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The Republicans Should Pray for Rain: Weather, Turnout, and Voting in U.S. Presidential Elections

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The relationship between bad weather and lower levels of voter turnout is widely espoused by media, political practitioners, and, perhaps, even political scientists. Yet, there is virtually no solid empirical evidence linking weather to voter participation. This paper provides an extensive test of the claim. We examine the effect of weather on voter turnout in 14 U.S. presidential elections. Using GIS interpolations, we employ meteorological data drawn from over 22,000 U.S. weather stations to provide election day estimates of rain and snow for each U.S. county. We find that, when compared to normal conditions, rain significantly reduces voter participation by a rate of just less than 1% per inch, while an inch of snowfall decreases turnout by almost .5%. Poor weather is also shown to benefit the Republican party's vote share. Indeed, the weather may have contributed to two Electoral College outcomes, the 1960 and 2000 presidential elections.

> "The weather was clear all across Massachusetts and New England perfect for voting as far as the crest of the Alleghenies. But from Michigan through Illinois and the Northern Plains states it was cloudy: rain in Detroit and Chicago, light snow falling in some states on the approaches of the Rockies. The South was enjoying magnificently balmy weather which ran north as far as the Ohio River; so, too, was the entire Pacific Coast. The weather and the year's efforts were to call out the greatest free vote in the history of this or any other country."
>
> – Theodore H. White
> (1960, *The Making of the President*)

Voter participation is among the most widely studied aspects of political life. Scholars have long examined the individual and systemic factors that guide the decision to turnout on any given election day. It is both well established and widely accepted that individuals with higher levels of education and income, among other socioeconomic factors, participate in elections at a rate greater than their lower resourced counterparts (e.g., Wolfinger and Rosenstone 1980). Individuals low in socioeconomic status simply find it more difficult to bear the costs of voting, which includes both decision costs and the direct costs of registering and going to the polls. Government-imposed barriers also stand as a significant obstacle to voter participation (e.g., Nagler 1991). Yet, among all the factors that might affect the decision to vote, one potential correlate stands out, both for its broad acceptance in the popular mind and its near utter lack of empirical validation—the weather.

The relationship between bad weather and lower levels of voter turnout is widely espoused by media, political practitioners, and, perhaps, even political scientists.[1] In his book, *The Weather Factor* (1984), the historian David Ludlum suggests that popular acceptance of the weather-turnout thesis dates to at least the nineteenth century, where New York newspapers provided readers with detailed weather reports for polling places around the state. Today, more modern methods are used to propagate the weather-turnout thesis. For instance, preceding the 2004 U.S. presidential election, the highly respected meteorological firm, Accu-Weather, issued a press release offering election day

[1]William G. Andrews (1966) authored one of the earliest political science articles to cite weather as a correlate with voter turnout. We thank Michael P. McDonald for bringing this work to our attention.

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forecasts for 17 battleground states and went so far as to offer a rationale for how weather might affect voter turnout.[2] Given that AccuWeather's clients include CNN, ABC News, *The New York Times*, and numerous other local and national media outlets, it is likely that the weather-turnout thesis was disseminated to millions of Americans as fact. Among political practitioners, acceptance of the thesis also seems strong. On the morning of the 2004 New Hampshire presidential primary, noted Democratic consultant, James Carville, told CNN "heavy snow [expected in the state] could affect the turnout, particularly among the elderly."[3] Republican campaign operatives seem no less likely to accept the linkage. Indeed, the oft cited mantra, "Republicans, pray for rain," suggests that some in the GOP not only believe the thesis to be valid, but that depressed voter turnout attributable to bad weather benefits their party at the expense of Democrats.

Despite its seemingly general acceptance as a truism of electoral politics, there is virtually no solid evidence linking bad weather to voter turnout. Our search of the scholarly literature for such tests produced sparse results, and existing studies suffer from inherent limitations. One problem is the lack of geographical coverage and variation in meteorological conditions. Stephen Knack's (1994) study, for instance, examines the effect of bad weather on voter turnout at the individual level using data from three American National Election Studies and finds no direct relationship. Yet, Knack concedes that two of his panels (1984 and 1988) offered particularly dry election days with "disturbingly little variation in rainfall" (1994, 197), thereby possibly suppressing any discernible effect. The analysis of a single state and model specification issues are problematic in the work of geographers Jay Gatrell and Gregory Bierly (2002). Examining the effect of weather on turnout in Kentucky from 1990 to 2000, the authors find that rain decreases turnout in primary elections. However, the authors exclude several correlates that political scientists might expect to see in a turnout model, factors that if included could reveal the weather-turnout linkage to be spurious. Ron Shachar and Barry Nalebuff (1999) provide, perhaps, the most robust test of the weather-turnout hypothesis to date. The authors include a measure of rainfall as an ancillary control in their state-level study of turnout in 11 U.S. presidential elections and find a significant negative relationship between rain and turnout. Yet, a weakness of this work is that Shachar and Nalebuff's measure of the state's rainfall—the amount of rain (in inches) in the state's largest city on election day—could bias its estimate. The measure may *underestimate* the effect of rain on turnout in cases where low levels of rainfall in the largest city do not reflect rainy conditions elsewhere in the state. This is especially problematic in large states, where the city covers a small percentage of the geographic area. Alternatively, and more troubling, the measure could *overestimate* the effect of rain, if the variable is acting as a surrogate for low turnout in urban areas (a factor not controlled for by Shachar and Nalebuff). In short, the evidence in support of the weather-turnout thesis, in our view, is either not supportive or suspect, and, if nothing else, it is not in balance with its popular acceptance.

In this paper, we explore the theoretical and empirical merit of the weather-turnout thesis. We begin by placing the weather-turnout thesis within the broader theory of political participation. We argue that much of the intuitive appeal of the thesis results from it comporting well with both socioeconomic status and rational choice models of voter turnout. We also address the theoretical underpinnings of the partisan bias conjecture associated the weather-turnout thesis, which contends that if bad weather does affect voter turnout, the resulting suppression of voters may benefit one party over the other. We examine the effect of weather on voter turnout in the over 3,000 U.S. counties for 14 U.S. presidential elections (1948–2000)—the most exhaustive empirical test of the weather-turnout thesis to date. Our expansive dataset allows us great leverage over a number of important issues. With over 43,000 cases, we achieve great variability in both voter turnout and meteorological measures. In the end, we find that bad weather (rain and snow) significantly decreases the level of voter turnout within a county. We also demonstrate that poor weather conditions are positively related to Republican party vote share in presidential elections. The results not only lend credence to the weather-turnout thesis and the conventional wisdom regarding the determinants of aggregate voter turnout, they further add to the debate over how sensitive citizens may be to the costs of voting (e.g., Aldrich 1993).

[2]AccuWeather, which lauds itself as "The World's Weather Authority," provides meteorological information to over 130,000 institutional clients. AccuWeather suggests three ways that weather might affect election day outcomes: bad weather may (1) restrict elderly or infirm voters, (2) cause less committed voters to abstain, and (3) change the partisan vote share when distributed unevenly across party strongholds within a state. The report can be found online at http://www.accuweather.com/iwxpage/adc/pressroom/prs/wx/wx_122.htm.

[3]The interview transcript can be found online at http://www.cnn.com/2004/ALLPOLITICS/01/27/otsc.carville.index.html.

The *C*-term is for Cost (and Cumulative Rainfall?)

In her review essay on the state of knowledge about political participation, Leighley (1995) argues that three major theoretical perspectives structure our understanding of voter turnout: the socioeconomic status model, rational choice model, and mobilization model. The first and oldest of these is the broadly accepted *socioeconomic status (SES) model* (e.g., Almond and Verba 1963; Verba and Nie 1972), which holds that participation is driven primarily by individual resources (time, money, skills) and civic orientation (see also, Wolfinger and Rosenstone 1980). The model argues that citizens low in SES tend not to participate for one of two reasons: either (*a*) they cannot manage the tangible costs of political participation (learning how to participate, registering to vote, taking time from work, etc.) or (*b*) the need to concentrate on their personal material welfare does not foster a strong civic orientation within these individuals, thus making them both less interested in politics and less efficacious.

The *rational choice model* also highlights the costs (and benefits) of participation, but does so by focusing on the inherent collective action problem associated with political action. The theory centers around the "calculus of participation" (or "calculus of voting" when specifically applied; Downs, 1957; Riker and Ordeshook 1968) and examines the costs and benefits associated with the individual's decision to join the collective action, such that $R = PB - C$, where R stands for the net rewards from participation (voting), P is the probability that one's participation will be decisive, B is the individual's utility benefits if participation is successful (e.g., the preferred candidate wins), and C is the costs of participation. Since P is a function of the size of the electorate, the individual's contribution to political action is minute when the electorate is large. Thus, the costs of participating, the "*C*-term," will outweigh the benefits and make participation irrational.[4]

Lastly, the *mobilization model* (Rosenstone and Hansen 1993) offers a logical extension of the rational choice model. To solve the collective action dilemma, political parties and grassroots organizations act as political entrepreneurs, coordinating collective action and absorbing some of the costs of participation so as to reap the larger rewards that follow from political victory. Citizen participation, therefore, results when political organizations significantly reduce C to the point at which it no longer outweighs B. Thus, the model places much of the onus for participation on the shoulders of political organizations, which must mobilize a rationally deactivated public, through "get out the vote" campaigns, etc., to win at the polls. Clearly, the mobilization model is inherently more "political" than the others.

No matter which of the theoretical models one favors (and there is much to admire about each), the common thread that runs through each is that the costs of participation are a major obstacle to citizen involvement.[5] Likewise, the inherent assumption of the weather-turnout thesis is simply that bad weather adds to the costs of voting, but is this assumption reasonable?

Particularly bad weather can have devastating consequences. Floods, hurricanes, and blizzards, for example, can be incredibly costly in both economic and human terms. Yet, less extreme weather still affects day-to-day life and choices. One obvious decision brought about by inclement weather is the choice to spend time outdoors or stay inside a climate-controlled house (Harries and Stadler 1988). Weather also has less obvious effects. Research suggests that both uncomfortably high (e.g., Baron 1972) and low temperatures (Boyanowsky et al. 1981–82) increase human aggression, perhaps due to the physical stresses associated with temperature extremes (Cohn 1990).[6] Not surprisingly, weather-induced increases in aggression can translate into increases in various forms of

[4]Riker and Ordeshook (1968) argue that the costs of participation are often outweighed by the expressive benefits the individual accrues from the act itself. These expressive benefits, frequently referred to as the "*D*-term" because of the notation used by Riker and Ordeshook, include the satisfaction one receives from complying with the ethic of voting (civic duty), affirming allegiance to a political party or to the political system at large, and affirming one's efficacy. Some scholars, however, most notably Fiorina (1976; Ferejohn and Fiorina 1974), argue that the *D*-term is overly "psychological" in form and should not be included in a strictly rational-choice model.

[5]At least one scholar argues that the costs of participation may be a bit exaggerated. Aldrich (1993) argues that the costs of voting are actually quite low and that expressive and long-term benefits should also be incorporated into the model. If such is the case, it becomes easier for the benefits to outweigh costs in the rational choice model.

[6]In supplemental analyses, we find that cold temperatures do not significantly decrease voter turnout as might be expected. This finding is robust across a number of model specifications. We do not present these findings here, but they are available upon request from the authors.

crime, including criminal assault (Cohn 1990).[7] Weather also seems to affect the availability of potential victims of crime, making it difficult, for instance, to mug people who choose to stay inside to avoid rain or extreme temperatures (Cohn 1990; Rotton and Cohn 2000). While the theoretical connection between weather and the availability of potential victims is not explicitly couched in terms of "costs," the implicit assumption is that there is some sort of cost to exposing oneself to bad weather.

Similarly, there are several ways in which bad weather on election day could be considered a cost borne by voters. Uncomfortable weather may make waiting in line at the polls a less desirable activity. Bad weather may also limit one's ability to travel. Roads soaked by rain or perhaps covered by snow may make for a more hazardous journey to the polls. Again, these are not major costs. But for many citizens, the imposition of an additional minor cost may make the difference between voting and abstaining.

If the decision to vote is the result of a cost-benefit calculus, and the potential benefits of voting are relatively small, then minor changes in the perceived cost of voting may exert a significant effect on the probability of someone going to the polls. Exposing oneself to bad weather may constitute one such minor cost. This is the logic underlying the oft repeated conventional wisdom that bad weather depresses voter turnout, a logic that comports well with existing theories of voter participation.

Should Republicans Pray for Rain?

An often cited aphorism in American campaign politics is that "Republicans should pray for rain." The supposition made in this phrase is that turnout by Democratic voters is disproportionately suppressed by bad weather. That is, all things equal, as the percentage of voters who abstain due to bad weather increases, Republican vote share should also increase. But does this presumed bias comport with existing theory? Clearly, the assumption is not that Democratic voters are more likely to experience rain than Republicans. So, if bad weather does raise participation costs, we must assume that all segments of society might incur them from time to time.

The Republican bias conjecture is a product of the belief that higher turnout benefits Democrats. The "conventional turnout effect model," as it is often called (e.g., Tucker, Vedlitz, and DeNardo 1986) supports this claim. The conventional model assumes that the electorate is divided into core and peripheral voters. The former are very likely to turnout, while the latter are significantly less likely to vote but can be responsive to mobilization efforts. It is argued that peripheral voters are more likely to be Democrats and thus high-turnout elections (i.e., elections in which peripheral voters turn out) will benefit Democrats in relative terms. Jack Citrin, Eric Schickler, and John Sides' (2003) simulations of elections, in which every eligible voter turns out to vote, provide some support for the conventional argument, although they conclude that, overall, the Democratic Party only marginally benefits from high turnout.

DeNardo (1980) revises this conventional model by contending that peripheral voters are actually more likely to "defect" (i.e., vote for the other party's candidate) than core voters. As such, peripheral voters behave more like independents than dedicated partisans. For example, while a dedicated, core Republican voter and a core Democratic voter might have probabilities of voting for a Republican candidate of .95 and .05, respectively, a peripheral voter's probability of voting for this candidate will be much closer to .5. The important implication of DeNardo's argument is that increases in voter turnout will help, to some extent, the minority party, since increases in the numbers of peripheral voters will push the vote share in the direction of a 50-50 split. We should be clear that DeNardo argues that there exists "two effects"—*both* a pro-Democratic and pro-minority party turnout effect. Thus, increases in turnout will help the Democrats particularly when they are the minority party and will help less and less as the percentage of Democrats increases.[8] Nagel and McNulty (1996) provide further evidence of the existence of these two turnout effects.

If the conventional model is accurate, then bad weather should *always* benefit Republican candidates. If DeNardo's more complex model better captures the effect of turnout levels on vote shares, then bad weather will *usually* benefit a Republican candidate, but the effect will be conditioned by the partisan tendency of a county (our unit of analysis). We test the predictions made by these models by assessing the

[7]In an interesting examination of the effect of weather on foreign policy, Starr (1977) finds that hot summer weather did not exacerbate tensions between nations in the days preceding World War I.

[8]DeNardo (1980) suggests that in heavily Democratic areas increases in voter turnout can actually benefit the GOP because the minority party effect, in this circumstance, will outweigh the pro-Democratic effect.

effect of weather-depressed turnout on the aggregate vote for presidential candidates.

Data

Our primary phenomenon of interest is voter turnout. To test the weather hypothesis, we chose to measure our dependent variable at the county level. Our dataset consists of observations from the over 3,000 counties in the continental United States for each presidential election from 1948 to 2000. Because Alaska and Hawaii did not enter the union until 1959, and because Alaska records election data by Election District rather than county, we excluded these states from the analysis. We also excluded Oregon from our 2000 data because the state implemented an early voting program that resulted in nearly all votes being cast before election day.[9] Our measure of the estimated voter turnout in each county was based on the number of votes cast at the presidential level divided by the estimated voting age population.[10] When appropriate the denominator for our measure was altered so as to reflect state level differences in voting age requirements; only a few states allowed citizens younger than 21 years old to vote before 1970.

The data were compiled from various sources. County-level vote returns were gathered primarily from Congressional Quarterly's *America Votes* series and Congressional Quarterly's Voting and Elections online module. County-level voting age population were gathered from two primary sources: data from 1944 (our lag year) to 1968 were entered by hand from the U.S. Census Bureau's *City and County Data Book*, while data from the 1972 to 2000 elections were retrieved from the Census Bureau's website.

Our meteorological variables were drawn from the National Climatic Data Center's "Summary of the Day" database (made available by EarthInfo, Inc). The Summary of the Day data reports various measures of the day's weather, including rainfall and snowfall totals, for over 20,000 weather stations located in the United States. Despite the large number of observations, not all U.S. counties have weather stations located within their borders, while many counties have multiple weather stations. Moreover, most of these weather stations are not centrally located within a county. To interpolate weather data for all U.S. counties, we created a surface grid for spatial analysis using geographic information systems (specifically, ArcGIS 9.1). Our method divided the national map into a set of small cells.[11] The weather station data were then mapped onto the surface grid based upon each station's reported geographic coordinates. Using the weather station data, we then used a geostatistical method known as Kriging to estimate the weather for each unit cell on the surface grid (see Childs 2004).[12] County lines were then mapped onto the grid, and the average estimated value for each county was calculated for each of the weather variables.

Estimated rainfall and snowfall are measured in inches. The highest average rainfall for any election day in our sample occurred in 1972 (national average

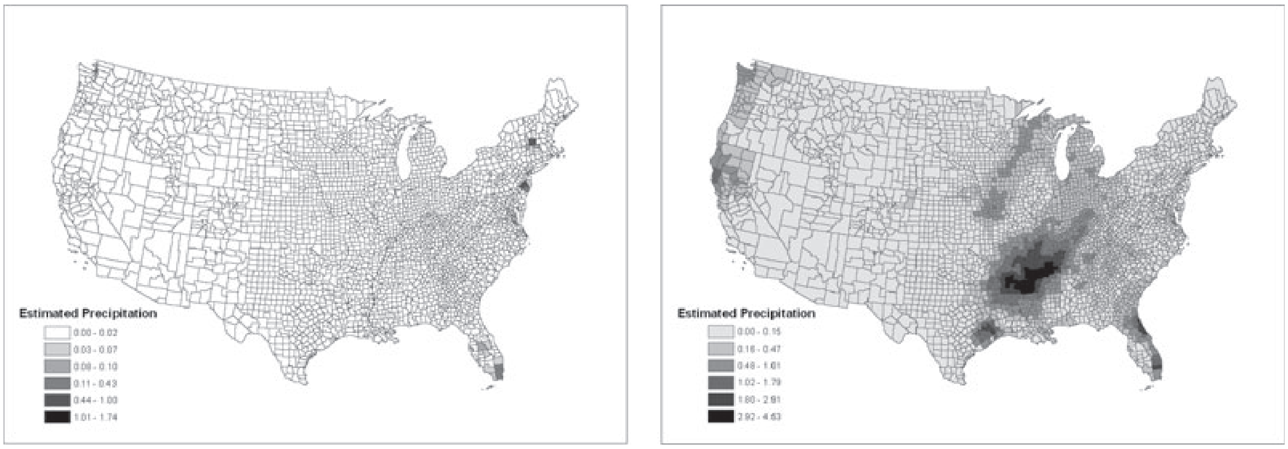
[9]Our dependent variable does not distinguish between those who voted on election day and those who voted absentee. Bad weather cannot deter absentee voters, so it is possible that the effect of bad weather on voters deciding whether to vote on election day is somewhat attenuated in our models. In other words, the coefficient estimates for *Rain* and *Snow* should be viewed as conservative.

[10]McDonald and Popkin (2001) argue that voting eligible population (VEP) is the appropriate denominator when studying voter turnout. VEP differs from VAP in that it excludes noncitizens and disenfranchised felons and includes overseas citizens. McDonald and Popkin find that the decline in turnout witnessed nationally after the 1960 election is an artifact attributable to using VAP rather than VEP. Unfortunately, their VEP data are only available at the national and not at the county level, forcing us to utilize the traditional denominator, VAP. It is possible that by using VAP, our intercept estimate may be deflated (i.e., the "true" baseline turnout may be somewhat higher than indicated by the estimate). Our use of VAP may artificially depress the turnout rates for Southern counties in particular (see McDonald and Popkin 2001). Given that our model includes most of the institutional correlates associated with the restrictive voting practices of the South before (and in some cases after) the passage of the Voting Rights Act of 1965, we do not believe that our use of VAP affects our core results.

[11]In constructing our surface grid, we set the cell size equal to 4,000 squared meters so as to maintain at least one cell for each county. The process was not concerned with maintaining a cell for the independent cities of Virginia, which are small in area and situated geographically (but not politically) within county boundaries. We used the estimated weather conditions for the respective surrounding counties as a surrogate measure for conditions in each of the cities.

[12]The Kriging method is considered a best linear unbiased estimator for spatial data. The method assumes the data to be Gaussian in its distribution and accounts for spatial dependence between observations via the construction of a semivariogram. Comparative diagnostics indicated that "Universal Kriging with linear drift" provided the best model fit for our data and thus was used to generate our data.
An alternative approach to interpolation was tested using an inverse distance weighting (IDW) function. IDW interpolation methods, though commonly used, are deterministic rather than statistical, and thus do not account for error in the interpolation process (e.g., Willmott and Matsuura 1995). Our Kriging and IDW rainfall variables were correlated at .964 ($p < .001$) and the snow variables were correlated at .954 ($p < .001$). Nevertheless, we also estimated our models while using IDW interpolations and the statistical inferences and substantive results remain the same as those presented here.

FIGURE 1 Maps of Election Days with Minimum and Maximum Rainfall



Minimum Rainfall – November 2, 1976 Maximum Rainfall – November 7, 1972

Minimum Rainfall—November 2, 1976 Maximum Rainfall—November 7, 1972

rainfall = .279 inches) and the lowest average rainfall occurred in 1976 (national average rainfall = .002 inches). The distribution of rainfall on these two election days is shown on the national maps presented in Figure 1. Snowfall varies from 0 inches in 1952 to an average of .202 inches in 1992.[13]

We utilize two alternative measures of weather in our initial test. First, we measure rainfall and snowfall at their election day levels. Alternatively, it is possible that an inch of rain in soggy Seattle has a different effect on turnout than an inch of rain in dry Los Angeles. For this reason, we also calculated the normal (average) rainfalls and snowfalls for each election date (ranging November 2–9) for each county using data from the entire 1948–2000 time span. We then subtracted the appropriate daily normal value from the rainfall or snowfall estimated to have occurred on each election day under analysis. This measure of rain and snow as a deviation from their normals accounts for typical regional variations in weather. For example, if the normal rainfall for an early November day in Yuma County, Arizona is .005 inches, while for Pacific County, Washington the normal rainfall is .273 inches, then an election day rainfall of .1 inches would thus yield values of .095 for the former county and −.173 for the latter.

In our model, we control for a number of socioeconomic factors that are associated with voter turnout. Specifically, we include *% High School Graduates*, median household *Income* in the county, and *% African American*.[14] We also control for how *Rural* the county is.[15] A number of studies demonstrate the important effect of voter registration laws on voter turnout (e.g., Kelley, Ayres, and Bowen 1967; Rosenstone and Wolfinger 1978). Highton's (2004) recent review of this literature points to a number of registration laws that have been demonstrated to influence voter turnout rates over space and time: poll taxes, literacy requirements, registration closing dates, and motor voter programs. We control for all of these registration requirements. Specifically, *Poll Tax*, *Literacy Test*, and *Property Requirement* are dummy variables noting the presence of these requirements. *Closing Date* is the number of days between the last day to register to vote and election day.[16] *Motor Voter* equals 1 if the state employed some form of this

[13]The average snowfall for election day 2000 is skewed upward thanks to significant snowfalls in the Dakotas and the mountainous counties of New Mexico.

[14]We control for over-time changes in the proportion of Americans graduating from high school by normalizing this variable for each election. *Income* is inflation-adjusted (CPI set to 1982 − 84 = 100).

[15]We measure this as the number of farms per capita in the county, as reported by the Census Bureau.

[16]Data on voter registration laws come from Bernard (1950), Knack (1995), Rosenstone and Wolfinger (1978), Smith (1960), and various editions of *The Book of the States*. There are some missing data points for the Closing Date variable in the 1960s. When confronted with missing data, we averaged a state's Closing Date for the preceding and subsequent elections and utilized this value.

program, and 0 otherwise.[17] We also control for the possibility that other important elections in a state might drive up voter turnout by including dummy variables denoting whether there is a *Gubernatorial Election* or *U.S. Senate Election* on the same day. Finally, to control for behavioral persistence in turnout, we include the county's turnout from the previous presidential election as an independent variable ($Turnout_{t-1}$).[18]

Methods

Our data conform to a panel design. We wish to predict county-level voter turnout and GOP presidential vote choice by the electorate through time, respectively. Specifically, our cross-sectional units are defined as a maximum of 3,115 counties in the continental United States, for each of the 14 presidential election events occurring in our 1948–2000 sample period ($T = 14$; $N = 3{,}115$ (max); Total Number of Observations = 43,340). Given the panel structure of the research design, several issues must be considered. First, since our panel is *heavily* cross-section dominant ($N > T$), linear cross-sectional random effects (CSRE) estimation is deemed the most appropriate model. The CSRE approach allows for stochastic variation across counties by providing estimates that constitute a weighted average involving cross-county (between) and within-county (fixed) effects. The advantage of CSRE is that it does not omit unobserved heterogeneity, while also providing more efficient parameter estimates than a within-county (fixed) effects model, since as many as 3,114 cross-sectional (county level) dummies need not be included in each regression model.[19]

In addition, we also allow for timewise unobserved heterogeneity by incorporating T–1 election year dummies during our sample period (the 1948 presidential election is captured by the intercept term). Substantively, we believe that each presidential election event will bring to bear a unique electoral environment since elections vary in salience, policy conditions, and the like. Moreover, both county-level voter turnout and GOP presidential vote share might vary through time in ways that are distinct from the exogenous variables in a given model specification. The use of time dummies to account for temporal heterogeneity is appropriate in relatively shorter panels since proper stochastic modeling of the dependent variable is difficult when T is small (Arellano 2003, 60–64). Therefore, econometricians advocate allowing for time-varying intercepts when one has a cross-sectional dominant panel (large N relative to T) (Wooldridge 2003, 170).[20]

Results

In Table 1, we present alternative models of county-level voter turnout. Each model includes a set of predictors aimed at explaining cross-sectional variation in turnout, as well as a lagged dependent variable to control for temporal dynamics in the variation in the data.[21] Model 1 includes rain and snow measured at their election day levels. Model 2 measures rain and snow as deviations from their election date normal values. The results of these models are presented in Table 1. As demonstrated by the likelihood-ratio tests and the statistical significance of almost all the independent variables in each estimation, the models perform quite well.[22]

[17]Our measure accounts for the fact that a number of states implemented Motor Voter programs before federal law required it in 1993.

[18]At the individual-level, scholars have noted that voting and nonvoting can become habitual over the individual's lifespan (Plutzer 2002; Fowler 2006). In the aggregate, we expect, similarly, that counties low (or high) in voter turnout at the beginning of our sample period will persist in this state over time.

[19]Because the number of cross-sectional units exceeds time units by as much as a factor of over 226, a county-level fixed effects modeling strategy is inappropriate on both econometric and substantive grounds. In the former case, modeling cross-sectional fixed effects (CSFEs) in these voter turnout and partisan vote share equations is problematic for reasons due to collinearity (see Baltagi 1999, 309), and also the standard rank condition assumption pertaining to the CSFEs will not be met (Assumption FE.2: Wooldridge 2003, 269). On a substantive level, our model contains several county-level control variables that are viewed as critical determinants of cross-sectional variance in turnout and vote share models. The inclusion of county-level fixed effects would unnecessarily diminish these explanatory factors.

[20]Details regarding the estimation of alternative panel models are given in the online appendix at http://journalofpolitics.org/articles.html.

[21]Besides controlling for the temporal dynamics of voter turnout, the use of the lagged dependent variable in our models also ensures that the coefficient estimates of the exogenous variables are conservative (Achen 2000). Therefore, we can be confident that if a weather-voter turnout statistical relationship does exist, that it is a conservative estimate of this linkage.

[22]The coefficient estimate for σ_{μ} represents the square root of the residual variance corresponding to unobservable county-specific effects. The estimate of ρ represents the variance ratio of the unobservable county-specific effect component of the residuals to the total residuals (Hsiao 2003, 38).

TABLE 1 Maximum-Likelihood Random Effects Model of County-Level Voter Turnout in U.S. Presidential Elections, 1948–2000

Independent Variable	Model 1 Coefficient Estimate (Standard Error)	Model 2 Coefficient Estimate (Standard Error)
Election Day Rain	−.833*	—
	(.107)	
Election Day Snow	−.152	—
	(.092)	
Election Day Rain—Normal Rain	—	−.885*
		(.109)
Election Day Snow—Normal Snow	—	−.452*
		(.093)
% High School Graduates	.536*	.553*
	(.045)	(.045)
Income	.234*	.222*
	(.092)	(.092)
% African American	−.029*	−.029*
	(.003)	(.003)
Rural	21.389*	21.938*
	(.917)	(.920)
Registration Closing Date	−.031*	−.032*
	(.001)	(.001)
Motor Voter	.037	.023
	(.111)	(.111)
Property Requirement	−3.093*	−3.095*
	(.318)	(.318)
Literacy Test	−.168	−.173
	(.107)	(.107)
Poll Tax	−6.085*	−6.116*
	(.154)	(.153)
Gubernatorial Election	−.083	−.077
	(.066)	(.066)
Senate Election	.016	.015
	(.051)	(.051)
$Turnout_{t-1}$	.758*	.757*
	(.004)	(.004)
Constant	13.187*	13.126*
	(.305)	(.303)
σ_μ	1.060*	1.075*
	(.056)	(.055)
ρ	.044*	.046*
	(.005)	(.005)
Number of Observations	43,340	43,340
Log-Likelihood	−131,289	−131,274
LR Test (chi-square, 27 d.f.)	91,363*	91,360*

*$p \le .05$ (two-tailed test). Model also includes fixed effects for election; coefficient estimates can be obtained from the authors.

The control variables in both our models perform largely as expected and are stable across each model specification. Indicators of socioeconomic status are significant predictors, with each in the hypothesized direction. Voters turn out at a higher rate in counties with a high percentage of high school graduates and with high median incomes. Counties with a substantial proportion of African Americans exhibit lower voter turnout rates, while rural counties appear to have higher turnout rates. Electoral institutions also influence voter turnout. State voter registration laws, for instance, exert a statistically significant and often substantively large effect on voter turnout. Poll taxes and property requirements, when they existed, suppressed the voter turnout percentage by approximately 6.1% and 3.1%, respectively, in each equation. Registration closing dates that are temporally proximate to election day increase voter turnout, while earlier closing dates decrease the percentage of the voting age population who actually vote. These results comport with those presented in a number of prior studies on electoral rules and turnout (e.g., Highton 2004). Finally, in both model specifications, whether there is a gubernatorial or U.S. Senate election on the same day as the presidential election apparently has no effect on aggregate voter turnout numbers.

Our main concern, of course, is whether meteorological conditions affect turnout in the presence of these controls. The specific results for the two precipitation variables reveal that bad weather does indeed reduce voter turnout, though the effect of snow seems to depend on the measurement strategy used. In Model 1, we include the precipitation variables in their election day levels. In this specification, the behavioral assumption is that voters do not acclimate to normal conditions. As such, an inch of rain or snow is expected to affect all voters equally. The results indicate that election day rainfall reduces turnout in a county at roughly .8% per inch. Snow, at its election day level, does not affect turnout.[23]

When measured as deviations from their normal values, rain and snow elicit a negative and statistically significant effect on voter turnout. In this specification, the behavioral assumption is that voters are acclimated to weather that is typical for their region of the country. The results indicate that if a county experi-

[23]A larger effect for rain than snow might seem surprising at first. However, we must remember that one inch of rain is *more* precipitation than one inch of snow. According to the U.S. Geological Survey's Washington Water Center, though it possesses greater volume, 8–10 inches of snow only contains one inch of water (http://wa.water.usgs.gov/outreach/rain.htm).

ences an inch of rain more than what is normal for the county for that election date, the percentage of the voting age population that turns out to vote decreases by approximately .9%.[24] Interestingly, accounting for normal expectations clearly matters when estimating the effect of snow on turnout. For every inch of snow above the county's average snowfall, voter turnout diminishes by nearly .5%.[25] Thus, our evidence supports the claim that bad weather lowers voter turnout.

How Meaningful is the Effect of Precipitation on Voter Turnout?

Thus far, we have demonstrated that rain and snow have negative and statistically significant effects on voter turnout. Of course, large sample sizes allow for more precise point estimates and thus open the possibility of discovering statistical significant results that may be of questionable substantive importance. To address the issue of the substantive importance of election day precipitation, we first consider the relative effects of rain and snow at the county level using in-sample predictions. Next, we use our model to estimate the number of voters who stayed home for presidential elections due to rainy or snowy weather. Finally, we examine the partisan implications of bad weather on election day and assess the electoral consequences.

The Relative Effects of Rain and Snow

To put the effect of rain into perspective, consider that for counties that experienced rain on election day, the average rainfall was approximately .23 inches. For these counties, this rainfall total is .14 inches greater than the normal rainfall. The results from Model 2 suggest that the average election day rain event decreased a county's voter turnout percentage by only .12%. The greatest deviation from the normal amount of rainfall in our data occurred in Tunica County, Mississippi, which experienced 4.35 inches of rain more than usual (.179 is the normal) on election day 1972. This heavy rainfall, according to our model, decreased voter turnout in the county by a more impressive 3.8%.

Counties experiencing snow on election day averaged an accumulation of .60 inches. For these counties, this total is an average of .47 inches greater than normal snowfall for early November. This translates to a .21% decrease in voter turnout. The high-elevation Lincoln County of New Mexico experienced the greatest deviation from normal early November snowfall when on election day 2000 it received 7.11 inches of snow more than usual. Based on the coefficient estimate for *Snow*, this led to a 3.21% decrease in voter turnout.

The Number of Potential Voters Deterred by Precipitation

Figure 2 presents for each presidential election our model's estimates of the number of potential voters who opted not to vote as a result of precipitation. To generate these estimates, we used our turnout model using deviations from normal weather (Model 2) to predict voter turnout rates for our entire sample.[26] We then used the model to generate counterfactual voter turnout predictions while setting the precipitation variables at their minimum possible values. For both sets of predicted voter turnout rates, we multiplied the rates by the number of voting age citizens in the county to obtain turnout numbers. We calculated the number of voters deterred by rain or snow in a given presidential election by subtracting the predictions based on the actual observed weather from the counterfactual predictions based on the no-rain or snow scenario.

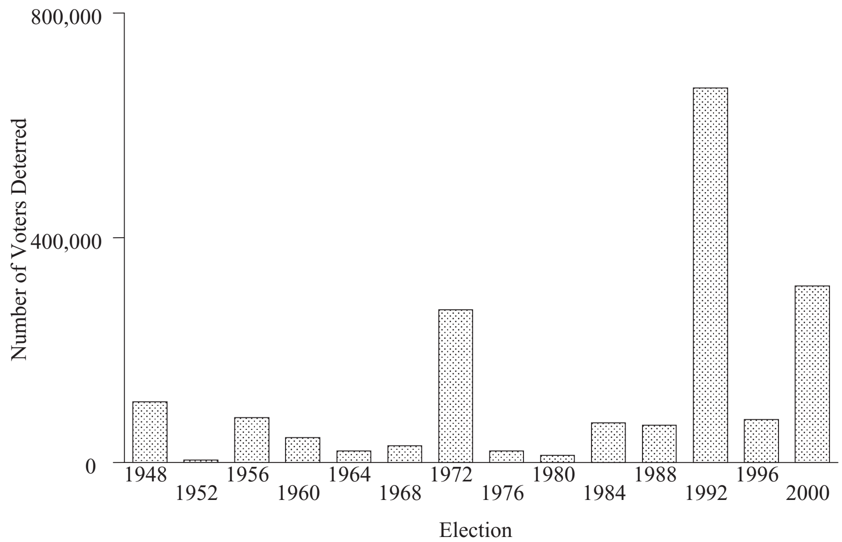
Figure 2 reveals that the 1972, 1992, and 2000 elections stand out as elections in which rainy and/or snowy weather caused hundreds of thousands of voters to stay home. The 1952, 1960, 1964, 1968, 1976, and 1980 elections, on the other hand, were relatively dry affairs and thus few voters were deterred by precipitation.

[24] To provide conservative estimates of weather effects, we limit our discussion of the statistical findings to the immediate (short-term) effects, net of the lagged dependent variable. The dynamic (full) effects will be larger in magnitude for each regression coefficient by a factor of $(1 - \delta)^{-1}$, where δ equals the coefficient for $Turnout_{t-1}$.

[25] The significance of the "snow" variable in Model 2 may be a function of the timing of the election. Given that U.S. national elections occur in early November, many parts of the country may not be prepared for a late autumn snowfall. (Indeed, an election day snowfall may be the first snow of the season.) Thus, by measuring snow as a deviation from its election day normal, we may be controlling for both a population's acclimation to snowy weather and a county's level of preparedness for a snow event.

[26] We use Model 2, because the AIC and BIC statistics indicate that Model 2 provides a better fit to the data than does Model 1.

Figure 2 Estimated Number of Potential Voters Deterred by Precipitation (Rain and Snow) on Election Day, 1948–2000



The Partisan Consequences of Voter Turnout Decline Attributable to Rain and Snow

Bad weather may be the last straw for peripheral voters, and according to the conventional wisdom, these voters may be disproportionately inclined to support the Democratic presidential candidate. If this is the case, then precipitation will increase the percentage of votes cast for the Republican presidential candidate. We test this link between the precipitation and partisan vote share by estimating a model in which county-level Republican presidential candidate vote share is the dependent variable. The main independent variables of interest are the deviations of rain and snow from their election day normals. We include dummy variables for the various elections to control for all election-specific factors that influence vote share (e.g., state of the economy or presence of a third-party candidate). We also control for the partisan tendencies of a county by including a moving average of the Republican vote share from the three previous presidential elections.

We model the effect of precipitation on Republican vote share using two alternative specification—the first mimics the "conventional turnout effect model" discussed earlier, while the second follows DeNardo's "two effects model." The estimates from the conventional model are presented in first column of Table 2. The coefficient estimates for both weather variables are positive and statistically significant, indicating that as rain and snow increase above their respective election day normals, the better the Republican presidential candidate fared. More precisely, for every one-inch increase in rain above its election day normal, the Republican presidential candidate received approximately an extra 2.5% of the vote. For every one-inch increase in snow above normal, the Republican candidate's vote share increases by approximately .6%. The magnitude of the coefficient estimate for rain is admittedly quite large, especially in relation to the estimated effects of rain on voter turnout given in Table 1.[27] It is important to point out, however, that the size of this estimate for rain does not decrease as the result of the inclusion of numerous additional control variables. For example, we estimated our model with controls for the changes that have occurred in the partisanship of the South and of rural areas. The inclusion of these controls does not meaningfully decrease the size of the estimate estimates for rain (in fact, some specifications lead to larger coefficient estimates for this variable). Thus, the strong positive effect of rain is robust in the face of more comprehensive and complex model specifications. The results of the model appear to validate the old Republican adage, "pray for rain."

[27]It is important to note that the coefficients presented in Table 1 (and for all of our analyses) are our most conservative estimates (see online appendix for alternative specifications). As such, it is possible that the true effect of weather on voter turnout is larger than the estimated effect reported in Table 1. If this is the case, then the relationship between weather's effect on turnout and weather's effect on vote share might be in closer agreement.

TABLE 2 Maximum-Likelihood Random Effects Model of County-Level Republican Candidate Vote Share in U.S. Presidential Elections, 1948–2000

Independent Variable	*Conventional Model* Coefficient Estimate (Standard Error)	*Two Effects Model* Coefficient Estimate (Standard Error)
(Election Day Rain—Normal Rain)	2.43* (.192)	−.797 (.613)
(Election Day Snow—Normal Snow)	.624* (.163)	.471 (.829)
(Election Day Rain—Normal Rain) × Previous Republican Vote Share	—	.075* (.014)
(Election Day Snow—Normal Snow) × Previous Republican Vote Share	—	.002 (.015)
Moving Average of Previous Republican Vote Share in Three Previous Elections	.734* (.004)	.736* (.004)
Constant	10.989* (.223)	10.973* (.222)
σ_μ	1.582* (.075)	1.567* (.075)
ρ	.032* (.003)	.031* (.003)
Number of Observations	43,294	43,294
Log-Likelihood	−155,668	−155,652
LR Test (chi-square, 16 and 18 d.f., respectively)	47,807*	47,861*

*$p \leq .05$ (two-tailed test). Model also includes fixed effects for election; coefficient estimates can be obtained from the authors.

As noted earlier, however, DeNardo (1980) proposes an alternative "two effects" model of the implications of voter turnout. In DeNardo's model, Republican candidates typically are hurt by higher turnout, but the size and direction of the turnout effect depends on the partisan composition of the electorate in question. The higher the proportion of Republicans in the electorate, the more they are hurt by higher turnout (and thus the more they are helped by decreases in turnout). Electorates with very small proportions of Republicans, on the other hand, may actually be helped by higher turnout. To test this alternative model of the effect of turnout, we estimated our vote share model while including two multiplicative terms consisting of the products of each of the weather variables (as deviations from their normals) and the moving average of the vote shares for the Republican candidates in the three previous presidential elections. This latter component of the multiplicative term, while not a perfect representation of a county's partisan composition at time *t*, should constitute a reasonable proxy for its partisan leanings. The inclusion of these multiplicative terms allows the effects of rain and snow on Republican vote share to vary based on the partisan leanings of the county.

According to DeNardo's model, the estimate for the multiplicative term should be positive, indicating that the more Republican a county is, the more declines in voter turnout attributable to weather should benefit the Republican candidate. The coefficient estimate for the interaction term including rainfall does comport with this expectation, as it is positive and statistically significant.[28] The effect of rain on Republican vote share is amplified in heavily Republican counties. The estimate for the direct effect of rainfall on GOP vote share is negative and statistically insignificant. Yet, examining the conditional coefficient for rain reveals that rain has a positive and statistically significant effect on Republican vote share for all counties in which the moving average for previous Republican vote share is greater than or equal to 20.2%. Given the distribution of this variable in our data, this result means that for nearly 95% of our observations the effect of rain on vote share is positive, significant, and increases in magnitude as the county becomes more Republican. In counties for which the moving average is below 20.2%, rain does not have a statistically significant effect on Republican vote share.[29] The estimate for the interaction term involving snow (see Table 2) is not statistically significant, but recall that a conditional relationship may be significant over a specific range of the variable (Friedrich 1982); and, this is the case with snow. Based on the conditional standard errors, the effect of snow on Republican vote share is positive and significant

[28] Unlike all of the other results presented in this article, the evidence supporting the interaction term is not always robust to changes in model specification and estimation approach. See the online appendix for details.

[29] To determine the range of Previous Republican Vote Share for which rain exerts a statistically significant effect, we calculated the conditional standard errors associated with the conditional coefficient (see Friedrich 1982).

($p < .05$) when the three election moving average for Republican vote share (the conditioning variable) is greater than or equal to 37%, which is true for 84% of the cases in our sample. This means that snow has a positive and significant effect on Republican vote share for 84% of the counties in our study. In sum, the conditional relationships between the weather variables and partisan tendencies on Republican vote share provide support for DeNardo's two-effects argument.

Has Weather Affected Electoral College Outcomes?

The partisan consequences of precipitation on election day naturally leads one to wonder if the weather affected any electoral outcomes. To address this question, we simulated the partisan vote share in each state (aggregating county vote totals so as to mimic the Electoral College) under two hypothetical scenarios, which we then compare to the actual electoral results. In the first scenario, we assume no rain or snow. In the second, each county has the maximum rainfall experienced by that county during all the election days in our analysis. We do the same with the snow variable.[30] We then use our vote share model with the multiplicative terms to predict the changes in the Republican presidential candidate vote share that result from changes in weather.[31] Finally, we compare these predicted changes in vote share with the margin by which the Republican candidate actually won or lost the popular vote in each of the states over the time period.

The results of this simulation reveal that in several instances during the latter half of the twentieth century weather may have altered Electoral College outcomes. Under the maximum rain and snow scenario, Republican presidential candidates would have added Electoral College votes in 1948 (53 votes), 1952 (10 votes), 1956 (13 votes), 1964 (14 votes), 1968 (35 votes), 1976 (43 votes), 1984 (10 votes), 1992 (13 votes), 1996 (8 votes), and 2000 (11 votes).[32] None of these additional Electoral College votes would have led to a different occupant of the White House.[33] In 1960, however, our results indicate that Richard Nixon would have received an additional 106 Electoral College votes, 55 votes more than needed to become president. In other words, a very rainy and snowy election day, 1960—the election highlighted in the Theodore White quotation above—would have led to an earlier Nixon presidency. Lower turnout resulting from bad weather would have led Nixon, not John F. Kennedy, to win Delaware, Illinois, Minnesota, Missouri, New Jersey, New Mexico, and Pennsylvania.

The results of the zero precipitation scenarios reveal only two instances in which a perfectly dry election day would have changed an Electoral College outcome. Dry elections would have led Bill Clinton to win North Carolina in 1992 and Al Gore to win Florida in 2000. This latter change in the allocation of Florida's electors would have swung the incredibly close 2000 election in Gore's favor. Of course, the converse is that a rainier day would have increased George W. Bush's margin and may have reduced the importance of issues with the butterfly ballot, overvotes, etc. Scholars have identified a number of other factors that may have affected the Florida outcome (see Brady et al. 2001; Imai and King 2004; Mebane 2004)—it was, after all, a very close election with only 537 votes separating Bush and Gore—but to our knowledge we are the first to find that something as simple as rainy weather in some of the Florida counties may have played a critical role in determining the outcome of a presidential election.

Conclusion

That the weather affects voter turnout has long been held as a truism of American presidential elections. Indeed, come election day, it seems that no other possible correlate with voter turnout is discussed by the media as frequently as the weather. Yet, to date, political scientists have provided little systematic evidence to substantiate this claim. For the most part, scholars of voter turnout have simply treated the weather as part of the error term, perhaps assuming that it carries little weight in the decision calculus of voters. Our paper puts the weather-turnout hypothesis to the test, and we find the linkage not only to be statistically significant, but sometimes meaningful as well.

[30]Again, the weather variables are measured as deviations from their election day normals.

[31]We use the model with the multiplicative term instead of the simpler model because model fit statistics (AIC and BIC) indicate that the inclusion of the multiplicative term does improve upon model fit.

[32]See the online appendix for additional details of shifts in Electoral College votes under these hypothetical scenarios.

[33]The Republican gain in 1948 would have denied Truman an Electoral College majority, however, and forced the contest into the House of Representatives. We will not speculate on the outcome in the House.

In a broad theoretical perspective, our results testify to the sensitivity of voters to the cost of participation. Some scholars, most notably Aldrich (1993), argue that the costs of voting are actually quite low, suggesting that early scholarship may have exaggerated its significance. However, here we find that voters seem to be rather sensitive to what is presumably a minor increase in participation costs—the weather.

In addition to its direct effect on voter turnout, we have shown that bad weather may affect electoral outcomes by significantly decreasing Democratic presidential vote share, to the benefit of Republicans. There has been an ongoing debate regarding the effect of turnout levels on electoral outcomes (e.g, Tucker, Vedlitz, and DeNardo 1986; Citrin, Schickler, and Sides 2003). These studies typically assess the impact of the raw level of voter turnout on election results. The issue with this approach is that if Republicans are more likely to turn out than Democrats, then higher turnout levels may correlate with particularly Republican electorates and thus may appear to actually cause higher vote shares for Republican candidates. The approach advanced in this study is not meant as an encompassing test of how voter turnout affects electoral outcomes. Rather, our investigation is aimed at parceling out variations in voter turnout attributable to weather conditions—net the partisan tendencies of the electorate—as an explanation for partisan vote shares in U.S. presidential elections. As such, we provide a complimentary test of the consequences of variations in turnout, and our results clearly indicate that Republican candidates benefit electorally from the turnout-depressing effects of bad weather.

The partisan bias associated with weather-depressed voter turnout can have meaningful repercussions for election outcomes. Our simulation results for the 1960 and 2000 presidential elections are key examples. The closeness of the 1960 race (a scant 118,000 popular votes separated Kennedy and Nixon) made several states pivotal in the Electoral College, including Illinois, where allegations of vote fraud undertaken by Chicago Mayor Richard J. Daley followed Kennedy's 9,000 vote victory. We cannot say whether Kennedy's victory benefited from such actions, but we can claim that Kennedy benefited from relatively good weather. In responding to the Florida debacle in the 2000 presidential election, Democrats complained incessantly about a litany of factors that stood as obstacles to a Gore victory: "butterfly ballots," "hanging chads," the Florida Secretary of State, the newly elected president's brother (the Governor of Florida), and, of course, the Republican appointed Justices on the United States Supreme Court. Yet, our results show that the weather may have hurt their cause just as much. In close elections, the weather becomes one of many factors that can be determinative.

Our results also offer insight for those who study (or partake in) election day mobilization. It is possible that forecasts of bad weather motivate political parties to increase their voter mobilization efforts, so as to negate the diminishing turnout effect of precipitation. We are unable to incorporate partisan mobilization efforts into our model, but if these activities were undertaken *and effective* during our sampling period, we believe the implications for our study are twofold. First, to the extent that mobilization efforts counteract the negative effects of precipitation, our models provide conservative estimates of bad weather's effect on turnout. In other words, if mobilization were held constant, we expect that the percentage of voters deterred by precipitation would increase. Second, our results suggest that Democrats may need to increase significantly their mobilization efforts when rain is on the horizon. It is clear from our results that Republicans benefit from precipitation on election day. To offset these Republican gains, Democrats must take action to counteract the increased cost of voting among their supporters. Otherwise, Democrats may wish to "pray for dry weather."

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