The Effects and Duration of Political Advertising in U.S. Senate Elections *

Hyun Woo Lim †

Washington University in St. Louis

April 3, 2020

*Notes: This paper would not have been possible without the guidance of Professor John Zaller. I especially thank him for his support and advice. I also thank Professor Kathleen Bawn and Jacob Montgomery for their helpful comments. Lastly, I thank to Washington University data lab attendees. All errors are my own.

†Ph.D. Student, Department of Political Science, Campus Box 1063, One Brookings Drive, St. Louis, MO 63130; hyunwoolim@wustl.edu.

Abstract

How long do the effects of candidate advertising last? This paper explores this question using time series models with 901 polls in 54 competitive U.S. Senate elections in 2010, 2012 and 2014. My results suggest that advertising influences voters in Senate elections, but the effect decays so rapidly that after a few days only a minimal effect is left. These findings are consistent with findings of previous studies of short-lived advertising effects. However, previous studies do not study competitive elections where real campaigns and campaign advertising exist. I address this limitation and find that in subnational elections, advertising effects decay very quickly that after three days from advertising, only less than 20 percent of initial effects are left. However, I argue that for the short period of time right after TV advertising, the advertising can be effective to win polls and elections.

Keywords: campaign advertising, decay, competitive elections

Introduction

Television advertising is the mainstay form of communication in most major elections in the United States and many other democracies, but despite its importance, existing research leaves a big question unanswered: Do the effects of advertising last more than a few days? It is important because most advertising is run weeks or months ahead of election day, which would be hugely wasteful if, as some research suggests, the effects decay rapidly.

To answer this question, I have conducted a time series analysis of 901 polls conducted in the general election phase of 54 Senate elections in 2010, 2012 and 2014. My results provide the strongest support to date for the view that the effects of typical advertising in subnational elections that is, elections below the level of president decay rapidly.

This paper starts by reviewing theories of mass communication, political advertising and campaign effects. In an early study, Klapper argued that mass communication rarely brings about meaningful opinion change (1960). However, many later scholars have vigorously attacked this earlier theory. Recently, a handful of scholars have focused on studying how quickly the substantial effects of mass communication die out and whether these effects can accumulate over time. Therefore, this paper focuses on examining two key questions regarding campaign advertising: is advertising effective to win vote share in public opinion polls and election? And if advertising is effective, how long the advertising effects can last?

To explore my research questions, I study campaign advertising during general elections after primaries where elected two candidates from two parties compete with each other, more importantly, I study advertising effects in competitive Senate races where significant TV advertisements are aired from both candidates. I use 2010, 2012 and 2014 U.S. Senate elections advertising data from Wesleyan advertising project (CMAG) and state-level polls from RealClearPolitics.com and actual election outcomes. I used state level partisanship as main control in my statistical models and fixed effects model by each race.

Two main statistical models are used in this paper. The first model to study the general patterns of decaying effects of advertising is a blocked model used by Hill et al. (2013). The

second model to estimate advertising effects and their decay rates is a close form models. They are originally developed by Rubin and Wenzel (1996) and adopted by political scientists to study political communication (Hill et al. 2013).

This paper reveals important findings regarding campaign advertising effects and they are important for candidates, campaign strategists, law makers and citizens of democracy. The results show that after one day, only about a half of advertising effect remained while after 20 days, there are only minimal effects. However, these small remaining effects could survive and may accumulate over time, generating larger effects if ads are run continuously. The findings of this paper reaffirm the findings of Hill et al.s (2013) articles that mass communication produces consequential effects on election outcomes, but the effects decay very quickly. Together, these two studies provide a strong indication that the effects of advertising decay rapidly.

This paper has four parts. The first part reviews previous studies. The second part overviews the data and explains the methods. The third part shows the empirical findings and analysis. The last part concludes the article by discussing the implications of my findings.

Previous Literature

I briefly review various studies on mass communication effects and decay analysis of advertising effects. After that, I argue that these findings need further verification because of the distinctive characteristics of competitive elections and campaigns. Therefore, I also review previous studies that explain how competitive races are different from other races in light of campaigns.

Short-lived effects of mass communication

Scholars argue that mass communication cannot exert durable persuasion effects, but until recently, scholars have not investigated how quickly the effects decay and why mass com-

munication cannot bring about durable effects. For instance, one of the outstanding early studies is Fox news study by Della Vigna and Kaplan (2007). The study finds that mass media influences voting behaviors by studying natural experiments of introducing Fox news in cable markets, and they observed that the media effects disappear over time (DellaVigna and Kaplan 2007).

Among various ways of mass communication, particularly, scholars have been interested in campaign advertising effects and their duration. Recently, a randomized control experiment study by Gerber et al. (2011) also found fast decaying effect of campaign advertising that the effects disappear in one or two weeks. In the only other study of duration of advertising effects, Hill et al. (2013) adopted memory and persuasion theories from Hastie and Park (1986) and used memory-based, online-based, and dual process model to theoretically explain short-lived effects of mass communication. Although many studies considered campaign effects and voters knowledge, opinion, and behavior, Hill et al. (2013) focuses on advertising effects among other mass communication effects and their study is the only study that measures the speed with which the effects decay (Lodge, McGraw, and Stroh 1989; Lodge, Steenbergen, and Brau 1995; Mitchell 2012). The key findings of Hill et al. (2013) showed that the dual-process model of communication, which is a mixed version of memory and online process, could explain short-lived effects of mass communication because most voters engage campaign communication with non-effortful memory process. However, even if most recipients cared less about the information from the campaign advertising, some would accept campaign messages with an effortful information process the effects of which can last longer (Hill et al. 2013, 525).

Thus, the existing literature has developed a theory of short-lived mass communication effects. Particularly, political scientists have focused on examining political TV advertising, which is one of the most expensive and popular methods of campaign communication. However, further studies are required to verify this theory.

Why a theory of short-lived advertising effects needs to be further verified?

There are two main reasons that we need further study to verify short-lived advertising effects: The first reason is Hill et al. (2013) only study a short period of campaign advertising and the second reason is they do not focus on competitive elections where significant advertising exists.

Gerber et al. (2011) and Hill et al.s (2013) studies provide a strong indication that the effects of advertising decay rapidly, but the results need to be verified. Hill et al. only study a short period of campaigns in case of subnational elections (25 days before election). Because their study for subnational elections are based on 2006 CCES, the respondents of CCES were interviewed for 25 days before elections (Oct 13- Nov 7) although their advertising data is 42 days before elections[1] (Hill et al. 2013, 527). It means that they only study a short period of campaign. This makes them difficult to study possible long-term effects of advertising.

Most importantly, only a small portion of their sample for subnational elections, 16 out of 60 House races (except 1 Senate and 5 governor elections), had significant advertising (2013, 542). If 44 House races in their study do not have significant advertising, it is uncertain whether there were real campaigns in those races. I discuss more about the distinctive characteristics of competitive elections, the relationship between electoral closeness and campaign activeness, and why I need to focus on competitive races to examine advertising effects and their decay in the next section.

Campaigns, advertising and closeness of elections

As Caughey and Sekhon (2011) summarize and Enos and Hersh (2015) point out, close elections are different from other elections in many aspects, and they have some distinctive characteristics. However, the main reason that I need to focus on competitive races

[1]Maximum 67 days before elections (25 days before election + 42 days before the first interview)

(battlegrounds) to study advertising effects is these races are where the real campaigns and campaign advertising exist and the election outcomes of the states where they have strong partisanship regardless of advertising. To examine effects of campaigns, particularly campaign advertising, I need to study the races where the real campaigns ran from both candidates and the both candidates have a feasible chance to win an election. As RealClearPolitics.com shows, about 40 percent (41 out of 103) of 2010, 2012 and 2014 Senate elections were safe seats. Indeed, various factors including partisanship and incumbent advantage strongly affect election outcomes (Ansolabehere and Snyder 2002; Bartels 2000; Stone, Maisel, and Maestas 2004; Zaller 1998). Particularly, in case of safe seats, winners of these uncompetitive races are often predetermined without campaigns. Also, candidates, parties and outside groups are reluctant to invest their resources in those uncompetitive races (Ansolabehere and Snyder 2000; Erikson and Palfrey 2000). Therefore, it is unlikely to observe real campaigns in uncompetitive races, and it is unsuitable to study these races for analyzing advertising effects because simply campaigns are not there.

Considering these studies findings, the fact that Hill et al.s (2013) study has many uncompetitive races (44 out of 60 House races) in their sample for subnational elections is a weakness in their study. Therefore, in this study, I focus on competitive battleground races that have active campaign advertising.

In sum, scholars found that campaign advertising effect is substantial but short-lived from observational and experimental study (Hill et al. 2013; Gerber et al. 2011). However, Hill et al. (2013) only studied the decay of advertising effect in short period campaign and large portion of their samples are uncompetitive races and Gerber et al.s (2011) unit of measurement of advertising is weekly sum, so it is not possible to examine how fast the effect decays. How long do the effects of candidate advertising last? The following seeks to answer the question.

Table 1: The competitiveness of 2010, 2012 & 2014 Senate elections

Year	Likely Democrat	Leans Democrat	Toss up	Leans Republican	Likely Repbulican
2010	NY, OR	CT	CA, CO, IL NV, PA, WA, WV	KY, MO	IN, LA, NC, OH
2012	HI, MI, NJ, NM, WA, WV	CT, FL, MO, OH, PA	IN, MA, MT, NV, ND, VA, WI	AZ, NE	
2014	IL, MI, MN, NM, OR	VA	AK, CO, GA, IA, KS, NH, NC	AR, KY	MS, WV

Data and Methods

Overview of data and variables

Two main variables in this study are advertisements and polls, and the data is obtained mainly from two sources: advertising data from Wesleyan Media Project (CMAG) and poll data from RealClearPolitcs.com. RealClearPolitics.com provides various polls from many sources during campaigns. For this study, I used RealClearPolitics state-level polls of U.S. Senate races. Polls and election outcomes from 54 U.S. competitive Senate races are selected, specifically, 17 races in 2010, 20 races in 2012, and 17 races in 2014, totaling 847 polls and 54 actual election outcomes. Overall, 16 out of 37, 12 out of 33 and 14 out of 34 U.S. Senate elections winners in 2010, 2012 and 2014 respectively, were from races of safe seats that a winner of a race is almost predetermined irrespective of campaigns and before elections. In these uncompetitive races, a winner of the race is often decided regardless of advertising effect. Therefore, I only focus on the remaining competitive races because these races involve active campaigning, including TV advertising, by both candidates of elections. Additionally, this study concentrated on general elections after primaries that elected two candidates from two parties[2]. Table 1 shows the competitiveness of elections categorized by RealClarPolitics.com into five different levels.

However, is it really true that there is a notable difference in activeness of campaigns

[2]In all cases, I only consider two candidates from Republican or Democratic parties. The only exception is the case of 2014 Kansas Senate election in that there were two major candidates in the general election: Pat Roberts (Republican) and Greg Orman (Indpendent).

including advertising between competitive and uncompetitive elections? Therefore, I briefly examine the relationships between competitiveness of elections and activeness of campaigns. There are several indicators that can be used as a measurement of campaign intensity, although it is difficult to measure campaign intensity. Westlye studies Senate elections and campaign intensity, and he argues that margin of victory, quantity of news coverage, volume of advertising, candidates expenditure and Congressional Qaurterlys evaluations can be used as a measurement of campaign intensity (1991). However, in this paper, I use state partisanship as Cook Partisan Voting Index (Cook PVI) for a proxy to represent competitiveness of an election and total volume of TV ads in all candidates during general elections for the Senate to show campaign intensity.

As shown in Figure 1, there is a clear negative relationship between partisanship and total volume of TV advertisements[3]. It strongly implies that there is a negative relationship between electoral competitiveness and campaign activeness. In other words, competitive races are more likely to have active campaigns, and races for safe seats are unlikely to have active campaigns. Figure 2 also shows that relationship. The right panel is competitive races based on RealClearPoliticss Senate battleground map including Leans Republican/Democrat, Likely Republican/Democrat and Toss up races. These races have much larger volume of advertisements compared to the left panel of Figure 2 which is the races for Safe seats. Figure 2 shows that in competitive races of winnable seats, both candidates actually ran heavy campaign advertising. On the other hand, in the races for safe seats, real campaigns with TV advertising rarely exist. Therefore, it is unsuitable to study races for safe seats to examine advertising effects because they virtually do not have campaigns and campaign advertising.

[3]I used absolute values of Cook PVI for each state: Hawaiis 2014 Cook PVI is D+20 and Wyomings 2010 Cook PVI is R+20. In Figure 1, they are both 20 in the X axis.). Dependent variable which is the volume of ads is logged sum of entire advertising for general elections.

Figure 1: The Relationship between Electoral Competition and Volume of Ads in US Senate Races (2010, 2012 & 2014)

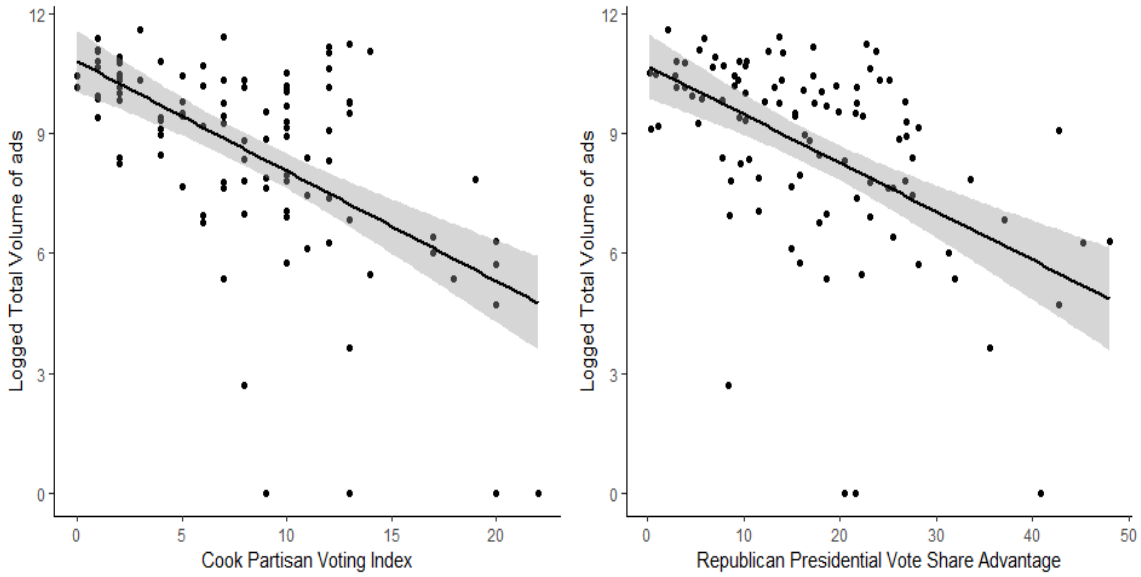
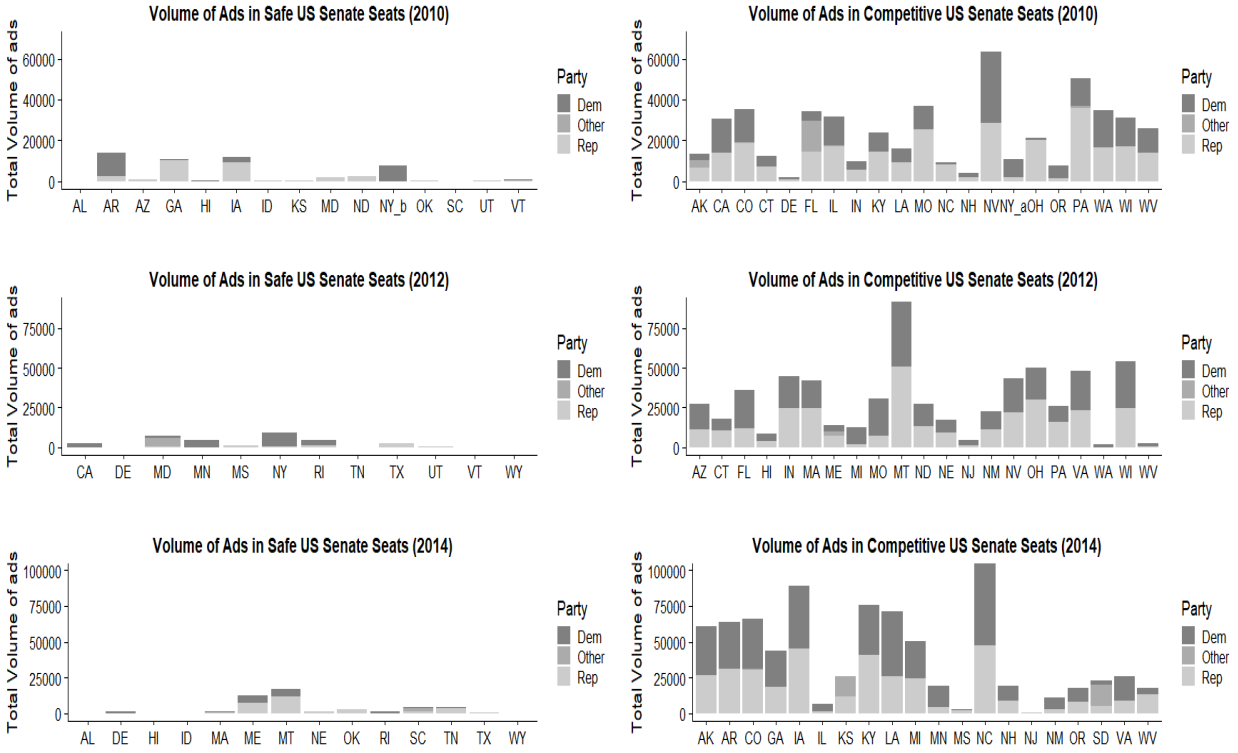


Figure 2: Volume of Advertisements between Battleground and Safe Seat Races



Polls plays two crucial roles in this study. They are the main dependent variables,

and at the same time, they were important controls that can support causal claims of my arguments. First, I will explain how statistical models deal with these polls and election outcomes. All polls are regarded equally comparable, which causes several concerns. First, polls are conducted by different organizations such that some organizations are known as Republican-leaning or Democrat-leaning in accordance with their foundations and panels. Therefore, there could be a slight selection bias in panels. Nevertheless, I believe these polls are cancelling each other out, causing no problems in studying ad effects. Second, the period of days during which polls are conducted varies. To address this problem, I dropped polls done more than 7 days. polls done more than 7 days are not useful because polls taken in a long period cannot provide accurate information of public opinion on a day.[4] Also I decided to use the last day of poll as a poll date for this study. Most polls are conducted over no more than 3 days (about 70 percent of polls are done less than 4 days), so the last day of a poll can be a reasonable standard that can reflect all ad effects during polling. However, this allows a problem in estimating accurate size of advertising effects because when we suppose a poll is done by three days, the respondents of first day of the poll is not affected by advertisements of the second and third day of polling that my arbitrary standard can limit accurate estimation of advertising effects. Third, some polls are done on the same date. This means that in an ideal world, these polls should provide the same estimates. However, because different polls have different sample sizes, collecting period, and panels, they are slightly different in some cases. In this case, I dropped polls that have longer polling period and a smaller sample size in comparison to others. If they differed by more than 5 percentage points, I averaged the polls to decide the poll results. Fourth, undecided voters in polls were not considered in the model, as actual election outcomes do not have undecided voters. It means, strictly speaking, polls and actual election outcomes differ in nature, but they are treated the same in my models. Lastly, polls have different sample sizes. Because of the

[4]The reason why I choose 7 days as a threshold to drop polls is based on Gerber et al. and Hill et al.s findings that there is no evidence that ad effects lasted more than a week in case of subnational elections and gubernatorial primary elections (2011; 2013, 532)

different sample sizes, each poll might have different weights in a regression because some polls that have a larger sample contain more information compared to the polls that have smaller sample size. I acknowledge that these limits could have precluded me from finding a precise advertising effect because I treat each poll and actual election outcome as equally comparable dependent variable.

Additionally, I need to note that the state-level polls data in this paper are different from cross sectional time series data (panel data) that is often used in observational studies. Panel data usually has certain members of panel for a study, but the polls in my studies were collected from various sources with different numbers and members of respondents in almost every poll.

The main explanatory variable, advertisement, is the number of daily ads broadcasted in each state. To acquire a more realistic analysis, ads are weighted by state population coverage of media market size. The weights are calculated based on Nielson media market 2010, 2012 and 2014 TV household Designated Market Area (DMA). (A clear example is the Hawaii media market that only has one media market. In this case, Honolulu DMA is weighted by 1. On the other hand, New Yorks DMA weights are more complicated because New York is covered by 12 different DMAs, and these DMAs also cover other states.) Gerber et al. and Hill et al. use rates of advertising as gross ratings points (GRPs), that is, estimated advertising frequency focused on reaching recipients (2011; 2013). It measures how many times targeted households watch ads. This GRP can be useful for panel data because it can provide more precise estimation of advertising exposure to the targeted recipients of panel. However, in my study, I focus on the number of ads ran in each state. Because my main dependent variables are state-level polls, and with these polls, it is impossible to estimate how many times the targeted house household watched advertisements. In other words, in this study, estimating GRPs is not available. Rather, my main explanatory variable, advertisement, is simply a daily count of ads in each DMA, and I weight them by the size of DMA in each state. It could be less precise compared to GRPs in terms of identifying the

effects of ads on the recipients who watched TV, but the ad variable in this study is a more straightforward and clear indicator showoff the effects of number of ads ran in states.

The final version of ad variable is logged Republican advantage advertisement. This format of the independent variable is accordance with the dependent variable, which is Republican advantage point in polls. Let us suppose that after the ads are weighted by media markets, the weighted value is 100, indicating that there are 100 advertisements for a Republican candidate in a day. The 100 ads will be transformed to natural log of (100 + 1). Like the Republican case, let us suppose the weighted value of ads for a Democrat candidate is 50, indicating 50 ads for a Democrat candidate in that day. Then, it will be transformed to natural log of (50 + 1). Finally, that days ad variable will be about 0.68 (4.61 - 3.93). It means that a Republican candidate has 0.68 logged advertisement advantage over a Democrat candidate on that day.

Figure 3 shows the average Republican advantage advertisement during campaigns by election years. Near actual elections, it seems that there are more ads. I divide campaign period into three to represent advertising volume (Republican advertisement advantage) over time. Negative value of Republican advertising advantage means that Democrat candidate has advertising advantage. The gap between candidates is at most about 3 logged advertisements on average; hence, one side is not dominating in terms of advertising. Figure 4 shows some competitive races dynamics of advertising during campaigns, illustrating on daily basis. In the next section, I discuss in detail the models and variables.

Figure 3: Average Republican Advantage Ads per Day by Campaign Periods

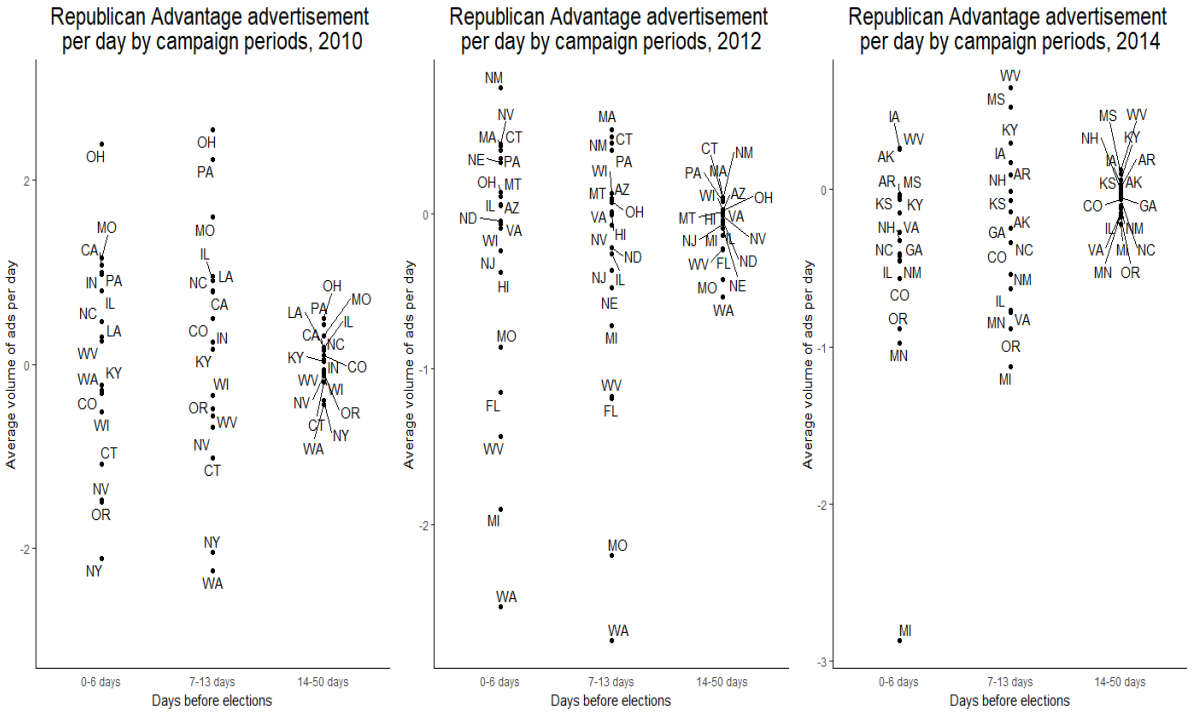
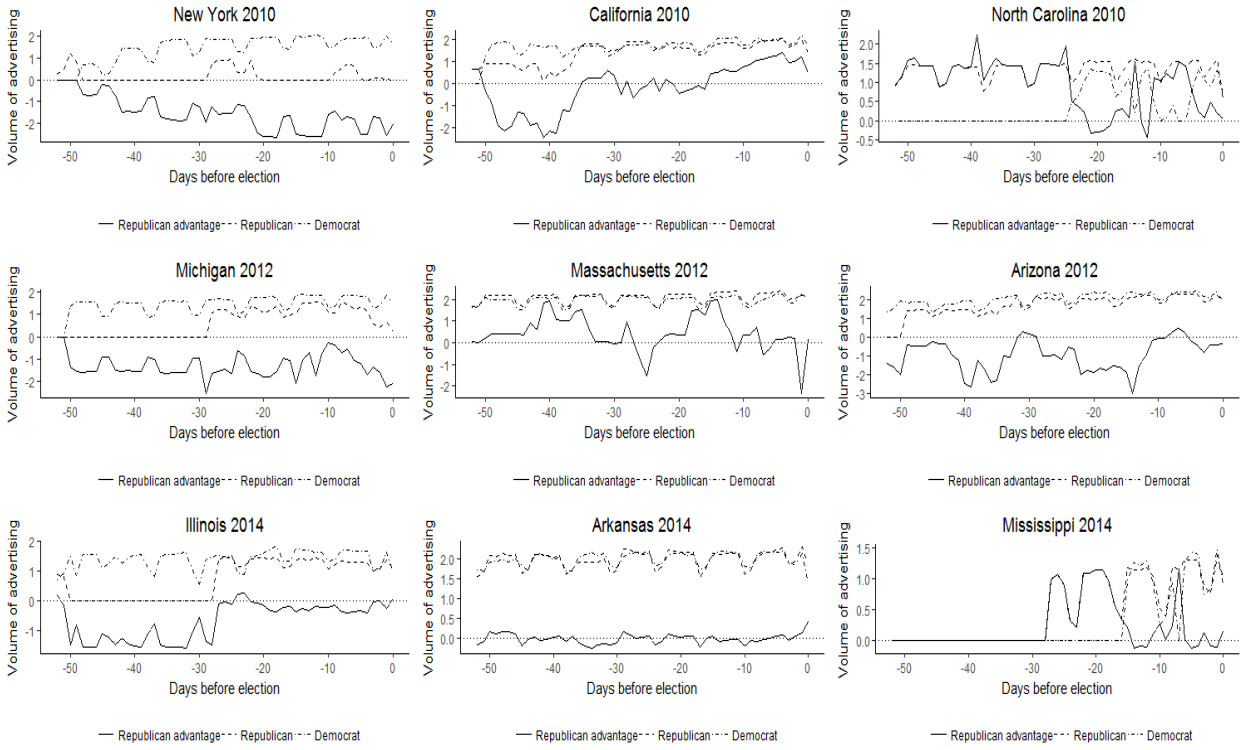


Figure 4: Advertising during Campaigns



Models

Block model: simple model for the decay of advertising effects

I start my analysis with a simple linear model, followed by non-linear closed-form decay models to estimate the decay of advertising effects. Following the study by Hill et al., I begin with a linear model employing blocks of advertising in order to find the basic pattern of decay (2013). I sum daily advertising into blocks of various lengths and examine these blocks against each other (e.g., effect of the first 3 days of ads versus the effect of next 27 days). To be specific, the blocks are aggregates of logged advertisements net differences in given periods. Block models are flexible in their modeling because of various lengths that can capture general patterns of decay.

The block model is basically OLS. The dependent variable is Republican advantage vote share (Republican vote share Democrat vote share). The main explanatory variable is logged Republican advantage advertisements (log of number of Republican ad plus 1 - log of number of Democrat ad plus 1) representing net advertising difference between Republican and Democrat candidates. One of the block models that I used is:

$$\begin{aligned}\text{Republican advantage vote share} = \beta_1 \text{ State partisanship} \\ + \beta_2 \text{ Ads from 0 to 3 days before a poll} \\ + \beta_3 \text{ Ads from 4 to 30 days before a poll} + \epsilon\end{aligned}$$

From block models, I found strong patterns of decaying effects, and the patterns imply possible application of more sophisticated closed-form decay models with finer-grained decay patterns of daily advertising.

Table 2: Equations for Decay Models

Model	Formula
Power	Republican advantage vote share $= k + g * \text{State partisanship} + \sum_{t=1}^{T} (t+1)^{-d} * \text{Republican advantage ad}$
Exponential	Republican advantage vote share $= k + g * \text{State partisanship} + \sum_{t=1}^{T} exp(-d * t) * \text{Republican advantage ad}$
Weibull	Republican advantage vote share $= k + g * \text{State partisanship} + \sum_{t=1}^{T} exp(-d * t^{0.5}) * \text{Republican advantage ad}$

Decay models: estimating initial advertising impact and decay rate

Decay model examine how well the data fits a given function, and the results are estimated parameters of ad impact and decay rate. Closed-form decay models in this paper are Exponential, Weibull and Power models, as used by Hill et al. (2013). I test all three models to check whether the models fit the data well. However, I select Weibull model as my main model, which is the median model among the three to analyze outcomes in detail. Same as block models, decay models dependent variable is Republican advantage vote share, and the main explanatory variable is Republican advantage ads. Table 2 shows the decay models with several parameters, specifically, k is an intercept, g is state partisanship (Republican presidential vote share Democrat presidential vote share), and i is the initial impact of advertising on the day of advertising. The initial impact i decays over time by the rate of d, which is a decay rate of initial impact over time t.

Main results

Block models

Block models can show general patterns of advertising effect decay. The ad variables represent the sum of net difference of logged ads in the period described. Table 4 shows the results.

In column 1, there are two groups (blocks) of ads. The results show that the sum of advertising 2 days before polls have statistically significant effects (three days including the day of polling) while the remaining ad blocks, the sum of advertising from 3 days before polls to 30 days before polls have no significant effects. In every different combinations of different ad blocks, ads more than a week before elections do not have significant effects on polls and elections. It implies that advertising a week before elections is not effective. The main takeaway from the decay model can be found from column 4: advertising a day before is only effective. It means advertising effect decays very quickly.

On the other hand, there are several interesting findings from the block models. In column 2 and 3, the coefficient of ads 3 to 5 days before polls is negative, -0.25 and -0.22 respectively, and they statistically significant. In column 4, advertising on the day of polls and elections is not significant, but only the advertising a day before polls and elections holds statistical significance. These findings leave two questions: First, is it really true that advertising a day before polls and elections has no effects? Second, do ads 3 to 5 days before polls and elections have negative effects? I believe the interpretations of these results in column 2, 3 and 4 are not straightforward due to a problem with the polls in my study. As discussed, the last day of poll is set as a poll day; therefore, I believe more reasonable interpretations are advertising only a few days before polls and elections has effects. Overall, the findings from block models are consistent with the results from Hill et. al.s paper in that in the subnational elections, the effect of TV campaign advertising decays rapidly (2013).

To sum up, the key finding from block models are even if these models show different size

Table 3: Results of OLS Models for 2010, 2012 & 2014 Senate Elections

	Dependent variable:				
	Repadvantage				
	(1)	(2)	(3)	(4)	(5)
Presidentialadv	0.542***	0.532***	0.539***	0.533***	0.537***
	(0.076)	(0.076)	(0.076)	(0.076)	(0.076)
ad123_sum	0.315***	0.394***	0.395***		
	(0.076)	(0.089)	(0.089)		
ad4_30_sum	0.018				
	(0.026)				
ad456_sum		−0.114	−0.193		
		(0.134)	(0.123)		
ad789_sum		−0.166			
		(0.151)			
ad10_30_sum		0.091**			
		(0.041)			
ad1_6_sum					0.160***
					(0.048)
ad7_30_sum			0.053		0.022
			(0.032)		(0.031)
ad1				0.663***	
				(0.231)	
ad2				0.402	
				(0.296)	
ad3				−0.186	
				(0.358)	
ad4				0.391	
				(0.412)	
ad5				−0.155	
				(0.450)	
ad6				−0.338	
				(0.534)	
ad7				−0.296	
				(0.424)	
ad8_30_sum				0.079**	
				(0.037)	
Observations	901	901	901	901	901
Each race fixed effects	✓	✓	✓	✓	✓
R^2	0.771	0.772	0.771	0.773	0.769
Adjusted R^2	0.755	0.756	0.756	0.756	0.754
Residual Std. Error	4.477 (df = 845)	4.468 (df = 843)	4.472 (df = 844)	4.469 (df = 839)	4.495 (df = 845)
F Statistic	50.694*** (df = 56; 845)	49.229*** (df = 58; 843)	49.981*** (df = 57; 844)	46.107*** (df = 62; 839)	50.184*** (df = 56; 845)
Note:					*p<0.1; **p<0.05; ***p<0.01

of effect, we can clearly observe that advertising only a few days before polls and elections has significant effects. Early advertising is ineffective and advertising only a few days before polls and elections are effective. Possibly, advertising could be only effective for a day or two. From block model, I observe strong patterns of decay, so now I will explain a closed-form decay model to measure decay rates of communication effects.

Closed-form decay model

Different from block model, decay model can estimate the effect of daily advertising more accurately. For decay model, the net difference in advertising per day is required, which is log of Republican number of ad (plus 1) minus log of Democrat number of ad (plus 1) for each day. Advertising effects can be interpreted in two ways: First, the decay models advertising impact parameter is the size of advertising effect on the day of advertising. Second, to check the total advertising effects for the given time, the advertising impact should be weighted by decay parameter in the decay model, and I need to sum the weighted advertising impact for the given period of time. For instance, in this paper, I include 50 days of advertising for each polls and elections to estimate decay models parameters (including the day of polling) and to understand total effects of advertising for 50 days, I need to sum initial advertising impacts weighted by decay parameter. Hill et al. (2013) state that each decay model has unique mathematical properties; however, I independently choose Weibull model as my main model in this paper, although I test all three models with the data (2013a, 534). My aim in this section is to investigate more precise decay rates and the effect of advertising with the given data.

Table 4: Results of Decay Models Parameter Estimates U.S. Senate Elections

	Dependent variable: Logged Republican advantage vote share		
	(Power)	(Weibull)	(Exponential)
State partisanship	3.605***	3.605***	3.607***
	(0.708)	(0.709)	(0.710)
Ads impact parameter	0.327***	0.202***	0.115***
	(0.089)	(0.055)	(0.020)
Decay parameter	0.593***	0.273***	0.029**
	(0.103)	(0.069)	(0.008)
Intercept	-25.303***	-25.333***	-25.37***
	(5.893)	(5.903)	(5.914)
Observations	901	901	901
Each race fixed effects	✓	✓	✓
Quasi R^2	0.788	0.787	0.786
Log-likelihood	-2549.781	-2551.341	-2552.946
Note:			*p<0.1; **p<0.05; ***p<0.01

Figure 5: Decay of Advertising Effects

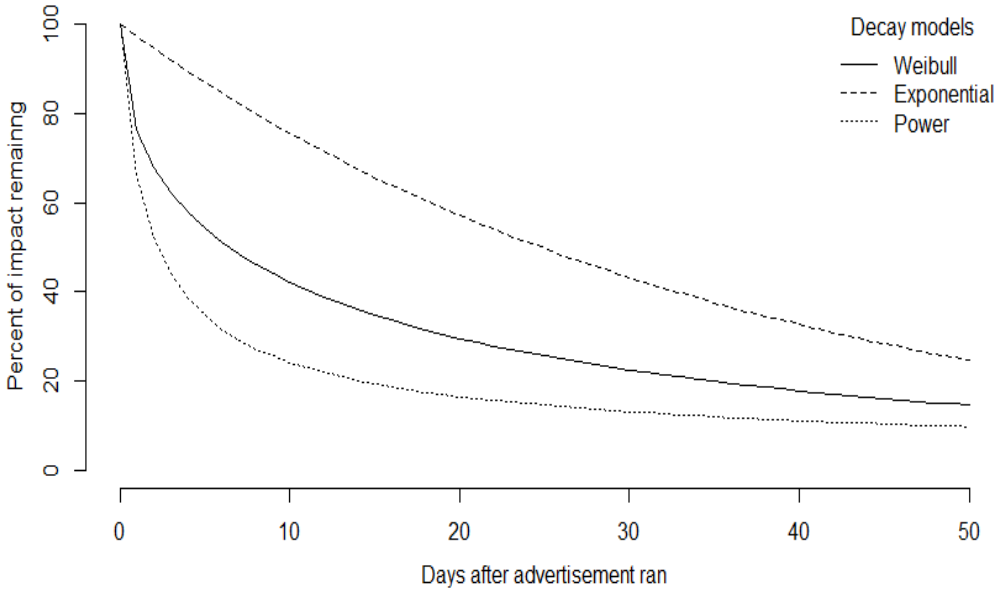


Table 5 shows the outcomes of the accumulated data of 2010, 2012 and 2014. There are two main findings: the size of initial advertising effects (impacts) and decay rates of the initial impact. At first, the size of advertising effects is about 0.67 on the day of advertising; if a candidate has one logged advertisement advantage on the day of advertising, the candidates vote share increases about 0.67 percent according to Weibull model. This initial impact decrease rapidly and to understand the speed of decay, I need to visualize decay rate. Figure 6 visualizes the decaying effects based on Table 5. The figure 6 shows the remaining percentage of initial advertising impact after the ad runs from day 0, and it clearly shows the fast decay of initial impact. A day after advertising, the advertising effects drop rapidly that only about a half of the initial effects left. After 5 days, about 10 percent of initial effect remains and after 20 days, only about 5 percent of the initial effect remained according to Weibull model. This rapid decay rate follows the findings of decay pattern from block models.

We could compare three models (Exponential, Power and Weibull) with their log-likelihood. Among three, Power model shows the best fit, but their differences are marginal. Exponential model shows stable statistical significance in all estimated parameters at 0.05 level and the next is power model. Weibull model holds statistical significance in decay parameter, but initial ad impact parameters standard errors include zero. Although Weibull model does not hold statistical significance in all parameters, as stated, I chose Weibull model to explain my findings because it is the median among three models. In the next section, to examine decay models further, I test advertising effects in various conditions considering majority of my data, polls characteristics.

Pools of polls

My data mainly consists of polls. As discussed in the data section, polls are useful indicators of how advertising effects affect election and polling outcomes. In an ideal world of studying advertising effects, all polls would be conducted in one day, like an actual election. However, in reality, only 324 out of 901 dependent variables are collected in one day, including 54 actual

elections, which precludes me from investigating more accurate decay rates and impact sizes of advertising. Therefore, to compare and examine polls that are surveyed more than one day, I create several pools of polls and applied decay models to each pool.

Interestingly, different pools of polls show slightly different outcomes in decay rates as well as the size of initial impacts. Figure 7 visualizes decay rates, and Table 6 lists the estimates. I originally expected different pools of polls to show different results or more significant estimations because the 1 day poll pool, including actual election outcomes, would allow me to estimate the decay rate as well as the advertising effect more precisely. I need to note that if the decay rate is larger, the advertising effect decays more rapidly. From the model 7, the full data (1-7 days polls) of my study, to the model 3, pools of 1 to 3 days polls, decay rates are almost same. Then, model 1 and 2 show smaller decay rates than the other models decay rates. The pattern is interesting that from model 7 to model 3, the decay rates increase but model 1 and 2 have relatively smaller decay rates. This pattern of smaller decay rates with pools of 1 day only and 1 to 2 days polls are observed in Exponential and Power models as well.[5] Moreover, this pattern can be found in case of initial ad impact. Perhaps, as model 1 and 2 show, actually, advertising effects could have more gradual decay rate and smaller initial impact. It is because model 1 and 2 with 1 day and 1 to 2 days polls are close to the conditions of real elections. However, model 1 and 2 have smaller sample and it is unclear why the estimated decay rate and initial ad impact in model 1 and 2 drop substantively after model 3. (The results from model 3 from model 7 are quite consistent.) Additionally, although best estimated parameters are different, all models estimates overlap with each other within standard errors. Therefore, even though models for the different pools of polls do not satisfy my original expectations, they consistently show a clear pattern of rapid decay, corresponding to my analysis in previous sections.

[5]The fuller explanation of Exponential and Power models with different pools of polls can be found in Appendix.

Table 5: Results of Decay Models Parameter Estimates

Days of polls	1 day	1-2 days	1-3 days	1-4 days	1-5 days	1-6 days	1-7 days
State partisanship	5.13***	3.942***	3.926***	3.660***	3.632***	3.615***	3.605***
	(1.264)	(0.901)	(0.860)	(5.934)	(0.707)	(0.708)	(0.709)
Ads impact parameter	0.204.	0.189*	0.194**	0.197**	0.201***	0.202***	0.202***
	(0.106)	(0.082)	(0.069)	(0.063)	(0.058)	(0.055)	(0.055)
Decay parameter	0.297*	0.278*	0.293**	0.289***	0.282***	0.273***	0.273***
	(0.134)	(0.110)	(0.090)	(0.081)	(0.058)	(0.070)	(0.069)
Constant	-37.552***	-28.552***	-28.362***	-25.920***	-25.620***	-25.439***	-25.333***
	(10.984)	(7.622)	(7.184)	(5.934)	(5.899)	(5.908)	(5.903)
Observation	324	447	644	753	819	859	901
Each race fixed effects	✓	✓	✓	✓	✓	✓	✓
Quasi R-squared	0.818	0.781	0.782	0.778	0.783	0.788	0.787
Log likihood	-889.2715	-1256.992	-1805.7	-2123.463	-2311.616	-2427.578	-2551.341

Note: Weibull model is used. *p<0.1; **p<0.05; ***p<0.01

Figure 6: Decay of Advertising Effects by Different Pools of Poll Dates

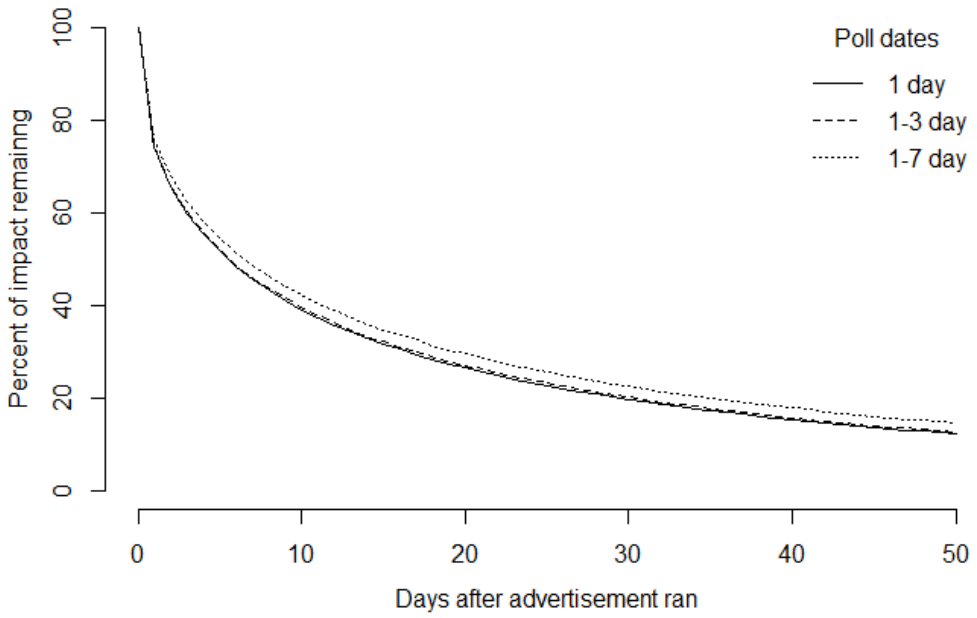


Table 6: Estimation of Total Advertising Effects over Time

Duration of advertising	3 days	7 days	50 days
Ad effect parameter	0.202***	0.202***	0.202***
	(0.055)	(0.055)	(0.055)
Total ad effect over time	0.618	1.047	3.242

Note: *p<0.1; **p<0.05; ***p<0.01
Imaginary scenarios of 2-1 advertising condition.
The estimates are from Table 6.

Estimating total advertising effects

I explained the decay rates and initial ad impacts from decay model. However, in addition to the analysis of estimated parameters, I need to explain how these decaying effects can be understood as a total effect over time. Therefore, I estimate and illustrate the size of advertising effects over time when advertisements are run continuously during campaigns in table 7. Let us suppose that Republican candidate has advantage of one logged advertisement per day over a Democrat candidate for 3 days, 7 days, and 50 days. According to Weibull model, in a scenario of 50 days of advertising, total effect of 50 days of advertising is about three times larger compared to the total effect of 3 days of advertising as shown in table 7. The difference of about 2.11 percent vote share is substantial, and it can change an election outcome. However, considering the difference between 3 days and 50 days of advertising, 0.98 percent vote share advantage of Republican candidate can be regarded as a marginal difference. This becomes clear when I compare 3 days and 7 days of advertising, and 3 days and 50 days of advertising. Four more days of advertising brings about 0.43 (1.56 1.13) percent advantage in vote share. However, 47 days of more advertising only results in about 0.98 (2.11 1.13) percent more advantage in vote share. The diminishing effects of advertising over time mean that advertising long before an election is highly ineffective. This finding suggests limitation of campaign advertising effects and importance of campaign strategies that late advertising advantage can easily outweigh early advertising advantage (Hill et al. 2013).

Discussion

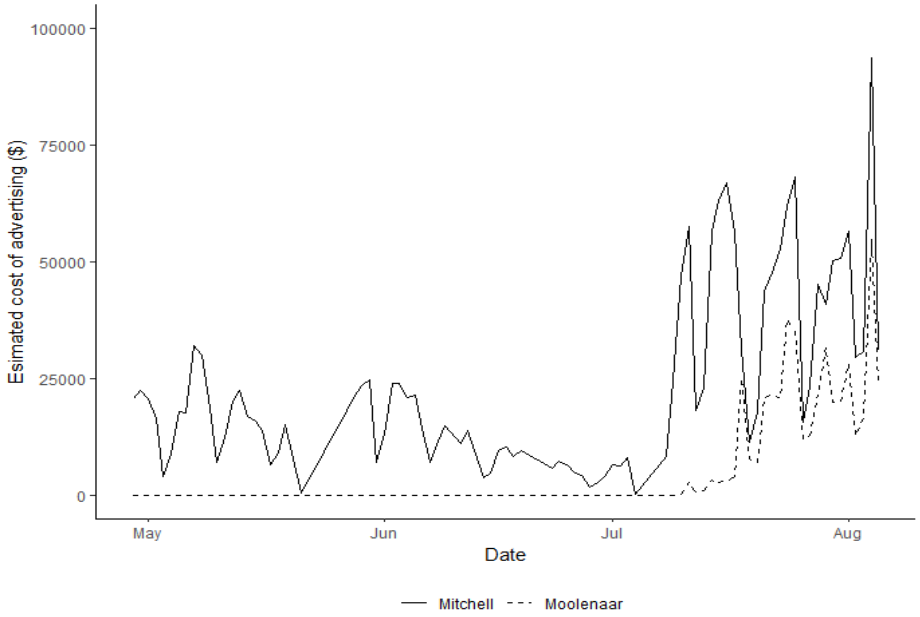
Importance of findings

There are three important findings in the context of campaigns. First, as Hill et al.s study shows, my finding is a good news for a relatively underfunded candidate because advertising effects on elections are somewhat limited that early advertising has almost no effect or very minimal effects (2013). In other words, political money has somewhat limited effects on elections. Also a candidate may save the money for early advertising to use it for a sprint finish because late advertising can override early advertising in competitive races. An exemplary real word case can be the Republican nomination in Michigan 4th district 2014. A millionaire candidate, Paul Mitchell outspent John Moolenaar about $3.65 million to $1.25 million, but Mitchell lost in the election. The interesting point is Mitchell had advertised starting from early campaign which is April, but Moolenaar started advertising in the mid July which is less than a month before the election date. A poll conducted by Practical EPIC-MRA on July 12th to 13th shows that Paul Mitchell (50%) is ahead of Moolenaar (23%) by 27 percent, and this is a big margin. However, the actual election outcome was the opposite. There can be many stories and other factors behind this surprising election outcome. For instance, it was a primary not a general election and there were different groups behind of these two candidates in that Mitchell was a Tea party candidate and Moolenaar was the Chamber of Commerce candidate. However, one of the most important points is, early advertising is ineffective, so Mitchell wasted lots of money in early campaigning. As figure 8 shows, from April 29th to July 10th, Mitchell spent $ 0.87 million that is about 40% of his total spending on TV advertising but Moolenaar spent nothing. Starting from July 10th, Moolenaar began his advertising.[6] Therefore, as my finding argues, less-funded candidates could have a chance to defeat well-funded candidates by spending money strategically. However, more studies are required to understand the rapid decay of advertising effects in

[6] I used the daily estimated cost of advertising made by Wesleyan Media Project for spending of advertising.

different settings and conditions.

Figure 7: Estimated Spending of Candidates by Dates
(House Primary Michigan 4th District 2014)



Second, advertising has significant effects on competitive races. Campaign advertising itself could not change the outcomes of elections probably in most cases. It is most likely because there are many safe seats in U.S. subnational elections, and the races for these safe seats are not accompanied with active campaigns. More than a half of U.S. Senate elections in 2010, 2012 and 2014 were safe seats. It is an empirical and theoretical question whether uncompetitive races and vanishing marginals in elections mean the declines of healthy vigorous democracy or not; however, competitive campaigns and elections are an important feature of democracy (Barrilleaux, Holbrook, and Langer 2002; Enos and Hersh 2015; Fiorina 1977; Holbrook and Dunk 1993; Mayhew 1974; Squire 2000). In competitive subnational races, my findings show that advertising has short-lived but substantial effects on winning votes. However, one could argue that my findings have limitations in that I only study competitive races accompanied with active campaigns. Indeed, in many uncompetitive races, campaign advertising may not have significant effects. It is because competitive elections have several important features. The competitive races have real campaigns and more media coverage;

voters could be more mobilized and have better knowledge about the elections, and show higher turnout (Geys 2006; Jackson 1996; Sides, Brady, and Johnston 2006; Stone, Maisel, and Maestas 2004; M. C. Westlye 1983). In this regard, my findings may not be applied to uncompetitive races where the winners of races are almost predetermined without proper campaigns. However, I argue that those uncompetitive races cannot be a good subject for a study of campaign and campaign advertising simply because they are not there.[7]

TV Advertising could have made a crucial difference in close races in close races. In 2010, Michael Bennet won the election by 0.9 percent vote share in Colorado senate race, in 2012, Heitkamp won the senate seat of North Dakota by 0.9 percent vote share, and in 2014 Warner barely defeated Gillespie by 0.8 percent vote share in Virginia. It means the defeated could have won if they had three logged advertising advantage on the day of elections. Indeed, advertising itself may not determine a winner of a race, as many other factors can have greater effects on elections. However, in a close race, advertising near elections can change the election outcomes. Lastly, my findings also suggest that voters may not engage elections and campaigns with thoughtful attentions (Hill et al. 2013). Because advertising has short-lived and substantial effects, it is doubtful whether voters actually receive and learn messages and information from candidates campaigns. However, on the other hand, it is not surprising if voters do not take 30 seconds length ads seriously. Maybe voters are affected by ads without knowing (cognitively), and that is the mechanism that advertising affects voters. Voters may engage in other types of political communication such as in-person canvassing, media coverage or Facebook posts differently, more seriously.

[7] A recent study by Kalla and Brookman argues that overall campaign contact and advertising decays immediately that the advertising effect of persuading voters on general election date almost always goes to zero in competitive as well as uncompetitive elections (2017). Moreover, they argue that it is difficult to expect even short-lived effects of campaign advertising once campaigns from all sides heat up (2, Kalla and Brookman 2017). Their meta analysis contain the results from two fields experiments by Gerber et al. (2011) and Kalla and Sekhon (2017), and argue TV advertising effects in general elections are almost zero. However, they did not measure how fast the effect decays and what is the size of initial effects right after advertising. In competitive races where all sides are covered by media and run substantive amount of ads, I argue that I could measure decay rate and advertising effects by using polls.

Conclusion

To recapitulate, this study offers two main findings. The first is that advertising effects decays rapidly. After a day, initial advertising effect drops by about 60 percent and only less than 20 of initial advertising effect remains after 5 days based on Weibull models. This pattern of rapid decay is largely similar in Power and Exponential models. After a few days, the remaining advertising effect is minimal. The second is advertising has substantial consequential effects on polls and election outcomes in subnational elections. One more logged advertising advantage on a day can result in about 0.67 percent vote share increase on that day. Although the effects decrease fast, advertising has substantial effects in a short period of time.

Regardless of tons of campaign advertisements, ads run only a few days before elections have meaningful effects on elections: less than a quarter of the advertising effects on day 0 is left after five days. Furthermore, not to mention, advertising a month before elections has minimal effects. Therefore, I believe that lots of money is wasted on early advertising to win an election. Although limitations of my study include the lack of strong statistical significance, the outcomes provide evidence that advertising has short-lived and substantial effects on polls and elections.

As a student of political science and a citizen of democracy, I wanted to identify the effect of political advertising on elections. Regardless of whether advertising is good for citizens, as it gives them political information and encourages us to participate in politics, or whether it is bad as it can psychologically and emotionally influence citizens, that it means the rich and the powerful has have a greater political influence on elections than do lay citizens. However, at least, I find that political advertising has sizeable effects on the results of polls and elections; therefore, we should avoid being simply swayed by advertising influence when making a political decision.

References

Ansolabehere, Stephen and James M Snyder Jr (2000). "Soft money, hard money, strong parties". In: *Columbia Law Review*, pp. 598–619.

— (2002). "The incumbency advantage in US elections: An analysis of state and federal offices, 1942–2000". In: *Election law journal* 1.3, pp. 315–338.

Barrilleaux, Charles, Thomas Holbrook, and Laura Langer (2002). "Electoral competition, legislative balance, and American state welfare policy". In: *American Journal of Political Science*, pp. 415–427.

Bartels, Larry M (2000). "Partisanship and voting behavior, 1952-1996". In: *American Journal of Political Science*, pp. 35–50.

Caughey, Devin and Jasjeet S Sekhon (2011). "Elections and the regression discontinuity design: Lessons from close US house races, 1942–2008". In: *Political Analysis* 19.4, pp. 385–408.

DellaVigna, Stefano and Ethan Kaplan (2007). "The Fox News effect: Media bias and voting". In: *The Quarterly Journal of Economics* 122.3, pp. 1187–1234.

Enos, Ryan D and Eitan D Hersh (2017). "Campaign perceptions of electoral closeness: Uncertainty, fear and over-confidence". In: *British Journal of Political Science* 47.3, pp. 501–519.

Erikson, Robert S and Thomas R Palfrey (2000). "Equilibria in campaign spending games: Theory and data". In: *American Political Science Review* 94.3, pp. 595–609.

Fiorina, Morris P (1977). "The case of the vanishing marginals: The bureaucracy did it". In: *American Political Science Review* 71.1, pp. 177–181.

Gerber, Alan S et al. (2011). "How large and long-lasting are the persuasive effects of televised campaign ads? Results from a randomized field experiment". In: *American Political Science Review* 105.1, pp. 135–150.

Geys, Benny (2006). "Explaining voter turnout: A review of aggregate-level research". In: *Electoral studies* 25.4, pp. 637–663.

Hastie, Reid and Bernadette Park (1986). "The relationship between memory and judgment depends on whether the judgment task is memory-based or on-line." In: *Psychological review* 93.3, p. 258.

Herb, Michael (2005). "No representation without taxation? Rents, development, and democracy". In: *Comparative Politics*, pp. 297–316.

Hill, Seth J et al. (2013). "How quickly we forget: The duration of persuasion effects from mass communication". In: *Political Communication* 30.4, pp. 521–547.

Holbrook, Thomas M and Emily Van Dunk (1993). "Electoral competition in the American states". In: *American Political Science Review* 87.4, pp. 955–962.

Jackson, Robert A (1996). "The mobilization of congressional electorates". In: *Legislative Studies Quarterly*, pp. 425–445.

Johnston, Richard GC, Henry E Brady, and Richard Johnston (2006). *Capturing campaign effects*. University of Michigan Press.

Kalla, Joshua L and David E Broockman (2018). "The minimal persuasive effects of campaign contact in general elections: Evidence from 49 field experiments". In: *American Political Science Review* 112.1, pp. 148–166.

Kalla, Joshua L. and Jasjeet S. Sekhon (2017). "Do TV Ads Persuade? A Randomized Experiment in the 2016 Presidential Election". In: *Working paper*.

Keele, Luke and Nathan J Kelly (2006). "Dynamic models for dynamic theories: The ins and outs of lagged dependent variables". In: *Political analysis* 14.2, pp. 186–205.

Klapper, Joseph T (1960). *The effects of mass communications*. Free Press of Glencoe.

Lodge, Milton, Kathleen M McGraw, and Patrick Stroh (1989). "An impression-driven model of candidate evaluation". In: *American Political Science Review* 83.2, pp. 399–419.

Lodge, Milton, Marco R Steenbergen, and Shawn Brau (1995). "The responsive voter: Campaign information and the dynamics of candidate evaluation". In: *American political science review* 89.2, pp. 309–326.

Mayhew, David R (1974). "Congressional elections: The case of the vanishing marginals". In: *Polity* 6.3, pp. 295–317.

Mehrabian, Lbert (1998). "Effects of poll reports on voter preferences". In: *Journal of Applied Social Psychology* 28.23, pp. 2119–2130.

Mitchell, Dona-Gene (2012). "It's about time: The lifespan of information effects in a multiweek campaign". In: *American Journal of Political Science* 56.2, pp. 298–311.

Rubin, David C and Amy E Wenzel (1996). "One hundred years of forgetting: A quantitative description of retention." In: *Psychological review* 103.4, p. 734.

Schneider, Saundra K and William G Jacoby (2005). "Elite discourse and American public opinion: The case of welfare spending". In: *Political Research Quarterly*, pp. 367–379.

Squire, Peverill (2000). "Uncontested seats in state legislative elections". In: *Legislative Studies Quarterly*, pp. 131–146.

Stone, Walter J, L Sandy Maisel, and Cherie D Maestas (2004). "Quality counts: Extending the strategic politician model of incumbent deterrence". In: *American Journal of Political Science* 48.3, pp. 479–495.

Westlye, Mark C (1983). "Competitiveness of Senate seats and voting behavior in Senate elections". In: *American Journal of Political Science*, pp. 253–283.

Westlye, Mark Christopher (1991). *Senate elections and campaign intensity*. Johns Hopkins University Press.

Zaller, John (1998). "Politicians as prize fighters: Electoral selection and incumbency advantage". In: *Politicians and party politics*, pp. 125–85.

Appendix

Summary statistics of ads and State partisanship

Table 7: Decay models with year and state fixed effects

	Mean	Standard deviation
Total ads (raw)	16215.28	12616.27
Republican ads	16318.87	12565.09
Democrat ads	16111.69	12784.38
Logged total ads (and weighted by DMAs)	7.96	1.21
Republican ads	7.86	1.38
Democrat ads	8.06	1.00
Logged Republican ad advantage (Logged Republican ad Logged Democrat ad)	-0.21	1.06
State partisanship	-1.43	8.65

Decay models with year and state fixed effects

Table 8: Decay models with year and state fixed effects

	Power		Weibull		Exponential	
State partisanship	0.244***	-0.075.	0.244***	-0.077*	0.245***	-0.076*
	(0.018)	(0.038)	(0.018)	(0.038)	(0.018)	(0.039)
Ads impact parameter	1.100***	0.503***	0.244***	0.319***	0.329***	0.187***
	(0.280)	(0.102)	(0.018)	(0.060)	(0.052)	(0.023)
Decay parameter	0.923***	0.517***	0.523***	0.231***	0.070***	0.021***
	(0.119)	(0.075)	(0.080)	(0.046)	(0.013)	(0.005)
Intercept	-0.429	16.592***	-0.478	16.539***	-0.538	16.487***
	(0.429)	(3.211)	(0.430)	(3.225)	(0.431)	(3.237)
Observations	901	901	901	901	901	901
Year fixed effects	✓		✓		✓	
State fixed effects		✓		✓		✓
Quasi R^2	0.441	0.637	0.439	0.633	0.435	0.631
Log-likelihood	-2986.617	-2792.583	-2988.451	-2796.497	-2991.471	-2799.849

Note: *p<0.1; **p<0.05; ***p<0.01

Effect of state partisanship on Senate election

Table 9: Effect of state partisanship on polls and election outcomes

	Dependent variable: Republican advantage vote share (Senate)			
	(1)	(2)	(3)	(4)
State partisanship	0.209***	0.565***	0.283***	−0.140***
	(0.022)	(0.076)	(0.021)	(0.047)
Constant	−0.306			
	(0.309)			
Observations	901	901	901	901
Race fixed effects		✓		
Year fixed effects			✓	
State fixed effects				✓
R^2	0.091	0.764	0.277	0.484
Adjusted R^2	0.090	0.749	0.274	0.462
Residual Std. Error	8.529 (df = 899)	4.535 (df = 847)	7.715 (df = 897)	6.639 (df = 864)
F Statistic	89.978*** (df = 1; 899)	50.813*** (df = 54; 847)	85.908*** (df = 4; 897)	21.924*** (df = 37; 864)

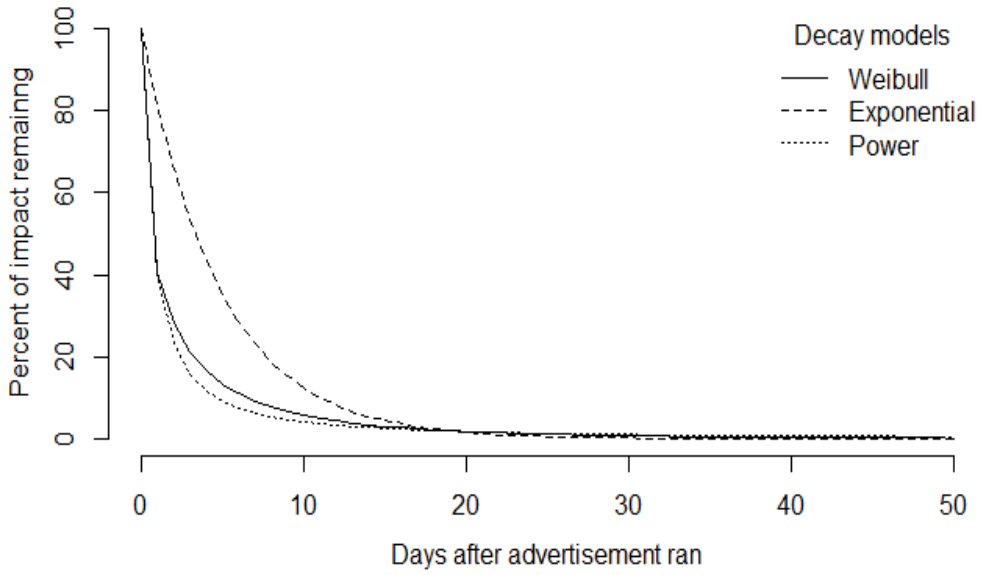
Note: *p<0.1; **p<0.05; ***p<0.01

Decay models with lagged dependent variables

Table 10: Results of Decay Models Parameter Estimates with lagged dependent variable (lagged polls)

	Dependent variable: Logged Republican advantage vote share		
	(Power)	(Weibull)	(Exponential)
Lagged polls	0.759***	0.759***	0.761***
	(0.022)	(0.022)	(0.022)
Ads impact parameter	0.831.	0.669	0.306*
	(0.436)	(0.407)	(0.135)
Decay parameter	1.329***	0.899*	0.209**
	(0.304)	(0.268)	(0.087)
Intercept	-0.276.	-0.260	-0.255
	(0.167)	(0.166)	(0.166)
Observations	847	847	847
Quasi R^2	0.731	0.732	0.732
Log-likelihood	-2525.906	-2524.719	-2524.961
Note:			*p<0.1; **p<0.05; ***p<0.01

Figure 8: Decay of Advertising Effects with Lagged Dependent Variable



Different size of market

Because unlike Hill et al. (2013)'s paper, my analysis is state level effect of advertising effect on polls and election outcomes. Their unit of analysis DMA, but because my unit of analysis is state level I gave different weights based on size of media market in each state (I explained this in detail in my paper). Therefore, one concern is possible measurement errors from this weights. The clearest case would be Hawaii where one state has only one media market. However, most states are covered by many media markets as table A.1 shows.

Table 11: Summary of the numbers of media markets and elections

Number of media market	1	2	3	4	5	6	7	8	9	11	12	17
Race	HI	CT, NV, ND, NJ, NM (12),	CO, AZ, MA, AK, NM	OR, WA, NE, NH	WV	NC, MT, PA	IN (10), MI (12), WI, AR, IL (14)	IL (10), KY (10), IN (12), VA, GA, IA, KS, MI (14), MS	NY, MO (2012), KY (14)	OH (10), FL	CA	OH (12)
Number of variables	3	111	85	77	32	112	90	197	61	59	31	43

Table 12: Different numbers of media markets and estimates of decay models

	Power				Weibull				Exponential			
Number of Markets	1-5	1-4	1-3	1-2	1-5	1-4	1-3	1-2	1-5	1-4	1-3	1-2
State partisanship	1.313**	3.456**	2.444***	0.368***	1.340**	3.631**	2.446***	0.369***	1.354**	3.678**	2.885***	0.369***
	(0.430)	(1.147)	(0.396)	(0.040)	(0.432)	(1.152)	(0.398)	(0.041)	(0.432)	(1.151)	(0.380)	(0.042)
Ads impact parameter	0.238	0.237	0.152.	0.172	0.109	0.095	0.078	0.079	0.055.	0.062*	0.376	0.064
	(0.314)	(0.145)	(0.837)	(0.145)	(0.091)	(0.063)	(0.053)	(0.077)	(0.030)	(0.026)	(0.498)	(0.040)
Decay parameter	0.691*	0.610*	0.390*	0.436	0.259	0.168	0.092	0.091	0.019	0.014	0.339	0.009
	(0.314)	(0.243)	(0.177)	(0.292)	(0.215)	(0.157)	(0.142)	(0.211)	(0.025)	(0.018)	(0.419)	(0.024)
Constant	0.438	25.483.	15.870***	-2.914 *	0.630	27.357*	15.816***	-2.937*	0.722	27.865*	17.894***	-2.943*
	(4.434)	(13.219)	(2.458)	(1.241)	(4.450)	(13.266)	(2.470)	(1.238)	(4.452)	(13.269)	(2.449)	(1.239)
Observation	308	276	199	114	308	276	199	114	308	276	199	114
Each race fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Quasi R-squared	0.795	0.800	0.773	0.779	0.794	0.800	0.771	0.779	0.794	0.799	0.764	0.779
Log likihood	-852.2317	-741.0718	-521	-305.4358	-852.6522	-741.1968	-521.6678	-305.2189	-852.8975	-741.3719	-524.6825	-305.2395

Note: Weibull model is used.

*p<0.1; **p<0.05; ***p<0.01