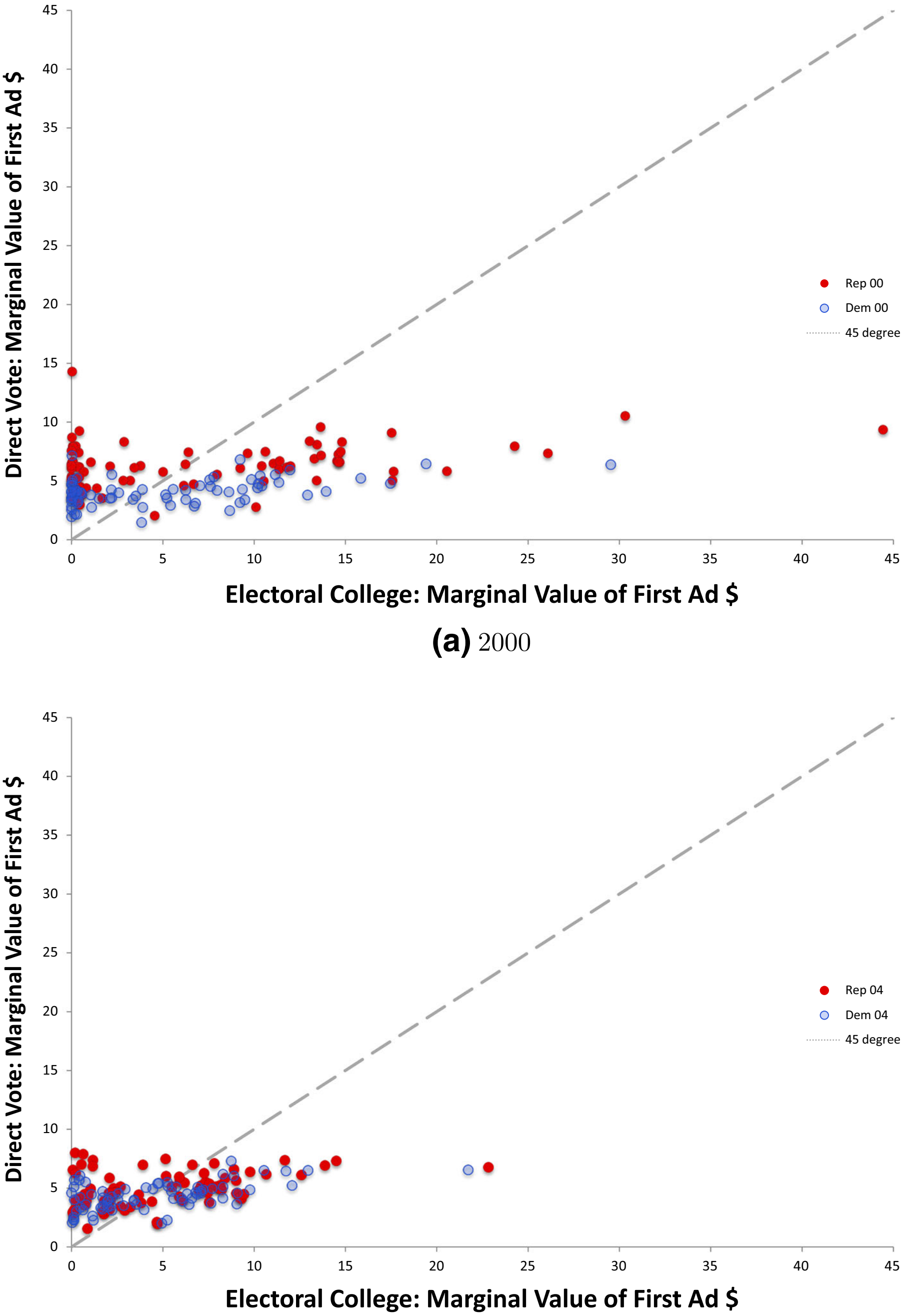
	2000				2004			
	Observed		Direct Vote		Observed		Direct Vote	
	Bush	Gore	Bush	Gore	Bush	Kerry	Bush	Kerry
Advertising								
Total Spending (m)	117.10		132.26		185.48		85.34	
Spending (m)	65.99	51.11	80.07	52.19	84.28	101.20	43.97	41.36
Avg. Exposures	90.68		103.35		138.51		64.89	
Std. Dev. of. Exp.	109.78		37.15		231.35		26.07	
Avg. Exposures (K)	50.53	40.15	62.74	40.62	61.27	77.25	33.75	31.14
Avg. Exposures in								
Battleground	115.14	108.59	71.96	45.82	158.81	204.31	41.46	37.37
Non-battleground	29.89	18.29	59.79	38.95	30.32	36.94	31.31	29.16
Voting								
Votes (m)	50.46	51.00	51.45	51.84	61.85	58.92	62.66	59.09
Vote Margin (m)	-0.54		-0.39		2.93		3.57	
% Voter Turnout	50.51		51.39		55.22		55.67	

compute the equilibrium by solving the system below for the advertising levels,

$$R_j\left[\frac{\partial\mathbb{E}\left[\tilde{d}\left(A,\bar{\delta},\boldsymbol{\eta};\alpha\right)|\sigma\right]}{\partial A_{mj}}\right]-\omega_{mj}\leq 0,\;\; A_{mj}\geq 0,\;\text{for } m=1,\ldots,M \text{ and } j=1,2 \tag{13}$$

imposing a set of complementarity conditions between the FOCs and the advertising choice variables to allow for zero advertising outcomes when the FOC is non-binding. Since the pure-strategy equilibrium in the counterfactual may not be unique, we use multiple starting points and check that the resulting solutions to the complementarity problem above are the same. Existence of a pure-strategy equilibrium follows from basic results because a candidate's objective is continuous and quasi-concave in the own advertising variables.

Before turning to the counterfactual equilibrium, it is useful to contrast the incentives under the Electoral College and Direct Vote. Their divergence is illustrated by comparing the marginal value of the first dollar of advertising in each market across the two election mechanisms. This quantity is calculated as $R_j\frac{\partial\mathbb{E}[d(A,\bar{\delta},\boldsymbol{\eta};\alpha)]}{\partial A_{mj}}/w_m$ in the Electoral College and as $R_j\frac{\partial\mathbb{E}[\tilde{d}(A,\bar{\delta},\boldsymbol{\eta};\alpha)]}{\partial A_{mj}}/w_m$ in the Direct Vote. Figure 4 plots the values for Electoral College on the horizontal axis and for the Direct Vote on the vertical axis for the two elections. The marginal value of advertising in the Direct Vote is nearly flat compared to the broad variation of marginal values in the Electoral College. The 45° line delineates the clear reduction in incentives in the battleground states (below the line and to the right) and the increased advertising incentives in formerly uncontested markets (above the line and to the left).



(a) 2000

(b) 2004

Fig. 4 Marginal value of first advertising dollar in electoral college and Direct Vote

5.2 Advertising in a Direct Vote

Table 4 summarizes the counterfactual equilibrium and compares outcomes to those in the Electoral College. In 2000, a Direct Vote leads candidates to expand their advertising campaigns to include all markets. The standard deviation of advertising exposures per voter across markets drops by 66 % from 110 to 37 exposures per voter. In battleground states, average exposures decrease by 37 and 58 % for the Republicans and Democrats, respectively, and more than double in other markets. On average, this constitutes a modest increase in average exposures from 91 to 103 per voter. As a consequence, the counterfactual suggests the total budget would increase by 13 % in the Direct Vote. Voter turnout increases from 50.5 to 51.4 %, or a difference of 1.8 million voters.[24] The change in turnout helps to flip the popular vote in four states (Iowa, New Mexico, Oregon, and Wisconsin) from favoring Gore to Bush. Although Gore receives 150,000 fewer votes in the Direct Vote, Gore still wins the popular vote margin by about 390,000 votes.

The results for 2004 produce similar changes to the cross-market distribution of advertising with an even greater drop in the standard deviation of exposures and a larger decline in battleground state advertising. Advertising increases modestly in non-battleground markets. The combined effect is an overall decrease in both exposures and spending in the Direct Vote relative to the Electoral College. The identity of the dominant advertiser in 2004 shifts between election mechanisms, going from the Democrat in the Electoral College to the Republican in the Direct Vote.

We use the voter model to calculate a simple measure of voters' party preferences without the potentially contaminating effects of advertising. Let s^0_{jm} be the vote share of candidate $j \in \{R, D\}$ in market m when all advertising is set to zero. A market's political leaning is the Republican share of the two-party vote with zero advertising:

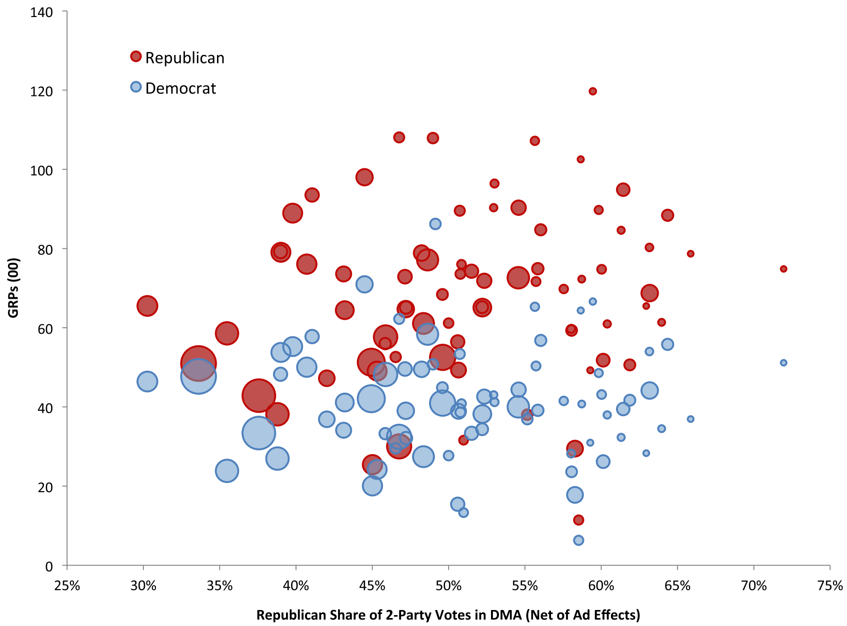
$$L_m = \frac{s^0_{Rm}}{s^0_{Rm} + s^0_{Dm}}.$$

This political leaning serves as the horizontal axis in Fig. 5, which plots advertising outcomes at the market level in each election. Focusing on outcomes in the 2000 election, a striking feature of the counterfactual advertising distribution is that, while it is less concentrated relative to the Electoral College, it is skewed to the right with 24 % fewer GRPs in left-leaning markets.[25] A second notable feature is that the Republican candidate advertises as much or more than the Democrat in nearly all markets. The basic pattern is similar in 2004 except for the notable difference that advertising levels across candidates are more similar, due to the closer estimates for R_j.

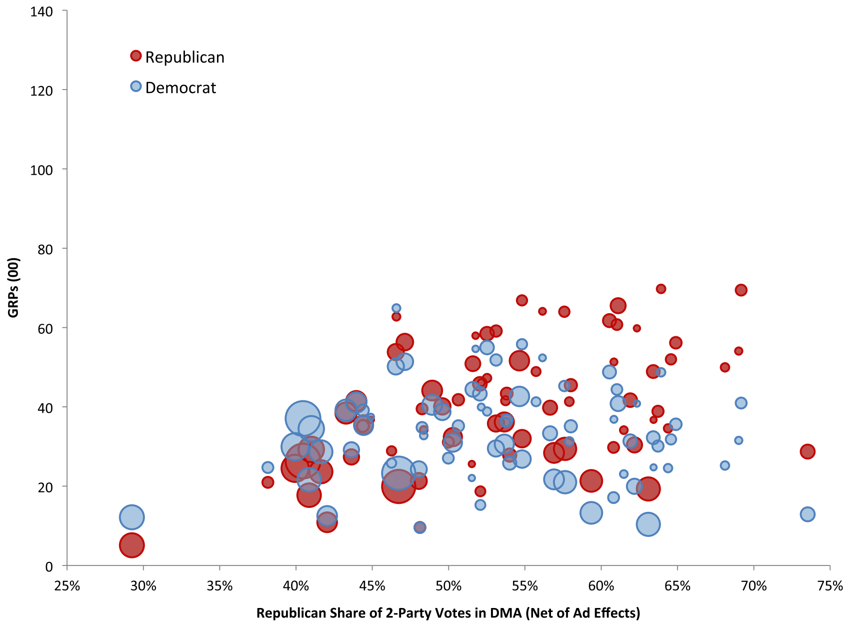
The remainder of the analysis focuses on the 2000 election with the goal of understanding how various forces shape the distribution of advertising across markets in the Direct Vote. We consider three determinants of this variation: asymmetries in the candidates (R_j), market-level variation in advertising costs (ω_{mj}), and county-level variation in voters' political preferences ($\bar{\delta}_{cj}$). Figure 6 presents the equilibrium

[24] Appendix C provides a state-level comparison of voter turnout under each election mechanism.

[25] We define left-leaning markets as those with $L_m < 0.45$ and right-leaning markets as $L_m > 0.55$.



(a) 2000



(b) 2004

Fig. 5 Advertising in the Direct Vote. The horizontal axis is the political leaning of the market L_m, defined as the Republican share of the two-party vote with zero advertising. Each bubble's size is proportional to the population in the market

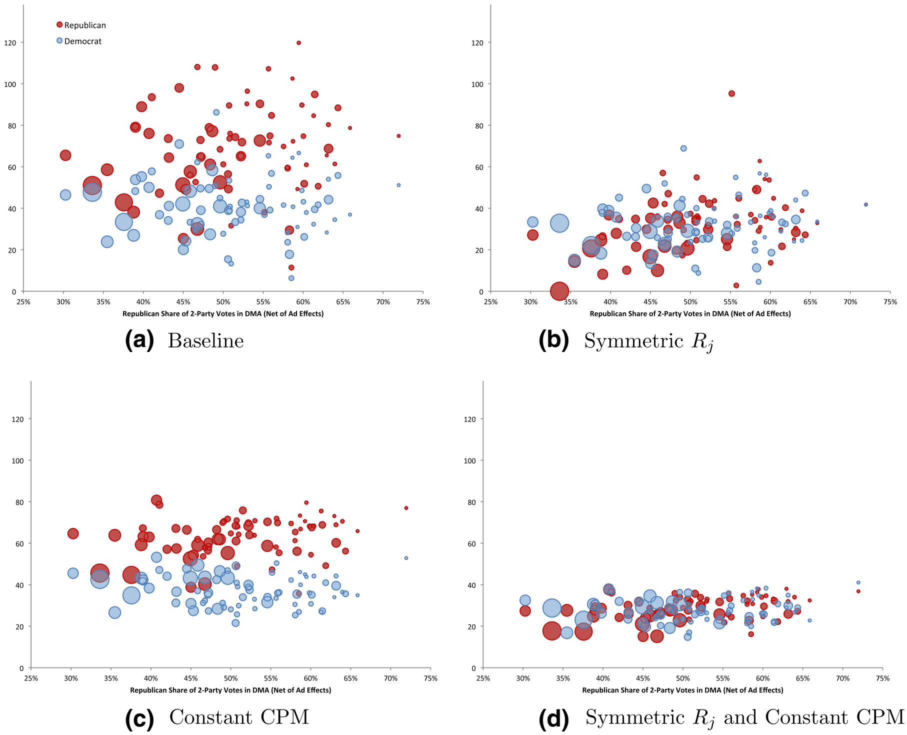


Fig. 6 Counterfactual simulations. These figures decompose the influence of different model features on equilibrium advertising in the Direct Vote. Panel **a** reproduces the equilibrium in Fig. 5a to facilitate comparison. Panel **b** sets each candidate's R_j to the average of their two values. Panel **c** equates advertising CPMs across markets but uses the estimated values of R_j. Panel **d** sets R_j to be the average and uses constant CPMs

advertising levels from a sequence of counterfactuals. To facilitate comparison, panel (a) duplicates Fig. 5a. Panel (b) plots advertising levels after setting each candidate's R_j equal to the average of their estimated values. This illustrates that the disparity in advertising levels across candidates is largely explained by their asymmetric financial strengths. Panel (c) uses the estimated values of R_j but sets advertising CPM's across all markets to the national population-weighed average. This change equalizes the cost to reach a thousand voters across markets. Finally, panel (d) combines the previous two subplots, setting the R_j to be equal and equalizing CPMs' across markets. The remaining variation in the model is solely due to differences in voters' mean utilities net of advertising ($\bar{\delta}_{cj}$), resulting in a standard deviation of 10 exposures per capita across markets.[26] Advertising exposures are nearly symmetric across markets, although total advertising exposures is lower due to more intense competition between candidates.

[26] If $\bar{\delta}_{cj}$ were constant across markets, the country effectively becomes one large undifferentiated market, and advertising would be uniform.

Panel (d) in Fig. 6 solely depicts the role of voter preferences on candidate advertising, and is informative about how other elements of candidate strategy could change in a Direct Vote. Under the Electoral College, Fig. 1 shows how candidates focus advertising disproportionately in the battleground states, and similar incentives apply to candidates' policy positions. Figure 6d illustrates that candidates do not exhibit any favoritism toward specific geographic regions. This finding supports work in political economy that examines how electoral rules determine economic policy (Persson and Tabellini 2009).

6 Conclusion

The winner-take-all rules for electoral votes concentrate advertising in closely contested states. This concentration of candidate resources minimizes the political role of roughly two-thirds of voters who reside in more polarized states. This paper develops a tractable empirical model of advertising competition between presidential candidates to understand how candidates' attention changes under different election mechanisms. We recover voter preferences using an aggregate discrete choice model and address the endogeneity of advertising levels. Estimating the candidate model allows us to identify the primitives that guide candidates' advertising allocations. With only three candidate structural parameters, the model is parsimonious yet flexible. Counterfactuals replacing the Electoral College with a Direct Vote find substantial reductions in advertising concentration, with local political preferences playing a small role in shaping the remaining cross-market variation in advertising.

Perhaps the greatest implication of a Direct Vote is on aggregate advertising spending. For the 2000 election, we find total advertising spending increases by 13 % because of the incredibly narrow popular vote margin (0.5 %). The 2004 vote margin was nearly five times greater and resulted in a 54 % reduction in spending. That margin of 2.5 % was, however, the next lowest (behind 2000) since 1976. Our findings therefore suggest the typical election would either see substantially less advertising spending or a substantial change in other candidate strategies, such as their policy positions.

Estimating our model and implementing the counterfactuals necessarily requires a number of assumptions. For example, we assume voters are not strategic, such that voters' decisions do not depend on the probability their votes could be pivotal in the election's outcome. Even in small states, the probability a voter is pivotal is extremely small, but it is possible some voters make decisions based on their votes' perceived, rather than correct, pivotallness. In the counterfactual, voters in former battleground states might be less motivated to turnout and voters in former non-battleground states could experience the converse. Our counterfactual assumes the unobservable component of demand remains unchanged in the counterfactual. Fortunately, a state's battleground status is not the primary determinant of state-level turnout. High turnout is observed in many uncontested states (e.g. Wyoming, Montana, Vermont, North Dakota, South Dakota) and low turnout exists in high profile battleground states. In 2000 Florida's turnout rate was 2.1 % below the national average, whereas Alaska voted 2:1 in favor Bush and had a turnout rate 15 % above the national average. Other dimensions of voter preferences that are unlikely to vary significantly over time seem to play a greater role in shaping voter turnout.[27]

Our static candidate model also ignores the potentially important and certainly interesting temporal dimension of advertising competition. The uncertainty candidates face likely varies over the election cycle as new information becomes available and candidates (and voters) update their beliefs. Our estimates of σ represent a weighted average of uncertainty over our period of study. Future work could formulate each candidate's problem as a forward-looking finite-horizon problem in which candidates decide how much to spend in a given period and form expectations about changes in voters' and donors' perceptions. It is possible such a model could incorporate polling data to serve as an intermediate outcome of interest prior to the general election.[28]

Finally, our paper must hold a number of factors fixed. We focus exclusively on candidates' advertising decisions. In a counterfactual Direct Vote, candidates' policy positions and other strategies would certainly change. Incorporating candidate policy choices, or other strategic variables, into our model is challenging but represent interesting avenues for future research. We also assume the shadow cost of raising funds for the presidential advertising budget is invariant to the election mechanism. As the closeness of the election changes, the ability to convince donors to focus on presidential, rather than local elections for example, might also change. Modeling the budget formation process more formally may be a valuable extension.

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Appendix A: Estimation in a contest

This appendix describes a general approach to estimating contest models. The method is applicable to any problem where an agent (or agents) exerts observed effort to pass a threshold while facing some unobservables. The general objective function under a threshold goal for agent $j \in J \geq 1$ choosing effort allocations $A_j \in \mathbb{R}_+^M$ is

$$\max_{A_j} \pi_j(A;\theta) = R_j \cdot \mathbb{E}\left[d_j\left(A, \eta; \theta\right)\right] - \omega' A\,,$$

where $R_j \in \mathbb{R}_{\geq 0}$ is the agent's prize for success, $A \in \mathbb{R}_{\geq 0}^{JM}$ is the collection of effort choices across agents, $\omega \in \mathbb{R}_{\geq 0}^{M}$ is the cost of effort, and $\theta \in \Theta^k$ is a set of

[27] To build an equilibrium model with strategic voting, one could look for insights from Shachar and Nalebuff (1999) and Kawai and Watanabe (2013), two of the few papers to empirically study strategic voting.

[28] One challenge with polling data is that it is unavailable at the county level. Even state-level polling data measured at consistent intervals can be difficult to obtain, so one challenge following this approach would be aligning the polling information to the proper period length and geographical unit.

structural parameters. $d_j \in \{0, 1\}$ is the success function that determines whether agent j wins the prize, such that $\mathbb{E}\left[d_j\right]$ is the probability of success that integrates over the unobservable $\eta \in \mathbb{R}^{JM}$ with known CDF F_η. An important component of d_j is the scoring function $s_{jm}(A, \eta; \theta) \in \mathbb{R}_{\geq 0}$, which determines the agent's score given all effort choices and the unobservables. For all m, we assume $s_{jm}(A, \eta; \theta)$ is strictly increasing in A_{jm} and η_{jm} and strictly decreasing in A_{km} and η_{km}, for $k \neq j$. These conditions ensure that $s(A, \eta)$ is invertible in η, which is necessary for the computational approach. We suppress θ for the rest of the exposition.

Our paper estimates θ using GMM based on the FOCs of the agent's problem with respect to A_j. To compute the FOC, one requires a method to estimate the marginal effect of (say) advertising $\frac{\partial \mathbb{E}[d_j(A,\eta;\theta^v)]}{\partial A_{mj}}$ on the probability of winning the contest. Below we discuss ways to calculate this quantity under different conditions.

Single agent with scalar uncertainty The simplest application involves a single agent ($J = 1$) who chooses a single effort level $A \geq 0$ ($M = 1$) with a scalar unobservable η in an attempt to exceed threshold $\overline{V}$. The success function is

$$d(A, \eta) = 1 \cdot \left\{s(A, \eta) > \overline{V}\right\} .$$

The scoring function produces a value $v = s(A, \eta)$, which is a random variable due to the presence of η. Assume the scoring function can produce a value high enough to exceed the threshold, such that $s(A, \eta) \geq \overline{V}$ for some combination of A and η. Otherwise, the agent is guaranteed to fail and she will not exert any effort. The probability of success can be expressed as

$$\begin{aligned}\mathbb{E}[d(A, \eta)] &= \Pr\left(s(A, \eta) > \overline{V}\right)\\ &= 1 - F_v\left(s(A, \eta) \leq \overline{V}\right) ,\end{aligned}$$

where $F_v(\cdot)$ is the unknown CDF of the score v. Let $s^{-1}(A, v)$ be the inverse of $s(A, \eta)$ through its second argument. Given the known distribution function for η, we use a change-of-variables to re-express the cumulative distribution F_v in terms of η,

$$F_v\left(s(A, \eta) \leq \overline{V}\right) = F_\eta\left(s^{-1}(A, v) \leq s^{-1}\left(A, \overline{V}\right)\right) , \tag{14}$$

$$= F_\eta\left(\eta \leq \eta^*\left(A, \overline{V}\right)\right) , \tag{15}$$

where $\eta^* \equiv \eta^*\left(A, \overline{V}\right) = s^{-1}\left(A, \overline{V}\right)$ is the critical value of the shock that equates the score and the threshold, such that $s(A, \eta^*) = \overline{V}$. Thus, given a particular value of A , the marginal effect of A on the probability of success is:

$$\begin{aligned}\frac{\partial \mathbb{E}[d(A, \eta)]}{\partial A} &= \frac{\partial\left[1 - F_\eta\left(\eta \leq \eta^*\left(A, \overline{V}\right)\right)\right]}{\partial A}\\ &= -f_\eta\left(\eta^*\left(A, \overline{V}\right)\right) \frac{\partial s^{-1}\left(A, \overline{V}\right)}{\partial A} .\end{aligned}$$

If $s^{-1}(A, v)$ and $\partial s^{-1}(A, v) / \partial A$ have closed forms, then knowledge of f_η yields an analytic expression for the marginal effect of effort.

Multiple markets and a competing agent Our presidential election application involves an extension to a competing agent and multiple markets, where each market requires an action and has an agent-market specific unobservable. The success function in such a contest is:

$$d_j(A, \eta) = 1 \cdot \left\{s_j(A, \eta) > s_k(A, \eta)\right\} .$$

The scoring function is

$$s_j(A, \eta) = \sum_m s_{mj}(A_m, \eta_m) ,$$

where A_m and η_m are those values relevant to market m across all agents. For a given market, we can rewrite the success function in the following way:

$$\begin{aligned} d_j(A, \eta) &= 1 \cdot \left\{ s_{mj}(A_m, \eta_m) - s_{mk}(A_m, \eta_m) > \sum_{n \neq m} s_{nk}(A_n, \eta_n) - s_{nj}(A_n, \eta_n) \right\} \\ &= 1 \cdot \left\{IM_{mj}(A_m, \eta_m) > EM_{mj}(A_{-m}, \eta_{-m})\right\} \end{aligned}$$

Intuitively, an agent's score relative to his opponent's in market m must be greater than his deficit across all other markets. We refer to these terms as the internal margin IM_{mj} and external margin EM_{mj}. The inversion to obtain a critical η^* is now in terms of the internal margin instead of a single agent's score. Note that an inverse of IM_{mj} through η_{mj} exists due to our shape assumptions on $s(A, \eta)$. The probability of success can now be expressed as

$$\begin{aligned} \mathbb{E}\left[d_j(A, \eta)\right] &= \Pr\left(s_j(A, \eta) > s_k(A, \eta)\right) \\ &= 1 - F_{IM}\left(IM_{mj}(A_m, \eta_m) \leq EM_{mj}(A_{-m}, \eta_{-m})\right) \\ &= 1 - F_\eta\left(IM_{mj}^{-1}\left(A_m, s_{mj} - s_{mk}, \eta_{mk}\right) \leq IM_{mj}^{-1}\left(A_m, EM_{mj}(A_{-m}, \eta_{-m}), \eta_{mk}\right)\right) \\ &= 1 - F_\eta\left(\eta_{mj} \leq IM_{mj}^{-1}\left(A_m, \eta_{mj}^*, \eta_{mk}\right)\right) \end{aligned}$$

Given values for A_{-m} and η_{-m}, EM_{mj} is just a scalar representing agent j's deficit or surplus outside market m. Thus the critical value of agent j's shock in market m is the $\eta_{mj}^* \equiv \eta_{mj}^*\left(A_m, EM_{mj}, \eta_{mk}\right)$ that sets

$$IM_{mj}\left(A_m, \eta_{mj}^*\left(A_m, EM_{mj}, \eta_{mk}\right), \eta_{mk}\right) = EM_{mj}(A_{-m}, \eta_{-m}) .$$

We combine this result with Monte Carlo simulation over the opponent's shock inside market m and the collection of shocks outside market m to produce an estimate of the marginal effect of A_{jm}. The key steps are:

1. Simulate $r = 1, \ldots, NS$ draws over η_{mk}^r and $\eta_{-m}^r = \left\{\eta_{-nj}^r, \eta_{-nk}^r\right\}_{n \neq m}$ using the known distributions $f_{\eta_{mj}}$. In our application, these are $N(0, \sigma^2)$, which can be generalized at higher computational cost.
2. Use η_{-m}^r to calculate the JM values of $EM_{mj}^r \equiv EM_{mj}^r\left(A_{-m}, \eta_{-m}^r\right)$, given some particular value A_{-m}.

3. Solve for the critical values $\eta_{mj}^{r*} \equiv \eta_{mj}^{r*}\left(A_m, EM_{mj}^r, \eta_{mk}^r\right)$ that set $IM_{mj}^r\left(A_m, \eta_{mj}^{r*}, \eta_{mk}^r\right) = EM_{mj}^r$ for all m and j.
4. The estimate of the marginal effect of A_{mj} is:

$$\frac{\partial \widehat{\mathbb{E}\left[d\left(A,\eta\right)\right]}}{\partial A_{mj}} = \frac{1}{NS}\sum_r - f_{\eta_{mj}}\left(\eta_{mj}^{r*}\right)\frac{\partial \eta\left(A_m, EM_{mj}^r, \eta_{mk}^r\right)}{\partial A_{mj}}. \tag{16}$$

where $\partial\eta(\cdot)/\partial A_{mj} \equiv \partial IM_{mj}^{-1}(\cdot)/\partial A_{mj}$ and evaluated at $\eta_{mj} = \eta_{mj}^{r*}$.

The next two sections discuss the details of implementing this general form of the derivative in the Direct Vote and Electoral College, respectively.

Application to a Direct Vote The realities of an election place certain restrictions on the empirical analogues of the score functions. Under a Direct Vote, Eq. 16 describes the derivative if it is always feasible for the internal margin of votes to exceed the external margin of votes in all markets. In practice, bounds on the internal margin are implied by the number of voters in the market, giving us the following expression for the derivative in a Direct Vote:

$$\frac{\partial \widehat{\mathbb{E}\left[d\left(A,\eta\right)\right]}}{\partial A_{mj}} = \frac{1}{NS}\sum_r - f_{\eta_{mj}}\left(\eta_{mj}^{r*}\right)\frac{\partial \eta\left(A_m, EM_{mj}^r, \eta_{mk}^r\right)}{\partial A_{mj}} 1\cdot\left\{N_m > EM_{mj}^r\right\}$$

where $N_m = \sum_{c\in C_m} N_c$ is the total number of voters in the market. If $N_m < EM_{mj}^r$, then there does not exist a η_{mj}^{r*} to equate the internal and external margins and the derivative at the r^{th} draw is zero.

Using the notation from the body of the paper, the marginal effect of advertising on the probability of winning is:

$$\begin{aligned}\frac{\partial \widehat{\mathbb{E}\left[\tilde{d}\left(A,\bar{\delta},\boldsymbol{\eta};\alpha\right)|\sigma\right]}}{\partial A_{mj}} &= \frac{1}{NS}\sum_r - f_{\eta_{mj}}\left(\eta_{mj}^{r*}|\sigma\right)\left(\frac{\partial \eta_{mj}\left(A_m, EM_{mj}^r, \eta_{mk}^r\right)}{\partial A_{mj}}\right).\\ &= \frac{1}{NS}\sum_r f_{\eta_{mj}}\left(\eta_{mj}^{r*}|\sigma\right)\frac{\alpha}{1+A_{mj}}\end{aligned}$$

where $EM_{mj}^r \equiv EM_{mj}^r\left(A_{-m}, \eta_{-m}^r\right)$ is the external margin in market m and $\eta_{mj}^{r*} = \eta_{mj}\left(A_m, EM_{mj}^r, \eta_{mk}^r\right)$ is the critical value of the shock that equates the external and internal margins. We have suppressed an indicator function that sets the derivative for the r^{th} draw equal to zero when $N_m < EM_m^r$. Note that an interior solution requires us to solve a system of $JM(1+NS)$ equations in as many unknowns. Setting $NS = 10{,}000$ helps ensure an accurate Monte Carlo approximation to the integral, but makes computing the equilibrium nontrivial.

Application to the Electoral College The Electoral College introduces an added layer of complexity because of the state-level contests. We need to introduce additional notation corresponding to multiple markets intersecting a single state and markets intersecting multiple states. Let $M_{s(m)}$ be the set of all markets intersecting state s (m), where m is the focal market for the derivative. Let C_{ms} denote the set of counties intersecting both state s and market m. Finally, let $\tilde{S}(m)$ denote the set of states that market m intersects.

The Electoral College involves two relevant thresholds for winning an election: (i) the electoral vote margin and (ii) the state-level popular vote margin. For a given r, the derivative is non-zero only if the electoral votes attainable through advertising in market m are greater than the electoral vote deficit implied by the shocks in all other markets:

$$\sum_{s\in\tilde{S}(m)} E_s > \sum_{s'\notin\tilde{S}(m)} E_{s'k}\left(\eta^r_{s'}\right) - E_{s'j}\left(\eta^r_{s'}\right) .$$

If a market is "in play" based on the electoral votes, then the state-level margin can be separated into an internal and external margin as above. If a market intersects multiple states there is a potentially relevant internal and external margin for each:

$$\begin{aligned} IM^{rs}_{mj} &= \sum_{c\in C_{ms}} N_c\left(s_{cj}(A_m,\eta_{mj},\eta_{mk}) - s_{ck}(A_m,\eta_{mj},\eta_{mk})\right) \\ EM^{rs}_{mj} &= \sum_{n\in M_{s(m)}\setminus m}\ \sum_{c\in C_{ns}} N_c\left(s_{ck}(A_m,\eta_n) - s_{cj}(A_m,\eta_n)\right) . \end{aligned}$$

We therefore calculate an η^{*rs}_{mj} , as described above, for each state $s \in \tilde{S}(m)$. Next, we define the relevant critical value, η^{*r}_{mj}, to be the smallest of these shocks that yields enough electoral votes to offset the electoral vote deficit implied by the r^{th} set of draws.

The derivative for the r^{th} draw is therefore:

$$\frac{\partial\mathbb{E}\left[d\left(A,\eta\right)\right]^r}{\partial A_{mj}} = \begin{cases} -f_{\eta_{mj}}\left(\eta^{r*}_{mj}\right)\frac{\partial\eta\left(A_m,EM^r_{mj},\eta^r_{mk}\right)}{\partial A_{mj}} & \text{if } \sum_{c\in C_{ms}} N_c > EM^r_{mj} \\ & \text{and } \sum\limits_{s\in\tilde{S}(m)} E_s > \sum\limits_{s'\notin\tilde{S}(m)} E_{s'k}\left(\eta^r_{s'}\right) - E_{s'j}\left(\eta^r_{s'}\right) \\ 0 & \text{otherwise} \end{cases}$$

and the overall derivative is

$$\frac{\partial\widehat{\mathbb{E}\left[d\left(A,\eta\right)\right]}}{\partial A_{mj}} = \frac{1}{NS}\sum_r\frac{\partial\mathbb{E}\left[d\left(A,\eta\right)\right]^r}{\partial A_{mj}} .$$

Using the notation from the body of the paper, the marginal effect of advertising is equal to:

$$\begin{aligned} \frac{\partial\mathbb{E}\left[d_j\left(\widehat{A,\bar{\delta},\boldsymbol{\eta}};\alpha\right)|\sigma\right]}{\partial A_{mj}} &= \frac{1}{NS}\sum_r f\left(\eta^{r*}_{mj}|\sigma\right)\frac{-\partial\eta\left(A_m,EM^r_{mj},\eta^r_{mk}\right)}{\partial A_{mj}} \\ &= \frac{1}{NS}\sum_r f\left(\eta^{r*}_{mj}|\sigma\right)\frac{\alpha}{1+A_{mj}} \\ &\qquad \text{if } E_s > \sum_{\ell\neq s} E_{\ell k}\left(A_\ell,\eta^r_\ell\right) - E_{\ell j}\left(A_\ell,\eta^r_\ell\right) \end{aligned}$$

where $\partial\eta(\cdot,\cdot,\cdot)/\partial A_{mj}$ is evaluated at η^{r*}_{mj}. The derivative of $\eta(\cdot)$ with respect to A_{mj} in our application is $\frac{-\alpha}{1+A_{mj}}$ because A_{mj} and η_{mj} are perfectly substitutable within the utility function as follows: $\delta_{cj} = \bar{\delta}_{cj} + \alpha \log\left(1 + A_{mj}\right) + \eta_{mj}$. Intuitively, the derivative we seek equals the probability of drawing a critical value η^{*}_{mj} times the derivative of this critical value with respect to advertising. The condition on the right requires that the state be pivotal in the election's outcome: the number of electoral votes at stake, E_s, must be larger than the candidate's electoral deficit outside that state, otherwise the derivative at the r^{th} draw is zero. A benefit of this approach is that the Monte Carlo integration is effectively over η_{mk} and EM_{mj}, combined with an analytic expression for η^{*}_{mj}, instead of the original $M \times J$ dimensional integral.

Note that the above characterizes the marginal effect of effort in a contest with a general contest success function. One primary focus of the theoretical contest literature has been on the derivation of analytically tractable success functions (Skaperdas 1996). In practice, contests such as elections have their own specific success functions implying CDFs for the probability of success that may inherently not be analytically tractable. We show that the above approach is beneficial by compressing a large multidimensional integration problem into unidimensional external and internal margins.

Appendix B: Advertising and advertising prices

We construct a market-candidate observed aggregate advertising level and advertising price (A_{mj} and w_{mj}) based on two observed variables. $\text{Expenditure}_{mjad}$ is CMAG's estimate of the dollars spent by candidate j in market m on an advertisement a in daypart d. CPP_{md} is SQAD's reported advertising price for the 18 and over demographic in market m during daypart d. We use the CPP from the 3rd quarter of the election year.[29]

Let the daypart level of advertising by candidate j in market m be:

$$GRP_{mjd} = \frac{\sum_{a \in \mathbb{A}_{mjd}} \text{Expenditure}_{mjad}}{\sum_{d=1}^{8} CPP_{md}}$$

where $\mathbb{A}_{tmjd}$ is the set of advertisements for a candidate in a market and daypart. Then total advertising by candidate j in market m is:

$$A_{mj} = \sum_{d=1}^{8} GRP_{mjd}.$$

[29] While the advertising primarily spans both September (3rd quarter) and October (4th quarter), it is problematic to use a separate cost for each quarter because a discontinuity in costs would be artificially generated on October 1. Furthermore, 4th quarter ad costs are likely not a good estimate of the true cost of the ad because they include the holiday season.

The market-specific advertising price for candidate j is defined as follows:

$$w_{mj} = \begin{cases} CPP_{md} \frac{GRP_{mjd}}{A_{mj}} & \text{if } A_{mj} > 0 \\ CPP_m & \text{if } A_{mj} = 0 \end{cases}$$

where

$$CPP_m = \sum_{d=1}^{8} \left[CPP_{md} \frac{\sum_{j=1}^{J} \sum_{m=1}^{M} GRP_{mjd}}{\sum_{j=1}^{J} \sum_{m=1}^{M} \sum_{d=1}^{8} GRP_{mjd}} \right].$$

In other words, we use a weighted average across the dayparts in which candidate j advertised in market m if the candidate did in fact advertise there, or a weighted average based on both candidates advertising in all markets within each daypart if the candidate did not advertise in the market.

The advertising price in our candidate-side estimation is $\omega_{mj} = w_{mj} + v_{mj}$ where v_{mj} is the candidate's market-specific unobservable component of advertising. (Recall that the SQAD prices are forecasts) When we analyze the cost per marginal vote, we use CPP_m in all markets to highlight the role of diminishing marginal effectiveness and political leaning in the costs of acquiring an additional vote. Finally, when we solve the Direct Vote counterfactual, we use w_{mj} as the price of advertising. This avoids odd implications from large local residuals that likely do not relate to costs, but retains a source of local variation in advertising. We remove both the candidate and local market ad price variation in the final simulation by setting an equal price per thousand people (CPM) such that $\tilde{w}_{mj} = ((\frac{1}{2M} \sum_{j=1}^{2} \sum_{m=1}^{M} CPM_{mj}) \times Pop)/100$.

Appendix C: A comparison of voter turnout in the Electoral College and the Direct Vote in 2000

Turnout in the 2000 Direct Vote increases by 0.9 %, or about 1.8 million voters. The popular vote in four states—Iowa, New Mexico, Oregon, and Wisconsin, all with thin margins—flips from Gore to Bush. Gore, however, gains enough votes in the Democratic stronghold of California to win the election even though his national vote margin shrinks from about 543,000 to 390,000.

An important distinction between the Electoral College and a Direct Vote is a state's relative influence in the election outcome. Under the Electoral College, a state's influence is fixed and proportional to its fraction of the total electoral votes.[30] The Electoral College essentially protects states from political losses if a state implements policies that make it more difficult or disqualifies certain voters from casting their votes. Furthermore, the winner-take-all rule gives partisan members of a state's government strong motivation to influence voter turnout to favor their own political

[30]The Constitution specifies the number of a state's electoral votes as equal to its number of Senators (two) plus its number of Representatives (proportional to its Census population). This allocation implies that each elector in a small state represents fewer voters compared to larger states: as of 2008, each of Wyoming's three electoral votes represented about 177,000 voters, compared to 715,000 for each of the 32 electors in Texas.

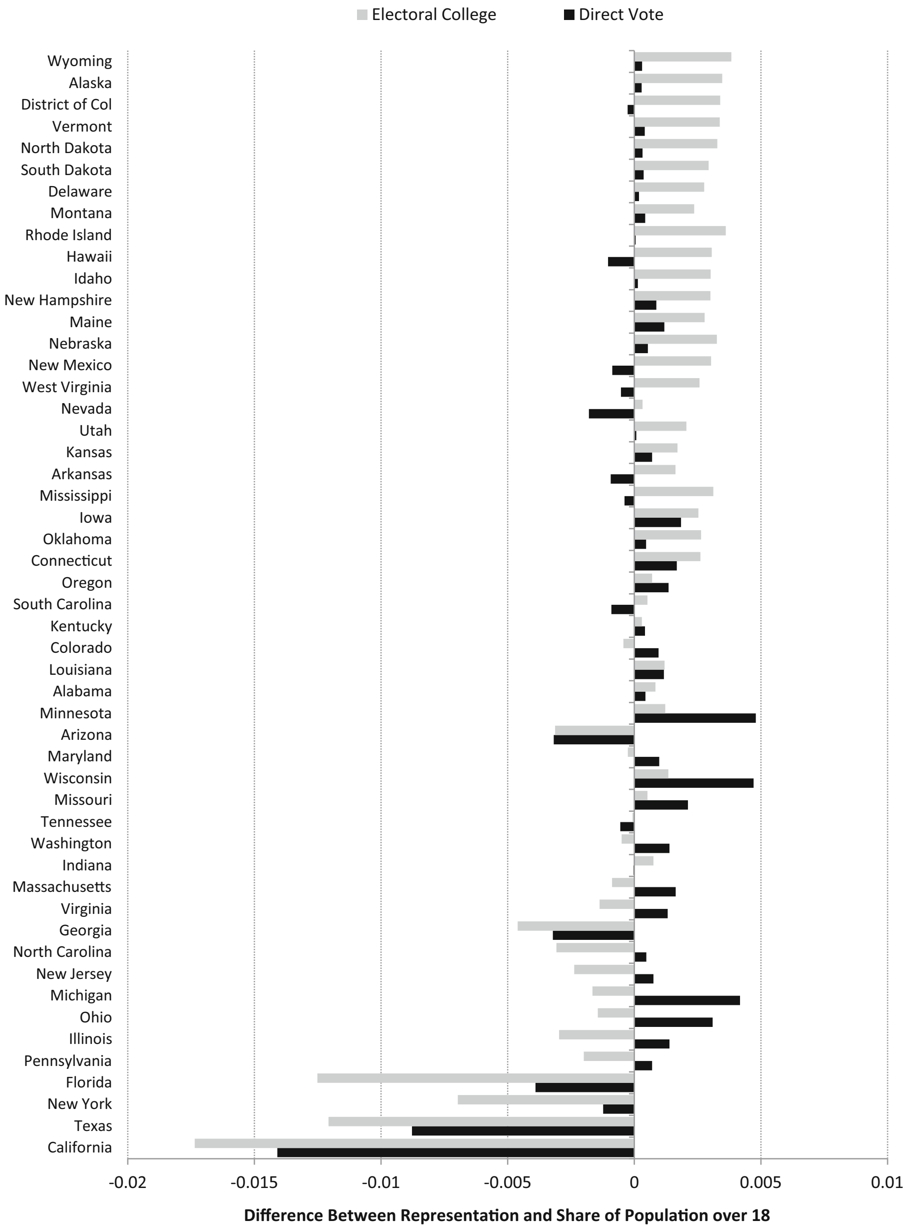

Fig. 7 States' election influence under the Electoral College and Direct Vote in 2000: the horizontal axis reports the difference between a state's relative influence in the election outcome under a particular electoral system relative to the state's voting-age population. Under the Electoral College, a state's influence is its number of electoral votes divided by the total number of electoral votes in the country. Under a Direct Vote, a state's influence is its voter turnout divided by the total voter turnout in the country. *Bars to the left* of zero indicate that a state has less influence under that system relative to its share of the total voting-age population. States are sorted from top to bottom in order of ascending population

party (as witnessed recently in the form of voter identification and anti-voter fraud laws proposed in many states).

In contrast, in a Direct Vote, a state's relative influence in the election outcome is endogenous—it is proportional to the percent of its population that turns out to vote relative to national voter turnout. Figure 7 depicts the difference in representation of a state between each electoral mechanism and the representation that their population constitutes as percentage of the US population over age 18. States are ordered on the left axis by increasing size of their voting age population. On the top, the series of positive bars reflect the electoral college's protection of small states. On the bottom, large states such as California, Texas and Florida are under-represented in both the electoral college and a Direct Vote. Under-representation in the Direct Vote arises from a smaller fraction of the state's voting age population actually voting. Other states such as Georgia, Arizona and Nevada also are under-represented in a Direct Vote. Minnesota, Wisconsin, Michigan and Ohio are however over-represented in a Direct Vote. A Direct Vote therefore eliminates both the electoral college's protection of small states and the tie in to state population size, as a state is now represented only by its voters turning out for the election.

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