Serving Democracy: Evidence of Voting Resource Disparity in Florida

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Florida, an important state in presidential elections in the United States, has received considerable media coverage in recent years for long lines to vote. Do some segments of the population receive a disproportionate share of the resources to serve the voting process, possibly to encourage some or to dissuade others from voting? We conduct the first empirical panel data study examining whether minority and Democrat voters in Florida experience lower poll worker staffing, which could lengthen the time to vote. We do not find evidence of a disparity directly due to race. Instead, we do observe a political party effect - a 1 percent increase in the percentage of voters registered as Democrat in a county increases the number of registered voters per poll worker by 2.8 percent. This effect appears to be meaningful - using a voting queue simulation, a 5 percent increase in voters registered as Democrat in a county could increase the average wait time to vote from 40 minutes (the estimated average wait time to vote in Florida in 2012) to about 100 minutes.

Key words: voting, queue, lines, waiting, politics, resource allocation

1. Introduction

Given the importance of voting in a democracy, a considerable amount of attention and study has been applied to how the design of the voting process can influence elections: e.g., gerrymandering of district boundaries (Abramowitz (1983), Cain (1985), Chen and Cottrell (2016), Friedman and Holden (2009)) and voter suppression through voter identification laws or the service provided by local election officials (Hood III and Bullock III (2012), Bentele and O'Brien (2013), White et al. (2015), Hajnal et al. (2017), Stein et al. (2019)). Our study investigates the allocation of voting resources, in particular the number of poll workers. All else being equal, the more registered voters there are per poll worker, the more time voters will experience in the voting process (waiting in queue, checking in, and casting a ballot) (Stein et al. (2019)). Long wait times to vote are not ubiquitous in the United States, but, depending on the election and location, some voters do experience wait times of 30 minutes or more (Ansolabehere and Shaw (2016)), the standard

Figure 1 Percent of non-white citizens who voted by state. Data taken from U.S. Census Bureau reports on the voting and registration for states by race (see `https://www.census.gov/topics/public-sector/voting/data/tables.html`). Florida had some counties covered by the Voting Rights Act which was meant to curb discriminatory voting practices in certain areas of the country prior to 2013, so its performance is compared to other states in the South (AL,GA,LA,MS,NC,SC,TX,VA) that had areas covered by the Voting Rights Act

set by a Presidential Commission (Bauer and Ginsberg (2014)). Long waits have been shown to influence choice in non-voting situations, such as blood donation (Gillespie and Hillyer (2002)), waiting in a call center queue (Mandelbaum and Zeltyn (2013)), and grocery shopping (Lu et al. (2013)), among others. In the context of voting, theory (Riker and Ordeshook (1968)) and empirical evidence (Alvarez et al. (2008), Cottrell et al. (2017), Stein et al. (2019)) suggest that long wait times also have the potential to dissuade voters in current and future elections by raising the actual or perceived cost to vote. This raises the possibility that one political party could gain an advantage over another if they are able to allocate more resources towards their likely voters and away from voters who are likely to support the other side.

In our study, we aim to identify whether there is any disparity in poll worker staffing levels within counties in Florida with respect to race and political party. We focus on Florida for several reasons:

(i) it is viewed as an important state in presidential elections; (ii) it experienced well-publicized long polling queues in the 2012 election (e.g., Famighetti et al. (2014)); (iii) it has a checkered past on voting discrimination issues (e.g., Childress (2014), Klas (2016a), Wood (2016), Hawkins (2018)); (iv) unlike most other states, Florida provides county-level data that include racial and political party affiliation; and (v) Florida has lagged behind many of its peer states in terms of minority voter turnout (Fig. 1) and registration (see Fig. EC.1)

We study election and demographic data from 2004 to 2016 across all 67 counties in Florida. Our empirical strategy is to identify the effect of political party and race within Florida counties across time so as to control for unobserved heterogeneity across counties. To summarize our results, we find no evidence of a disparity in poll worker staffing directly due to race. However, we do find that as the percentage of Democrat party voters increases in a county, the number of registered voters per poll worker also increases, i.e., there are fewer resources per voter. Our estimates indicate a large and meaningful effect size. Thus, changes in the composition of political parties across time can lead to larger disparities in wait times to vote.

2. The Voting Process

In Florida, general elections occur every two years with presidential and midterm elections alternating. All voters in a county registered at least 29 days before an election are allowed to cast a ballot in an election. On an early voting day (a practice that was mandated in Florida from 2004) or Election Day, a registered voter who has not voted via an absentee (or "mail-in") ballot may go to an early voting site (for early voting) or her assigned polling place in her precinct (on Election Day) to vote. Based on information from the Florida Division of Elections, the in-person voting process in Florida includes two primary steps: check-in and voting.

At the check-in step poll workers ensure voters are registered to vote using a photo identification with a signature (a practice used in Florida from 1998). If a voter is deemed eligible to vote at the polling place, the voter proceeds to the voting stage. Otherwise, a provisional ballot may be issued and counted later if voter eligibility is verified. Voting can be done via an electronic or a paper ballot. To exit the voting process a voter submits the electronic ballot on a voting machine or processes a paper ballot through an optical scanner.

Queues form at either stage of the voting process whenever the arrival rate of voters exceeds the rate of service. A number of factors contribute to the queue lengths, such as the overall level of service capacity, the variability of demand throughout the day, the complexity of the ballot, and the skill of the poll workers. Although poll workers may be primarily responsible for check-in, they may also play an important role in voting (e.g., via distributing ballots, assisting voters with questions on how to use voting equipment, etc.). Hence, the number of poll workers is a key factor to determine the service experience in elections (Stein et al. (2019)).

Equity in the voting process has received considerable attention. Some states (but not Florida) have laws to ensure there is equality among precincts with respect to voting resources. For example, South Carolina requires (but does not strictly enforce) that precincts not exceed 250 registered voters per voting machine and 500 registered voters per three poll workers for general elections (Famighetti et al. (2014)). Several studies focus on analytical methods to assign voting resources with some form of equity across voters as part of the objective (Allen and Bernshteyn (2006), Yang et al. (2009), Olabisi and Chukwunoso (2012), Yang et al. (2013)).

There are a number of empirical studies on equality in the voting process (Highton (2006), Mebane Jr. (2005), Brady and McNulty (2011), Stewart III (2012), Clinton et al. (2019), Shepherd et al. (2019)). With respect to Florida, a cross-sectional study of the 2012 general election finds that minorities faced longer wait times and racial disparities existed in the distribution of voting resources across precincts (Famighetti et al. (2014)). Cross-sectional studies are unable to control for unobserved differences across precincts that could influence voter waiting times that are not directly related to race or party affiliation (but may be correlated with race or party). The limited number of panel data studies on voter-reported wait times are unable to control for both race and party affiliation (Pettigrew (2017)). Without data on party affiliation it is not possible to distinguish between a direct racial bias and one that is due to a group's leaning towards an opposition party. For example, non-white voters tend to vote Democrat in the U.S. (Pew Research Center (2016)). Thus, a bias against Democratic voters would affect non-white voters as well as educated young white voters (who lean towards the Democratic party according to Pew Research Center (2015)), whereas a direct racial bias would affect only the former.

3. Data and Estimation

We study the 2008 to 2016 elections in Florida but collected data as early as the 2004 election to create lags for certain variables. Our data are from five sources: (1) Election Administration and Voting Survey (EAVS) conducted every two years by the U.S. Election Assistance Commission and collected, typically at the county level, from the 50 States, the District of Columbia, and the U.S. Territories; (2) the Florida Division of Elections publishes voter registration statistics for each of its counties in every election; (3) the U.S. Census Bureau data on annual demographic information on counties; (4) the Verified Voting Foundation data on voting equipment used across counties; and (5) the Federal Reserve Bank of St. Louis data on county-level housing prices. (See Section EC.1.1 for more information on the origin of the data.)

$$logVotersPerPW_{i,t} = \beta_1 PctDemocrat_{i,t} + \beta_2 PctWhite_{i,t} + \beta_3 logVotersPerPW_{i,t-1} +$$

$$\beta_4 logVotersPerPW_{i,t-2} + \beta_5 logAbsentBallotsPerPP_{i,t} +$$
$$\beta_6 logEarlyBallotsPerPP_{i,t} + \beta_7 logEDBallotsPerPP_{i,t} +$$
$$\beta_8 logProvBallotsPerPP_{i,t} + \beta_9 logPersonPerSqMile_{i,t} + \beta_{10} PollDiff_{i,t} +$$
$$\beta_{11} HousePrice_{i,t} + \beta_{12} logMedInc_{i,t} + \beta_{13} UseDRE_{i,t} + \beta_{14} Pct65Plus_{i,t} +$$
$$\beta_{15} Presidential_t + \beta_{16} Time_t + c_i + \varepsilon_{i,t} \quad (1)$$

The proposed regression model is specified in Eq. 1. The dependent variable of interest is $logVotersPerPW_{i,t}$ which is the log of the total number of active registered voters per poll worker (across both early voting and Election Day) for county i in election year t (t=3 for election year 2008). According to the Florida Division of Elections, inactive (as opposed to active) registered voters are those who fail "to respond to an address confirmation final notice and there is no voting or voter registration record activity for two subsequent general election cycles." All else equal, a smaller $logVotersPerPW_{i,t}$ should be better for voters, i.e., lead to a shorter time to vote.

Our main regressors of interest are $PctDemocrat_{i,t}$ and $PctWhite_{i,t}$. $PctDemocrat_{i,t}$ is the percentage of active registered voters who identified as Democrat in county i in election year t. In Florida voters have an incentive to keep their political party affiliation up-to-date because only members of a party can vote in the party's primary. Over the time of our study, Florida consistently had a higher number of counties vote Republican in the presidential or gubernatorial elections. $PctWhite_{i,t}$ is the percentage of active registered voters in county i who identified as white in the election year t.

$PctDemocrat_{i,t}$ and $PctWhite_{i,t}$ act as controls for each other because (as discussed) non-white voters tend to vote Democrat in the U.S., but some white voters (younger and more educated) do as well. If some counties become relatively more Democratic while also decreasing their relative percentage of non-white voters, then including only one variable may not be able to identify the effects of interest.

During the time period in our sample, $PctWhite_{i,t}$ is decreasing on average, while $logVotersPerPW_{i,t}$ is on average increasing (see Table 1). All counties had a negative linear trend for $PctDemocrat_{i,t}$ and the average across counties decreased over the time period (see Table 1).

Included in Eq. 1 is a number of controls. Poll staffing should depend on forecasted demand in an election, both in the total number of voters (presidential election years have higher demand) and how votes are cast (early voting may require different staffing than Election Day voting). How votes are cast (paper vs. electronic, early vs. on-the-day) may be linked to party or race (e.g., if Democrats prefer early voting). We use two sets of proxies for these forecasts. The first set of proxies for an election's forecasted demand is the staffing used in the previous elections of the

Table 1 Mean values of key variables across Florida's 67 counties within each general election.

Variable	2008	2010	2012	2014	2016
VotersPerPW	178.63	217.85	238.21	277.54	265.94
PctDemocrat	48.61	46.95	44.43	42.74	39.58
PctWhite	79.65	79.36	78.44	77.98	77.12
AbsentBallotsPerPP	270.33	182.56	387.29	314.01	447.01
EarlyBallotsPerPP	419.76	199.37	473.86	261.75	678.69
EDBallotsPerPP	530.26	480.01	620.79	523.51	548.87
ProvBallotsPerPP	4.00	1.87	6.42	1.98	3.90
PollDiff	3.07	3.21	3.37	3.39	4.00
PersonPerSqMile	339.77	338.23	342.46	349.71	360.72
HousePrice	174.30	132.69	119.34	132.22	152.62
MedInc	43959	44269	43876	43908	45205
UseDRE	0.94	0.82	0.78	0.70	0.36
Pct65Plus	17.17	17.56	18.26	19.21	20.32

*Values calculated based on one imputation for the variable

same county: we include two lags, $logVotersPerPW_{i,t-1}$ and $logVotersPerPW_{i,t-2}$ as controls. The second set of proxies relate to contemporaneous election turnout. Because staffing is done at the level of a polling place, in all cases we evaluate the turnout proxies as the ratio of the actual ballots in a county to the number of polling places in the county. $logAbsentBallotsPerPP_{i,t}$ is the log of the number of absentee ballots cast per polling place. Absentee ballots (also known as mail-in ballots) should represent a lighter workload per ballot cast for election workers, i.e., a positive β_5. $logEarlyBallotsPerPP_{i,t}$ is the log of the early voting ballots cast per polling place. Given that early voting occurs over multiple days and that voters physically cast a ballot just as they do during Election Day, we expect an increase in the early ballots cast per polling place to decrease $logVotersPerPW$ because more poll workers are needed over multiple days to service early voters, i.e., a negative β_6. $logEDBallotsPerPP_{i,t}$ is the log of the Election Day ballots cast per polling place. We expect increases in Election Day ballots cast per polling place to increase $logVotersPerPW$ because more of the demand for poll workers is concentrated on just one day, i.e., positive β_7. $logProvBallotsPerPP_{i,t}$ is the log of the provisional ballots cast per polling place (with one added in case a county reports zero provisional ballots). Although provisional ballots may not represent a large portion of total votes cast (less than 0.5% of total ballots cast from 2008 to 2016 in our sample), they can require a significant amount of work (Dixon (2012)), i.e., a negative β_8.

Staffing could depend on the difficulty to recruit poll workers (Burden and Milyo (2015)), which is a concern if this is linked to race or political party. In the EAVS, counties rate poll worker recruitment difficulty on a scale from 1 (very difficult) to 5 (very easy) for each election, which we include as the control $PollDiff_{i,t}$ in Eq. 1. For this variable there are four out of 67 counties missing data for 2014 and 30 out of 67 counties missing data for 2016. We use multiple imputation to account for the missing data values (see Section EC.1.2).

Race and party affiliation is correlated with where a person lives (Parker et al. (2018)). The variability of demand throughout the day may depend on a precinct's degree of urbanization, and that variability may influence staffing. For example, an area with greater morning and evening demand spikes should require more staffing to achieve the same waiting time. We control for any effects of urban versus rural by including in Eq. 1 the log of the number of people per square mile in a county, $logPersonPerSqMile_{i,t}$.

We include in Eq. 1 the log of the median income of a county, $logMedInc_{i,t}$, and the "All-Transactions House Price Index", $HousePrice_{i,t}$ (normalized at a value of 100 in the year 2000) to control for differences in staffing that could be related to the wealth of a county over time (Spencer and Markovits (2010)).

To control for voter age, which may influence the time a voter needs to cast a ballot (Glenn and Grimes (1968)), we use the U.S. Census estimate of the percentage of the population within each county that is above the age of 65 ($Pct65Plus_{i,t}$).

The method of voting may influence the needed capacity (Spencer and Markovits (2010)). From 2008 to 2016, many Florida counties switched from direct recording electronics (DREs) machines to paper ballots (see Fig. EC.2). We set $UseDRE_{i,t}$ to 1 if a county used any DRE equipment in an election, otherwise it defaults to 0. The Verified Voting Foundation does not provide data on voting equipment for Florida counties in 2010, so we use multiple imputation to account for this missing year (see Section EC.1.2).

To account for variation in interest across elections, we included a dummy variable, $Presidential_t$, to indicate whether the election year was a presidential election. We include a linear time trend in the dependent variable across all counties, $Time_t$ to control for statewide time dependent trends. For example, from Table 1, the total number of active registered voters per poll worker tends to rise across counties during the span of our study. Table EC.1 provides summary statistics for all key variables across all Florida counties and elections.

The regression in Eq. 1 includes county fixed effects, c_i, to control for unobserved heterogeneity across counties that does not vary across time yet influences the staffing level. The presence of fixed effects in Eq. 1 along with the lagged dependent variables and regressors raises a concern of endogeneity bias in its estimation (Nickell (1981)). We use Arellano and Bond (1991) dynamic panel data model with first differences and lagged variables as instruments to overcome this issue. We limit the number of lags used as instruments in the model (Bowsher (2002)). To be specific, for the voting resource regressors (*logVotersPerPW*, *logAbsentBallotsPerPP*, *logEarlyBallotsPerPP*, *logEDBallotsPerPP*, *logProvBallotsPerPP*) we use the second and third lags as instruments (corresponding to both a midterm and presidential election). For voter demographic variables (*PctDemocrat*, *PctWhite*), we use the second election lag as an instrument, and for poll worker recruitment difficulty (*PollDiff*), we use the most recent election lag as an instrument. We do not include lags of the other regressors (*logPersonPerSqMile*, *HousePrice*, *MedInc*, *UseDRE*, *Pct65Plus*) because we believe they should be uncorrelated with shocks to the number of voters or poll workers.

The Hansen test (robust to heteroscedasticity) for overidentifying restrictions assumes a null hypothesis that our instruments meet the exogeneity requirement. We do not find evidence that the exogeneity assumption is violated (Table EC.2). We also address two issues with Arellano-Bond estimation. First, it may perform poorly if instruments are weak, which could occur if changes in county election demographics were fully adjustable from one election to the next, thereby having no relation to past values. We believe, however, that county demographics are somewhat rigid over time. Consistent with that view, we do not find evidence of weakness using F-statistics from the first-stage 2SLS regressions of the first differences of each endogenous variable (pooled across counties and election years) on its lagged instrument(s) (see Table EC.3). Second, Arellano-Bond estimation requires serially uncorrelated errors, which is supported (Table EC.2)

4. Results

As shown in Fig. 2, our results provide support for a disparity in voting resources due to political party. (See Table EC.4 for our complete set of estimates.) For a base reference, Fig. 2, *Left* provides the fixed effects estimates from a model without instruments for endogenous regressors. Fig. 2, *Middle* and *Right* provide the estimates from our preferred models, the one-step and the two-step Arellano-Bond procedures, respectively. All three models indicate that the number of voters per poll worker increases as a county's percentage of Democrat voters increases. In particular, based on the two-step Arellano-Bond procedure (Fig. 2, *Right*), a one percent increase in the percentage of Democrat voters is associated with a 2.8% increase in voters per poll worker. This effect appears to be large - as a point of comparison, in a cross-sectional study of voter resource allocation in Florida's 2012 election, a one percent increase in the percentage of white voters is associated with an increase of 0.26% voters per poll worker on Election Day (Famighetti et al. (2014)). (See Section EC.1.3 for more details on this benchmark calculation.)

In contrast to prior studies (Pettigrew (2017), Famighetti et al. (2014)), our results do not support the existence of a racial bias: the coefficients on *PctWhite* in both the one-step and two-step Arellano-Bond procedures are not significant. However, those studies are unable to control for political party affiliation. Given that race and political party are correlated, it is possible to conflate racial bias with a political party bias.

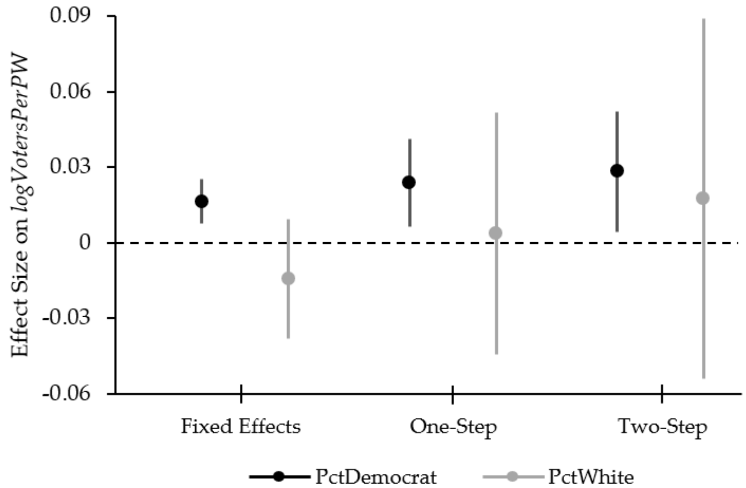

Figure 2 Displayed are coefficients from the regressions that estimate Eq. 1. Bars represent the 95% confidence intervals with robust standard errors used for the fixed effects and one-step estimation and Windmeijer corrected standard errors used for the two-step estimation (Windmeijer (2005))

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We estimate additional models (using the two-step Arellano-Bond procedure) to check the robustness of our results. In particular, we include different time controls, we utilize fewer instruments and lagged variables, we control for voters with no party affiliation, we control for the 2013 Supreme Court decision *Shelby County* v. *Holder* which influenced some of the counties in Florida during our study period, and we substitute our contemporaneous forecast turnout proxies with lagged variables. In all of these models the results are qualitatively similar to our main findings: there is a significant and negative coefficient for *PctDemocrat* and an insignificant effect of *PctWhite* (see Section EC.1.4 and Tables EC.5 to EC.7 for descriptions of the robustness checks, results, specification tests, and weak instrument tests).

5. Simulation

We use a queue simulation tool, developed by Mark Pelczarski, to examine the impact that changing the number of voters per poll worker could have on the wait time to vote (see `https://web.mit.edu/vtp/calc3.htm` for more information on the tool). This tool simulates the wait times voters could experience during a voting day based on queueing theory, historical data on polling places, and user-customized inputs on voter demand, voter arrival variability, and polling place capacity. We calibrate the simulation using data from the 2012 election in Florida because data are available on voter resource levels (Famighetti et al. (2014)) and the average voter wait time (Stewart III (2015)).

Table EC.8 reports the parameters selected for our base simulation. For the 2012 election in Florida, the average reported wait time is 42.3 minutes (Stewart III (2015)) and the average number of ballots cast per polling place on Election Day is 620.8 (EAVS). For our base simulation we selected 675 voters, 2 check-in machines, and 4 voting machines because the simulation tool with those parameters yields an average wait time of 40 minutes and 619 votes cast, similar to the actual results.

The simulation tool uses check-in stations and voting machines as the inputted resources. Our estimates focus on poll worker capacity. To make the linkage between our results and the simulation, we presume that voting resources are assigned proportionally. For example, it makes little sense to have three check-in stations and only one poll worker (or, with the other extreme, 6 poll workers).

We use three different methods to adjust capacity to measure the impact of a change in the percentage of Democrats on the average wait time. The first adjusts the average number of check-in stations in response to changes in *PctDemocrat*, leaving all other parameters constant, and assuming that the average change in check-in stations per polling place is proportional to our estimate for the average change in poll workers per polling place. (See Section EC.1.5 for details.) The second method is analogous to the first except now the number of voting stations is reduced. The third method increases the number of voters per polling place holding voting resources constant

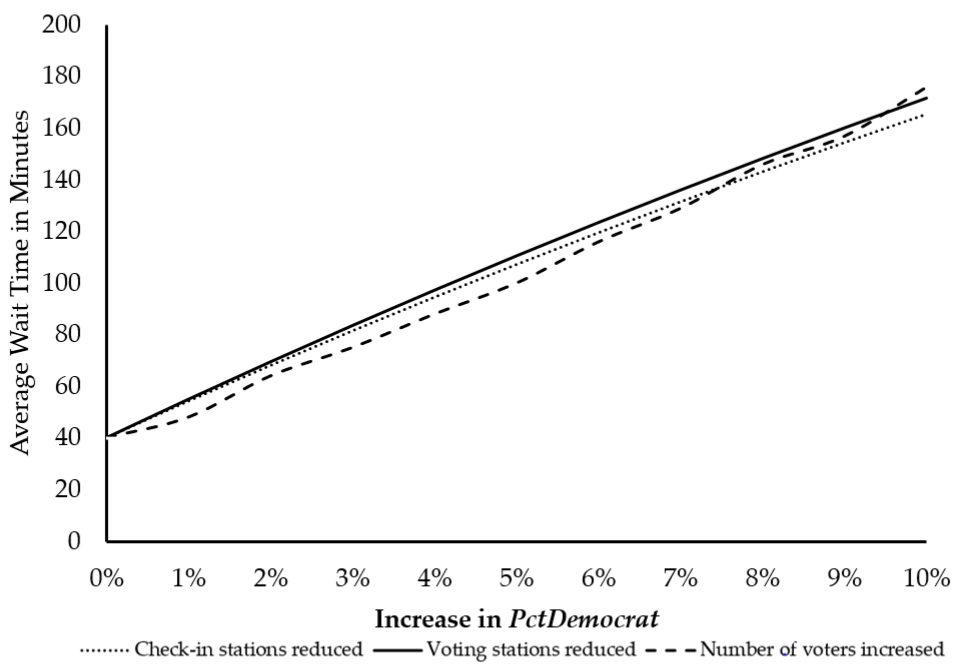

Figure 3 **Estimated average wait time in a county resulting from increases in PctDemocrat using three different methods for adjusting capacity.**

Fig. 3 reports the change in wait times as a function of the increase in *PctDemocrat*. The three methods provide comparable results. For example, a 5% increase in *PctDemocrat* raises the average wait time in a county from an initial 40 minutes to between 100 and 111 minutes. Our wait time

Table 2 Wait time (average of the three methods to adjust capacity) in a county resulting from changes in PctDemocrat predicted by changes in PctWhite (controlling for Presidential, Time, and county fixed effects between 2008 and 2016).

$\Delta PctWhite$	Predicted $\Delta PctDemocrat$	Average wait (min)
0%	0%	40
-1%	+1.28%	55.4
-5%	+6.41%	124.0

estimate seems realistic given that a 5% increase in *PctDemocrat* is 1.30 times the within-county standard deviation from 2008 to 2016 (3.85%), and the resulting average wait times are between 1.06 and 1.23 standard deviations above the average wait time reported by voters in Florida in the 2012 election across the Cooperative Congressional Election Study (Ansolabehere and Schaffner (2013)) and the Survey of the Performance of American Elections (Stewart (2013)).

Our study suggests that there may be no direct effect of race on voting resources and voter wait times. However, because race and political party are correlated, indirect effects of race could exist without controlling for political party. For example, when we regress *PctDemocrat* on *PctWhite*, controlling for *Presidential*, *Time*, and county fixed effects between 2008 and 2016, we find that a 1% decrease in *PctWhite* is associated with a 1.28% increase in *PctDemocrat*. Table 2 suggests that race could appear to drive voter wait times if political party is not observed.

6. Conclusion

Ensuring there is no disparity in voting resources among voters of different races or political party is an important endeavor. Ours is the first panel data study of voting resource disparities in elections. Unlike previous studies, we do not find a disparity with respect to race, *per se*. Instead, we provide evidence that as the percentage of Democrat voters in a Florida county increases, the voters in that county experience lower staffing levels (through more voters per poll worker) and longer waits to vote (via our simulation findings). Furthermore, our effect size estimates appear to be meaningful.

Rather than racial animosity, our results are consistent with parties using the allocation of voting resources to their advantage in the hope to dissuade voters from the opposition party from voting: the likelihood of a potential voter actually voting surely is different if the expected wait time is 100 minutes rather than 40 minutes. However, we are not able to rule out all possible explanations for the observed disparity. For example, if non-Democrats experience higher waiting costs per unit of time than Democrats, then a benevolent social planner would choose to bias resources away from Democrats: the unobserved cost of waiting can be equal even if the actual waits differ. Alternatively, if Democrats require less time to complete a ballot (or have lower variance in completion times), then equating waiting times would require different levels of resources per voter. If each poll worker is assigned more hours, as a county becomes more Democratic, then the reduction in poll workers might not imply a reduction in the total work hours dedicated to voting: i.e., fewer workers working more hours could yield a constant total resource level. Finally, unbalanced resources could be socially optimal if Democrats arrive to the polls more consistently throughout the day than non-Democrats. Although these hypotheses are potentially testable, they do not strike us as plausible.

We do emphasize that while our data indicates a resource bias based on political party, this bias does deferentially impact racial groups due to their varying support for the political parties. To the extent that non-white voters lean towards the Democratic party, they are more likely to be adversely affected.

While there are media stories regarding long waits to vote, there has not been reports that precincts have explicitly reduced voting resources. However there is reason to believe that such bias can occur and also be hard to detect. If the overall voting population is growing (as it was during our study period in Florida) but resources were not proportionally added, then Democratic leaning districts could be disadvantaged merely by keeping their resources constant without the need to explicitly have them reduced. They are only reduced relative to the demand they have to serve, which is less visible. Furthermore, voting resource allocations across polling places suffers from consequential integer constraints - the difference between one and two check-in stations can be significant. Thus, the one area that gets the additional resource is given a significant benefit relative to those in which resources are maintained at the status quo.

Given our findings, a practical solution is for a state to regulate the amount of resources in each polling location so as to attempt to equate waiting times across all voters. Unlike Florida, some states, such as South Carolina, have laws which mandate a maximum number of voters per voting resource. Although many laws related to the voting process are controversial (e.g., voter identification laws), laws that ensure democracy is equally served across all citizens should be less contentious.

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Supplementary Information

EC.1. Supporting Information Text

EC.1.1. Data Sources

logVotersPerPW

Florida Division of Elections provides information on the number of active registered voters by county for each election (see `https://dos.myflorida.com/elections/data-statistics/voter-registration-statistics/bookclosing/`). Election Administration Voting Survey provides county-level information on the number of poll workers by county from question D3 or equivalent (see `https://www.eac.gov/research-and-data/election-administration-voting-survey/`).

PctWhite/PctDemocrat/PctNoParty

Florida Division of Elections provides information on the number of active registered voters by county for each election (see `https://dos.myflorida.com/elections/data-statistics/voter-registration-statistics/bookclosing/`). Florida Division of Elections provides information on the racial and political party composition of active registered voters by county for each election (see `https://dos.myflorida.com/elections/data-statistics/voter-registration-statistics/bookclosing/`).

logAbsentBallotsPerPP

Election Administration Voting Survey provides county-level information on the number of Uniformed and Overseas Citizens Absentee Voters Act (UOCAVA) voters who voted absentee, Federal Write-in Absentee Ballots (FWAB), and domestic civilian absentee voters from question F1 or equivalent (see `https://www.eac.gov/research-and-data/election-administration-voting-survey/`). Election Administration Voting Survey provides county-level information on the number of polling places in an election from question D2 or equivalent (see `https://www.eac.gov/research-and-data/election-administration-voting-survey/`).

logEarlyBallotsPerPP

Election Administration Voting Survey provides county-level information on the number of ballots cast at an early vote center from question F1 or equivalent (see `https://www.eac.gov/research-and-data/election-administration-voting-survey/`). Election Administration Voting Survey provides county-level information on the number of polling places in an election from question D2 or equivalent (see `https://www.eac.gov/research-and-data/election-administration-voting-survey/`).

logEDBallotsPerPP

Election Administration Voting Survey provides county-level information on the number of ballots cast on Election Day from question F1 or equivalent (see `https://www.eac.gov/research-and-data/election-administration-voting-survey/`). Election Administration Voting Survey provides county-level information on the number of polling places in an election from question D2 or equivalent (see `https://www.eac.gov/research-and-data/election-administration-voting-survey/`).

logProvBallotsPerPP

Election Administration Voting Survey provides county-level information on the number of provisional ballots cast in an election from question E1 or equivalent (see `https://www.eac.gov/research-and-data/election-administration-voting-survey/`). Election Administration Voting Survey provides county-level information on the number of polling places in an election from question D2 or equivalent (see `https://www.eac.gov/research-and-data/election-administration-voting-survey/`).

PollDiff

Election Administration Voting Survey provides county-level information on poll worker recruitment difficulty in an election from question D5 or equivalent (see `https://www.eac.gov/research-and-data/election-administration-voting-survey/`).

HousePrice

Federal Reserve Bank of St. Louis collects county-level house price data through its "All-Transactions House Price Index" in the FRED database (see `https://fred.stlouisfed.org/`). The All-Transactions House Price Index was only available for 56 out of 67 counties. For the 11 counties missing data, we imputed the index based on the average of the housing indexes from adjacent counties.

logMedInc

U.S. Census Bureau collects county-level information on income in the past 12 months and publishes its 5-year estimates in report ID S1901 (see `https://www.census.gov/programs-surveys/acs/`). The U.S. Census only reports median income for all counties in Florida from 2009 and onward. We use the 2009 median incomes as a proxy for 2008.

logPeoplePerSqMile

Florida Office of Economic and Demographic Research publishes county-level information on population estimates used for calculating revenue sharing (see `http://www.edr.state.fl.us/Content/population-demographics/data/index-floridaproducts.cfm`). U.S. Census Bureau published information on the total square mileage in a county in 2010 (see https://www.census.gov/quickfacts/fact/note/US/LND110210).

UseDRE

Verified Voting Foundation publishes polling place equipment information by county (see https://www.verifiedvotingfoundation.org/about-vvf/). See below for how we impute missing data for the 2010 election.

Pct65Plus

U.S. Census Bureau collects county-level information on age and publishes its 5-year estimates in report ID S0101 (see https://www.census.gov/programs-surveys/acs/)

EC.1.2. Multiple Imputation Methodology

Predicting *PollDiff*

We use the following as predictors of *PollDiff* in counties: total active registered voters, male-to-female ratio, percentage of the population with a Bachelor's degree or higher, median age, median income, percentage Democrats, urban sprawl (people per square mile), political activeness (Election Day turnout percent) (Kimball et al. (2009), Burden and Milyo (2015)). We also use past values of *PollDiff* within a county as a predictor. Gender and age data is from the U.S. Census Bureau report ID S0101 (see https://www.census.gov/programs-surveys/acs/). Educational attainment data is from the U.S. Census Bureau report ID S1501 (see https://www.census.gov/programs-surveys/acs/). Election Day turnout data is calculated from the number of ballots cast on Election Day divided by the total number of active registered voters.

Predicting *UseDRE*

If a county used (or did not use) DREs during both the 2008 and 2012 elections, then we assume they would have used (or not used) DREs during the 2010 election. There are 56 counties for which we infer their 2010 usage in that manner. For the remaining 11 counties, we perform multiple imputation in which we randomly assigned each county to either use DREs or not use DREs across 10 imputations.

Imputing Results

We impute the regression coefficients and standard errors per Rubin (2004) with adjusted degrees of freedom suggested in Barnard and Rubin (1999) and 10 imputations based on guidance from White et al. (2011).

EC.1.3. Famighetti et al. (2014) Poll Worker Result Calculation with Percentage of White Voters

Famighetti et al. (2014) do not explicitly examine the relationship between the percentage of white registered voters and the number of Election Day eligible voters per poll worker in their study (i.e., they look at black, Latino, and other minority registered voters). However, using their data and regression methodology, we were able to examine this relationship by regressing the number of Election Day eligible voters per poll worker on the percentage of white registered voters in each precinct and included county fixed effects. To convert this regression estimate into a percentage (0.26%, as reported in our results), we divided the regression estimate by the mean number of Election Day eligible voters per poll worker in the data.

EC.1.4. Robustness Check Descriptions

TimeFE

We replace the variable *Presidential* and the linear time trend with time fixed effects and include exogenous dummy variables for election years 2010 through 2016 (*Election2010*, *Election2012*, *Election2014*, *Election2016*).

NoLag

We remove both lags of the dependent variable.

PctNoParty

We include the control *PctNoParty*, the percentage of active registered voters who had no political party affiliation.

Shelby

We include an exogenous variable, *ShelbyCounties* which equals 1 in the 2014 and 2016 elections and zero otherwise for those counties that were effected by the 2013 Supreme Court decision *Shelby County* v. *Holder*.

AltProxy

Instead of the contemporaneous forecast turnout proxies, we use the second lag of each variable (to match the previous election of the same type, midterm or presidential) and we eliminate the first lag of *VotersPerPW* because it is not significant in our main results.

ParsInstr

We examine a more parsimonious instrument model in which for all endogenous regressors, we use only the most recent election lag or lags as instruments that correct the first difference for endogeneity and pass our 2SLS F-test.

EC.1.5. Average Waiting Time Simulation

We use three different methods to measure the impact of a change in the percentage of Democrats on the average wait time. The first adjusts the average number of check-in stations in response to changes in *PctDemocrat*, leaving all other parameters constant. Let Q be the initial number of check-in stations. Assuming that the average change in check-in stations per polling place is proportional to the average change in poll workers per polling place, the average number of check-in stations after the change is

$$Q/e^{\hat{\beta}_1 P}$$

where $\hat{\beta}_1$ is our estimate for the change in voters per poll worker ($\hat{\beta}_1 = 0.028$), and P is the percentage change in Democrats in a county. To overcome the integer constraint on the number of voting resources (e.g., it is not possible to reduce the number of check-in stations across all polling locations by 0.1, but it is possible to reduce the number of check-in-stations in 10% of polling locations), we presume that the fraction ρ of polling places has $Q-\delta$ check-in stations and the remaining fraction, $1-\rho$, has $Q-\delta+1$ stations, where

$$\delta = Q - \left\lfloor \frac{Q}{e^{\hat{\beta}_1 P}} \right\rfloor$$

and

$$\rho = Q\left(1 - \frac{1}{e^{\hat{\beta}_1 P}}\right) + 1 - \delta$$

For most changes $\delta = 1$, but it is possible that a larger change in voting resources is needed. With our first measure we let W_1 be the new average waiting time due to a P percent change in Democrats

$$W_1 = \rho\Omega(675, 2-\delta, 4) + (1-\rho)\,\Omega(675, 2-\delta+1, 4)$$

where $\Omega(v, c, s)$ is the simulated average wait time for a polling place with v voters, c check-in stations, and s voting stations.

The second method is analogous to the first except now the number of voting stations is reduced:

$$W_2 = \rho\Omega(675, 2, 4-\delta) + (1-\rho)\,\Omega(675, 2, 4-\delta+1)$$

The third method increases the number of voters per polling place holding voting resources constant:

$$W_3 = \Omega\left(675e^{\hat{\beta}_1 P}, 2, 4\right)$$

EC.2. Figures

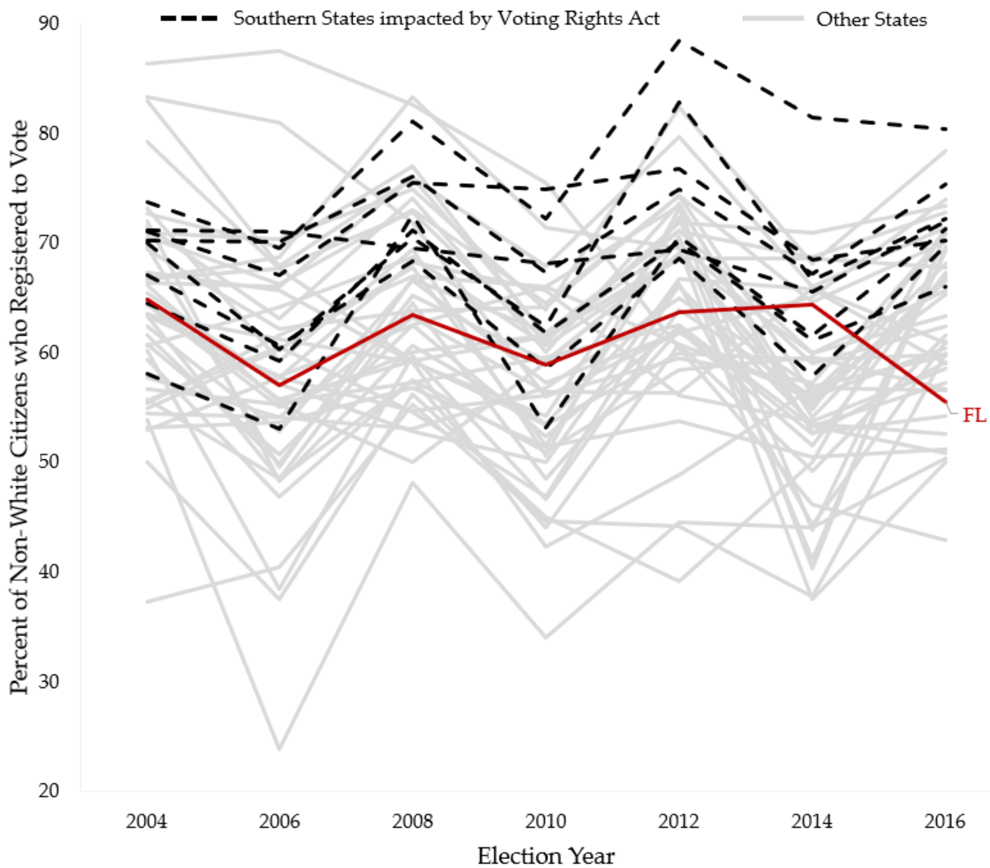

Figure EC.1 **Percent of non-white citizens who registered to vote by state. Data taken from U.S. Census Bureau reports on the voting and registration for states by race (see** `https://www.census.gov/topics/public-sector/voting/data/tables.html`**).**

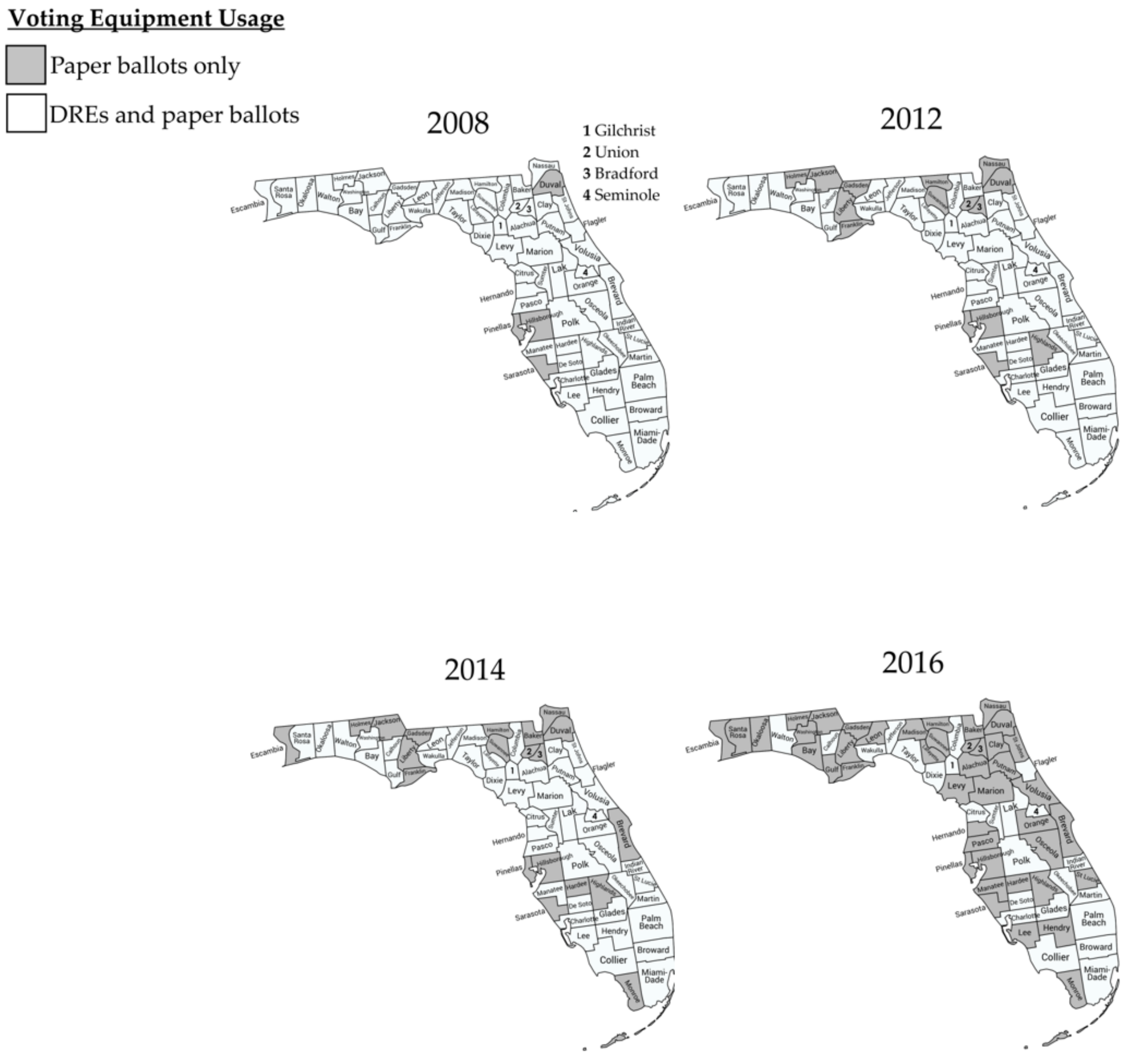

Figure EC.2 Change in Florida's voting equipment usage over time courtesy of the Verified Voting Foundation (figure created courtesy of `https://mapchart.net/`)

EC.3. Tables

Table EC.1 Summary statistics for key variables across Florida's 67 counties and the 2008 to 2016 general elections

Statistic	Voters Per PW	Pct Dem ocrat	Pct White	Absent Ballots PerPP	Early Ballots PerPP	ED Ballots PerPP	Prov Ballots PerPP	Poll Diff*	Person PerSq Mile	House Price	Med Inc	Use DRE*	Pct 65Plus
Mean	235.64	44.46	78.51	320.24	406.69	540.69	3.64	3.41	346.18	142.23	44243	0.72	18.51
Std. Dev.	93.11	14.60	14.09	229.48	295.14	223.86	4.02	1.05	531.99	23.53	7648	0.45	6.84
Minimum	79.70	19.42	18.37	30.88	16.00	142.69	0.00	1	9.76	97.55	29642	0	7.90
Maximum	581.74	88.38	95.80	1251.83	1591.49	1162.39	32.09	5	3486.37	214.61	69523	1	53.10
25th%ile	168.58	33.20	72.42	148.80	187.94	342.29	1.00	3	46.12	124.44	37778	0	13.80
50th%ile	220.01	42.28	82.84	257.12	315.44	543.90	2.22	3	166.57	137.22	43787	1	17.10
75th%ile	280.40	54.22	87.29	428.34	549.50	707.63	5.24	4	413.12	159.29	49135	1	21.70

*Calculated based on one of the ten imputations for the variable

Table EC.2 Main regression specification checks

Model Specification Checks (Note: $\triangle\hat{\varepsilon_{i,t}} = \triangle\hat{\varepsilon_{i,t}} - \triangle\varepsilon_{i,\hat{t-1}}$)	1-Step	2-Step
Number of instruments:	59	
H_0: No correlation between $\triangle\hat{\varepsilon_{i,t}}$ and $\triangle\varepsilon_{i,\hat{t-1}}$ | Max p-value among imputations:	0.008	0.014
H_0: No correlation between $\triangle\hat{\varepsilon_{i,t}}$ and $\triangle\varepsilon_{i,\hat{t-2}}$ | Min p-value among imputations:	0.876	0.813
H_0: No correlation between $\triangle\hat{\varepsilon_{i,t}}$ and $\triangle\varepsilon_{i,\hat{t-3}}$ | Min p-value among imputations:	0.728	0.766
Hansen test of overidentifying restrictions | Min p-value among imputations:	0.143	

Table EC.3 F-statistics resulting from the first-stage regression of the first differences of the covariate at time t (pooled across county and election years) on the lagged instrument candidate(s) for all endogenous covariates.

General Election Years: 2008 to 2016

First difference of covariate at time t	Lags used as Instruments	F-Statistic
PctDemocrat	t-2	59.92
PctWhite	t-2	52.00
logVotersPerPW$_{t-1}$	t-2/t-3	41.72
logVotersPerPW$_{t-2}$	t-2/t-3	33.77*
logAbsentBallotsPerPP	t-2/t-3	371.49
logEarlyBallotsPerPP	t-2/t-3	538.32
logEDBallotsPerPP	t-2/t-3	23.15
logProvBallotsPerPP	t-2/t-3	59.80
PollDiff† minimum among all imputations	t-1	73.53

*The first difference of logVotersPerPW$_{t-2}$ (i.e., logVotersPerPW$_{t-2}$ – logVotersPerPW$_{t-3}$) is fully identified by the two lags used as instruments so we report the minimum F-statistic resulting from the first-stage, pooled county regression of the first difference of the second lag on each individual lagged instrument candidate.

†We conducted the F-test for all 10 imputed cases for PollDiff and report the minimum F-statistic.

Table EC.4 Main regression results

General Election Years: 2008 to 2016 | Counties: 67

DV: logVotersPerPW	FE†	1-Step†	2-Step‡
PctDemocrat	0.017***	0.024***	0.028**
	(0.004)	(0.009)	(0.012)
PctWhite	-0.014	0.004	0.018
	(0.012)	(0.024)	(0.036)
logVotersPerPW$_{t-1}$	-0.033	-0.006	0.016
	(0.061)	(0.055)	(0.071)
logVotersPerPW$_{t-2}$	0.094	0.128*	0.150
	(0.058)	(0.073)	(0.108)
logAbsentBallotsPerPP	0.174***	0.205**	0.181**
	(0.061)	(0.089)	(0.086)
logEarlyBallotsPerPP	0.047	0.056	0.020
	(0.058)	(0.094)	(0.105)
logEDBallotsPerPP	0.238***	0.368***	0.385***
	(0.088)	(0.123)	(0.143)
logProvBallotstPerPP	-0.013	-0.068**	-0.071***
	(0.017)	(0.028)	(0.023)
PollDiff	-0.002	-0.023	-0.011
	(0.012)	(0.020)	(0.023)
logPersonPerSqMile	-0.275	-0.454	-0.419
	(0.381)	(0.425)	(0.554)
HousePrice	-0.001*	-0.001*	-0.001*
	(0.001)	(0.001)	(0.001)
logMedInc	-0.188	-0.042	-0.015
	(0.269)	(0.304)	(0.360)
UseDRE	0.006	-0.028	-0.028
	(0.035)	(0.042)	(0.042)
Pct65Plus	-0.004	-0.004	-0.007
	(0.006)	(0.007)	(0.009)
Presidential	-0.170***	-0.136**	-0.077
	(0.044)	(0.061)	(0.066)
Time trend	0.089***	0.107**	0.133**
	(0.022)	(0.042)	(0.063)
Constant	5.997*		
	(3.280)		

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

†Robust standard errors reported in parentheses

‡Windmeijer (2005) corrected standard errors reported in parentheses

Table EC.5 Robustness check results

General Election Years: 2008 to 2016 | Counties: 67

DV: logVotersPerPW	(1)TimeFE‡	(2)NoLag‡	(3)PctNoParty‡	(4)Shelby‡	(5)AltProxy‡	(6)ParsInstr‡
PctDemocrat	0.029**	0.030**	0.027**	0.029***	0.038***	0.035***
	(0.012)	(0.012)	(0.011)	(0.011)	(0.010)	(0.012)
PctWhite	0.024	0.021	0.017	0.023	0.013	0.032
	(0.035)	(0.035)	(0.027)	(0.035)	(0.028)	(0.036)
PctNoParty			0.035			
			(0.050)			
ShelbyCounties				0.098		
				(0.090)		
logVotersPerPW$_{t-2}$					0.098	
					(0.063)	
logAbsentBallotsPerPP$_{t-2}$					-0.002	
					(0.053)	
logEarlyBallotsPerPP$_{t-2}$					-0.029	
					(0.042)	
logEDBallotsPerPP$_{t-2}$					-0.005	
					(0.089)	
logProvBallotsPerPP$_{t-2}$					-0.024	
					(0.016)	
Election2010	0.244**					
	(0.108)					
Election2012	0.202					
	(0.141)					
Election2014	0.446***					
	(0.167)					
Election2016	0.553**					
	(0.232)					
logVotersPerPW lags	t-1/t-2	No	t-1/t-2	t-1/t-2	t-2	t-1/t-2
Presidential + Time trend	No	Yes	Yes	Yes	Yes	Yes
Other standard covariates	Yes	Yes	Yes	Yes	Yes	Yes

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

‡ Windmeijer (2005) corrected standard errors reported in parentheses

Table EC.6 Robustness specification checks

Model Specification Checks (Note: $\triangle\hat{\varepsilon_{i,t}} = \triangle\hat{\varepsilon_{i,t}} - \triangle\varepsilon_{i,\hat{t-1}}$)	TimeFE	NoLag	PctNoParty	Shelby	AltProxy	ParsInstr
Number of instruments:	61	51	67	60	59	43
H_0: No correlation between $\triangle\hat{\varepsilon_{i,t}}$ and $\triangle\varepsilon_{i,\hat{t-1}}$ | Max p-value among imputations:	0.011	0.006	0.017	0.015	0.013	0.042
H_0: No correlation between $\triangle\hat{\varepsilon_{i,t}}$ and $\triangle\varepsilon_{i,\hat{t-2}}$ | Min p-value among imputations:	0.565	0.5	0.656	0.805	0.544	0.762
H_0: No correlation between $\triangle\hat{\varepsilon_{i,t}}$ and $\triangle\varepsilon_{i,\hat{t-3}}$ | Min p-value among imputations:	0.873	0.818	0.734	0.808	0.22	0.646
Hansen test of overidentifying restrictions | Min p-value among imputations:	0.207	0.254	0.186	0.157	0.159	0.178

Table EC.7 F-statistics resulting from the first-stage regression of the first differences of the covariate at time t (pooled across county and election years) on the lagged instrument candidate(s) for the PctNoParty covariate and for the endogenous covariates with new instruments in the ParsInstr robustness check

General Election Years: 2008 to 2016

First difference of covariate at time t	Lags used as Instruments	F-Statistic
PctNoParty Robustness Check		
PctNoParty	t-2/t-3	13.22
ParsInstr Robustness Check		
logVotersPerPW$_{t-1}$	t-2	18.81
logVotersPerPW$_{t-2}$	t-2	96.97
logAbsentBallotsPerPP	t-2	72.57
logEarlyBallotsPerPP	t-2	167.26
logProvBallotsPerPP	t-2	19.38

Table EC.8 Base simulation inputs

Simulation parameter	Selection/Value
Polling hours (from Florida's Division of Elections website)	7am to 7pm
Arrival pattern	composite
Voting technology	paper ballot + optical scanner
Time to check in (minutes) Stewart III (2015)	2
Time to complete a ballot (minutes) Stewart III (2015)	5
Time to scan ballot (minutes) Stewart III (2015)	0.5
% voters unable to check-in (observed % of provisional ballots)	1%
% of voters arriving before polls open (default for simultation)	1.20%
Same day voter registration	no
Expected number of voters	675
Number of check-in stations	2
Number of voting stations	4

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