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Residual Vote in the 2004 Election

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IN 2000, AMERICANS learned that their elections are not always run according to the highest standards. This revelation led to two major developments. The first was a flurry of election reform activity at the state and national levels. The second was a degree of scrutiny over the conduct of the 2004 election that is probably unprecedented in American history.

The high degree of scrutiny over how the 2004 election was run, particularly in the "battleground states," has in turn led to a steady stream of election horror stories. A casual reading of American newspapers might lead a typical reader to conclude that state and local governments learned nothing from 2000—that the billion dollars spent on upgrading election equipment and practices under the Help America Vote Act (HAVA) had been wasted.

A careful consideration of reports from around the country about the conduct of elections in some jurisdictions reveals that election reform is still a work in progress. At the same time, a full consideration of all the evidence from the 2004 election should take into account the gains that four years of election reform did produce. Taking the American electoral system as a whole, the election of 2004 was run much better than the election of 2000. Participation certainly increased. Seventeen million more people voted for president in 2004 than in 2000, a 14% increase. Some of this increased turnout, approximately a million "new" voters, can be attributed to new equipment and changes in administrative practices.

This paper documents the improvement in one measure of election system performance, the "residual vote rate," which was first championed by the Caltech/MIT Voting Technology Project after the 2000 election (Caltech/MIT VTP 2001a,b; Ansolabehere and Stewart 2005). Based on official election returns from the states that report the turnout data necessary to form estimates, the residual vote rate fell from 1.90% in 2000 to 1.06% in 2004.[1] Assuming that the states that do not report turnout had improvements in ballot accuracy that are similar to states that do, this works out to a recovery of approximately one million "lost votes" between 2000 and 2004.[2]

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[1] The data in this paper were derived from the following sources. All election data were taken from the official election returns as reported by state divisions of elections and gathered directly by the author. In a few cases, anomalies were corrected by contacting local election officials directly. These data are available from the author upon request. (Those seeking county-level election returns for states that do not report turnout are directed to ⟨www.uselectionatlas.org⟩.) Data concerning voting technologies were purchased from Election Data Services (EDS). Requests for these data should be directed to EDS. The EDS data are only available at the county level. For states analyzed here that administer their elections at the municipality level (Connecticut, Massachusetts, Michigan, New Hampshire, Rhode Island, and Vermont), the author gathered municipality-level voting equipment data directly from state election officials. As part of the larger project of which this paper is a part, we have independently contacted state officials to ascertain the voting machines used throughout the country in 2000 and 2004. The EDS data set is particularly useful for filling in counties in those cases where state and local officials were unhelpful in providing the information to our research assistants. We have compared our own data with those purchased from EDS and found the two to be nearly identical, at the level of aggregation we use. Therefore, rather than mix data sources, I have chosen here to use only the EDS data to identify election machine types, except when I use the machine data at the municipality level.

[2] The calculation performed here is simple. The difference in the residual vote rate between 2000 and 2004 was 0.84%. Aggregate presidential turnout for 2004 is estimated to have been 122.2 million; 0.84% of 122.2 million is 1.03 million.

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Of course, this simple comparison ignores many complications in the use of the residual vote rate to assess the performance of voting machines. Part of the residual vote rate is composed of voters who intentionally abstain; what looks like a recovery of lost votes may simply be due to a drop in intentional abstentions in 2004. Most states that changed voting machines also undertook significant voter- and election worker education efforts. What looks like the recovery of lost votes due to improved machines may be due instead to better-informed workers and voters in states that also happened to change machines (Stewart 2004). Finally, election officials knew that their actions would be scrutinized in 2004 to an unprecedented degree. If this knowledge led them to more scrupulously round up stray votes that may have gone uncounted in years past, then the actual recovery of lost votes would be due to tighter election administration, not better machines.

Over time, researchers will accumulate the evidence necessary to parcel out credit for the drop in the residual vote rate among its various components. The purpose of this paper is to make an initial estimate that allocates credit for the reduction of the nationwide residual vote rate to machine changes, as opposed to other factors.

The remainder of this paper takes a deeper look at the initial patterns concerning the change in the presidential residual vote rate from 2000 to 2004. It shows that states (or, more precisely, counties and towns[3]) that changed their voting machines had the greatest improvement in the residual vote rate. However, it also shows that factors other than voting machine improvements, such as the intensely fought presidential election, produced residual vote improvements of similar magnitude. Buying new machines made a substantial positive difference in 2004, but new machines were only part of the story.

BACKGROUND: CALCULATION OF THE RESIDUAL VOTE RATE

The "residual vote rate" is a measure of voting machine accuracy that was first championed by the Caltech/MIT Voting Technology Project in 2001 and has been regularly used ever since by a number of researchers, reform commissions, and government agencies (Alvarez et al. 2004; Alvarez, Ansolabehere, and Stewart 2005; Ansolabehere 2002; Ansolabehere and Stewart 2005; Brady 2004; Hayduk 2002; Herron and Sekhon 2005; Buchler, Jarvis, and McNulty 2004; *Southwest Voter Registration Education Project v. Shelley*, 344 F.3d 914 [9th Cir.2003]). The residual vote rate in a geographic unit is the percentage of all ballots cast that did not record a vote for president. A vote can fail to be counted either because there was no vote for president on an individual's ballot (an "undervote") or multiple marks (an "overvote").

For the residual vote rate to be calculated, the political jurisdiction must report two things: (1) the number of votes cast for all presidential candidates, including write-ins, and (2) the total number of voters who appeared at the polls and were given a ballot. We call this latter statistic "turnout." All counties report the number of votes received by candidates who were printed on the ballot. Most, but not all, report the number of write-ins, if the state allows them. It is important to keep in mind that the residual vote rate can be inflated if a county does not report the number of write-in votes, since uncounted write-ins will be appear to be undervotes (Alvarez, Ansolabehere, and Stewart 2005).

Not all states require their counties to report turnout.[4] In 2004, twelve states did not report

[3] For most of the United States, counties are responsible for administering elections, and are ultimately the unit of analysis we study when we get down below the state level. In some states (notably New England and the upper Midwest), municipalities administer elections. For the sake of simplicity, when I refer to "counties" in this paper in their capacity as administrators of elections, I am also including municipalities that act in an identical capacity in these states.

[4] Some counties will report turnout even when the state does not require it. The election reporting software that now comes bundled with many of the newer machines facilitates these reports. However, when the state does not require its counties to report turnout, counties will adopt their own standards for what to include in their turnout report—for instance, many of these counties only report total turnout from Election Day, omitting absentees and provisional ballots or failing to update turnout reports to reflect the final, official, canvass. Our experience with working with turnout data from such counties is that their turnout reports are extremely variable and often unreliable. Therefore, this paper only examines turnout from counties in which the state requires a turnout report, and the turnout figures are reported officially by the state.

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actual turnout—Alabama, Kansas, Louisiana, Maine, Minnesota, Mississippi, Missouri, Oklahoma, Pennsylvania, South Carolina, Texas, and Wisconsin, which together accounted for approximately 25% of all presidential votes cast in the United States. This is a slightly smaller number of states not reporting turnout than in previous years.[5]

The residual vote rate is a convenient measure, but it must be used with care. Because of the secret ballot, it is impossible to know, for instance, how many ballots that contained a legal vote for president were cast in error. The residual vote rate must be used alongside other measures of voting technology accuracy to gain a complete understanding of how well voting machines perform.

The primary criticism levied against the residual vote rate is that it is impossible to distinguish between a ballot that contains no marks for president because of a technology-induced error and a ballot that contains no marks for president because the voter consciously abstained. If blank ballots primarily occur because of conscious abstentions and if blank ballots dominate residual votes, then the residual vote rate loses its utility.

For the thirty-seven states (including the District of Columbia) that reported total turnout in both 2000 and 2004, the aggregate residual vote rate was 1.1% in 2004; the residual vote rate was 1.9% in 2000 among the same states. Table 1 reports the residual vote rate among all the states from 2000 and 2004. Confining ourselves to the thirty-seven states for which we can calculate residual vote rates in both 2000 and 2004—the states we will refer to as "our sample"—six had residual vote rates above 2% in 2000, compared to only two in 2004. Of these thirty-seven states, six had residual vote rates below 1% in 2000, compared to eighteen in 2004. Florida and Georgia saw the biggest decreases in the residual vote rate, by 2.5% and 3.1%, respectively. They were also among the states that engaged in the most significant election reform efforts across the past four years. Only five states—Connecticut, Indiana, Iowa, Nebraska, and Rhode Island—saw increases in their residual vote rates from 2000 and 2004; with the exception of Connecticut, these increases were barely perceptible. In four of these states (Connecticut, Iowa, Nebraska, and Rhode Island), there was little-to-no change in the voting machines used, whereas Indiana experienced significant voting machine upgrades statewide.

FACTORS INFLUENCING RESIDUAL VOTE RATE IMPROVEMENT

My emphasis in this paper is on the role that voting machine improvements played in reducing residual vote rates. In order to estimate those effects precisely, we also need to account for other factors that may have reduced residual vote rates. In addition to changes in voting machines, I explore two other factors here, electoral competition and general statewide reform efforts. I address these latter two factors before examining changes in voting machines.

Electoral competition

A component of residual votes is intentional abstentions. Compared to other races, voters rarely blank their ballots for president. Nonetheless, public opinion surveys have identified a small number of voters (typically less than 1%) every four years who admit to not voting for president. We know that the residual vote rates vary from year-to-year and from county-to-county, even when voting machines stay unchanged. For instance, the 1988 residual vote rate for president was 2.4%, compared to 1.9% in 1992, even though there was very little nationwide change in voting machines between the two elections.

One explanation for this variation must be differences in how voters evaluate the presidential candidates, compared to each other and compared to other races on the ballot. The more energized the electorate, the lower the residual vote rate, as fewer voters consciously abstain. In the case of the residual vote rates in 1988 and

[5] South Carolina appears to report turnout on its Election Commission web page at ⟨www.state.sc.us/scsec/election.html⟩, but efforts to resolve numerous anomalies with election officials there revealed that the reported numbers for each county are a systematic undercount of actual turnout.

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TABLE 1. RESIDUAL VOTE RATES IN THE STATES, 2000 AND 2004

	Residual vote rate				
State	*2004*	*2000*	*State*	*2004*	*2000*
Alabama	*	*	Montana	1.2%	1.7%
Alaska	0.6%	0.8%	Nebraska	1.8%	1.4%
Arizona	1.3%	1.6%	Nevada	0.3%	0.6%
Arkansas	1.4%	*	New Hampshire	0.9%	1.9%
California	1.5%	1.6%	New Jersey	0.8%	1.0%
Colorado	0.9%	*	New Mexico	2.5%	2.8%
Connecticut	1.8%	1.0%	New York	0.8%	2.0%
Delaware	0.4%	1.7%	North Carolina	1.4%	3.5%
D.C.	1.1%	1.9%	North Dakota	1.0%	1.4%
Florida	0.4%	2.9%	Ohio	1.7%	1.9%
Georgia	0.4%	3.5%	Oklahoma	*	*
Hawaii	0.6%	1.2%	Oregon	0.8%	1.6%
Idaho	2.4%	2.9%	Pennsylvania	*	*
Illinois	1.4%	3.9%	Rhode Island	0.9%	0.9%
Indiana	1.8%	1.5%	South Carolina	*	*
Iowa	1.0%	0.9%	South Dakota	1.7%	1.8%
Kansas	*	*	Tennessee	1.1%	1.1%
Kentucky	0.9%	1.5%	Texas	*	*
Louisiana	*	*	Utah	1.5%	1.7%
Maine	*	*	Vermont	0.6%	1.0%
Maryland	0.3%	0.5%	Virginia	0.8%	1.8%
Massachusetts	0.5%	1.1%	Washington	0.8%	1.1%
Michigan	0.7%	1.1%	West Virginia	1.8%	1.9%
Minnesota	*	*	Wisconsin	*	*
Mississippi	*	*	Wyoming	1.0%	1.5%
Missouri	*	*			

*No turnout figures reported by state.

1992, the 1992 election featured a strong third party candidate, Ross Perot, who engaged a portion of the electorate that presumably was disengaged in 1988—either failing to go to the polls or altogether or abstaining from the presidential choice. The surge in the size of the electorate between these two dates, from 50.1% to 55.1% of the eligible electorate, was largely due to Perot's candidacy. What is equally likely is the drop in residual vote rate was also due to Perot being on the ballot.

By all accounts 2004 was an energized election. It was widely predicted ahead of time, by campaign professionals and the public at large, that 2004 was going to be a close. Both major party campaigns worked hard to turn out their most devoted voters, stoking the fires of political passion with "red state/blue state" rhetoric. Such dynamics might explain the general reduction in the residual vote rate from 2000 to 2004. In addition, the political passions were especially high in the "battleground states," where the outcome was perceived to be especially uncertain, and where the Electoral College outcome would be determined. Such a dynamic might also predict a greater reduction in the residual vote rate in battleground states, which in fact was true in 2004. The residual vote rate fell more in the battleground states than in the others. Of the thirty-seven states in our sample, seven were battleground states—Florida, Iowa, Nevada, New Hampshire, New Mexico, Ohio, and Oregon. The overall reduction in residual vote rate among these states was 1.2%, compared to 0.7% among the remainder.

General reform efforts

After the 2000 general election, a nationwide election reform effort was unleashed.[6] However, the effort was not uniformly distributed

[6] The most comprehensive reports of election reform nationwide can be found at ⟨www.electionline.org⟩.

across the states. Some states, like Florida, had highly visible statewide election reform commissions that met immediately on the heels of the election and recommended sweeping reforms of elections. Other states, like Connecticut, Massachusetts and New York, did virtually nothing. Some states had worse problems than others, and naturally they were the ones that were typically the most active. A major theme struck by many of these reform efforts, and reinforced when the federal Help America Vote Act (HAVA) was passed, was the replacement of antiquated punch card and mechanical lever machine equipment with more modern equipment. These efforts went beyond the machines, however, into the realm of registration practices, provisional ballots, voter education, and precinct worker training.

Unfortunately, there is no comprehensive set of measures to indicate which states were the most and least comprehensive in their approaches to reform, beyond buying new machines. Here, I make a crude attempt, constructing two indirect indicators of statewide reform activity. First, states with unusually high residual vote rates in 2000 may have worked harder to improve in 2004, and therefore may have had bigger reductions. Thus, we can think of the 2000 residual vote rate as measuring the "demand side" for reform in a state.[7] Second, states that saw more of its voters using new voting machines in 2004 may have had greater improvements, due to enhanced efforts at training voters and precinct workers how to use the new equipment. Thus, we can think of the percentage of new voting machines in a state as an indicator of how active state election officials were in pushing for reform within a state.

States with especially high residual vote rates in 2000 showed the biggest improvements in 2004. Among the states with residual vote rates over 2% in 2000, the overall residual vote rate was reduced by 2.4% points between 2000 and 2004. This compares to a tiny increase of 0.06% among states that had residual vote rates below 1% in 2000. States in the middle, with residual vote rates between 1% and 2% in 2000, experienced an intermediate reduction in residual vote rate of 0.4%.

Also, states that replaced more of their voting machines (regardless of type) experienced the greatest residual vote rate reductions. Roughly half of all votes were cast in states where 30% or fewer of the voters were using new voting machines.[8] These states, with the fewest new machines, experienced an aggregate 0.5% reduction in the residual vote rate. In the remaining states, where more than 30% of voters were using new machines in 2004, the residual vote rate fell by an average of 1.1% points. Within this group of heavy new-machine adopters, voters in the three states that experienced a complete changeover in voting machines (D.C., Georgia, and Nevada[9]) saw their residual vote rates fall by an aggregate of 1.8%

There is some evidence of "spillover effects" in changing voting technologies. For instance, if a county in a state that was experiencing substantial voting equipment upgrades changed its own voting equipment, too, the residual vote rate dropped an average of 1.2%; if a county in a state with little voting equipment

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[7] Anyone with a modicum of statistical training will recognize that I risk relying on "regression toward the mean" by using the 2000 residual vote rate in a state to predict changes in the residual vote rate from 2000 to 2004. The measurement problems introduced here can be corrected by the instrumental variables techniques described by Wald (1940), Bartlett (1949), and Durbin (1954), which produce the same substantive results as those described here. For instance, if we do the simple regression of the change in residual vote rate on the residual vote rate in 2000, the regression coefficient is −0.77 (s.e. = 0.11). If we apply the Bartlett (1949) instrumental variables technique to correct the measurement problem, the regression coefficient is −0.68 (s.e. = 0.15). Thus, the corrected regression coefficient is slightly smaller and the standard error is slightly larger, but not in any substantively important way. Thus, the regression toward the mean phenomenon is responsible for only a tiny portion of the results reported in this and the following two paragraphs. The fixed effects regression technique used later in this paper does not run afoul of the regression toward the mean phenomenon at all, because it does not rely on regressing *change* in a variable across time (i.e., $X_t - X_{t-1}$) on the lagged values of the variable (i.e., X_{t-1}).

[8] The states in which at least 30% of the voters used new voting machines in 2004 were Alabama, California, Colorado, District of Columbia, Delaware, Florida, Georgia, Illinois, Indiana, Kansas, Louisiana, Maryland, Maine, Minnesota, Missouri, Mississippi, New Jersey, Nevada, Oklahoma, Oregon, Pennsylvania, South Carolina, Texas, Washington, and Wisconsin. The remaining states had fewer than 30% of their voters using new machines.

[9] In Maryland, 91% of voters used new machines in 2004. Maryland's residual vote rate plummeted from 0.6% to 0.3%.

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change nonetheless implemented new equipment, its residual vote rate only dropped an average of 1.0%. Similarly, if a county in a state with substantial voting equipment upgrades nonetheless kept its old equipment, the average reduction in residual vote rate was 0.8%; if a county in a state with little statewide change in voting machines also stood pat, the average residual vote rate reduction was only 0.6%. These differences are small, but they are entirely consistent with the idea that there were spillover effects from one county to another that added to or detracted from the usability of voting equipment.

Voting machines at the county level

The comments that ended the previous section remind us that election reforms were a multi-level process between 2000 and 2004, with counties ultimately bearing the brunt of the effort. I thus turn my attention to changes in voting equipment in individual counties and towns, to document improvements in the residual vote rate at a more micro level.

Overall, counties that changed their voting technology between 2000 and 2004 experienced an aggregate 1.24% reduction in the residual vote rate, compared to an aggregate 0.59% reduction in the counties that did not. At the most basic level of analysis, changes in voting technologies appear to be associated with a substantial portion of the drop in the residual vote rate in 2004.

Within our sample of states, 656 counties changed their voting technologies between 2000 and 2004. These counties accounted for 36% of the votes casts in these states. Among these 656 counties, we see virtually every type of technology change. Still, some upgrade paths were much more common than others. For instance, 192 counties, representing 12.7 million voters, abandoned punch cards to adopt optical scanners and 148 counties, representing 2.7 million voters, abandoned lever machines to adopt direct recording electronic machines (DREs); at the same time, only three counties, representing 7400 voters, abandoned hand-counted paper for DREs and two counties, representing 19,000 voters, abandoned DREs for optical scanning.

If we want a precise measure of which upgrade paths produced the greatest reductions in the residual vote rate, we need to confine ourselves to the most common paths. There were six upgrade paths that involved more than 50 counties: from punch cards to optical scanners (192 counties and 12.7 million voters), from hand-counted paper to scanners (55 counties, 163 thousand voters), from punch cards to DREs (77 counties, 10.4 million voters), from lever machines to optical scanners (54 counties, 918 thousand voters), from lever machines to DREs (148, 2.7 million voters), and from optical scanners to DREs (96 counties, 4.1 million voters). All other voting technology changes involved a total of 31 counties and 463 thousand voters.

Table 2 reports the average improvement in the residual vote rates, according to the type of voting technology change from 2000 to 2004. The upgrade choices are ranked by their average improvement in the residual vote rate. Among the upgrade paths that affected the greatest number of voters—punch cards to DREs, scanners to DREs, and punch cards to

TABLE 2. AGGREGATE CHANGE IN RESIDUAL VOTE RATES, BY TYPE OF VOTING TECHNOLOGY CHANGE FROM 2000 TO 2004

Equipment used in 2000	*Equipment used in 2004*	*Change in residual vote rate*	*Number of counties/ voters (2004)*
Punch card	DRE	−1.61%	77/10.4 m
Optical scan	DRE	−1.23%	96/4.1 m
Punch card	Optical scan	−1.09%	192/12.7 m
All other equipment changes		−1.05%	82/0.6 m
Lever	Optical scan	−1.01%	54/0.9 m
Same equipment in 2000 and 2004		−0.64%	3,699/56.5 m
Lever	DRE	−0.35%	148/2.7 m
Paper	Optical scan	+0.04%	55/163 k

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scanners—the improvements in residual vote rates were roughly twice as great as the improvements experienced by voters who used the same equipment in 2004. The only common upgrade path that did not produce any improvements in residual vote rates was the one that went from hand-counted paper to optical scanners.

A MULTIVARIATE PERSPECTIVE

The previous section reviewed three different explanations for why the residual vote rate fell so substantially from 2000 to 2004—electoral competition in states, general reform efforts in states, and voting machine upgrades in counties. What that analysis did not do was consider how these factors were interrelated. Most importantly, it does not take into account that voting equipment upgrade paths and preexisting impediments to voting may have been correlated. The improvements in residual vote rates we attribute to changes in voting equipment could perhaps be attributed to the factors that led to the changes in equipment, not to the equipment itself. This point is underlined if we consider the fact that the upgrade path that produced the biggest gains in residual vote rates, from punch cards to DREs, was most common in the counties with the highest residual vote rates in 2000 (averaging 2.4%); the upgrade path that produced no gains, from hand-counted paper to scanners, was most common counties that already had relatively low residual vote rates (averaging 1.2% in 2000).

To disentangle the simultaneous effects that different causes of residual vote rate reduction may have had on voting in 2004, we need to conduct multivariate statistical analysis. Scholars have generally adopted two strategies in conducting multivariate analysis to study residual vote rates: cross-sectional analysis and panel studies. Cross-sectional analysis, which is by far the most common, conducts the analysis at one point in time. In this case, the dependent variable would be the residual vote rate in county *c* in 2004 and the independent variables would be measures of various factors also measured in 2004. The major independent variables of interest would be dummy variables measuring whether county *c* adopted a particular voting machine (or pursued a particular upgrade path) in 2004. It would be possible to throw the lagged value of the residual vote rate into the analysis—that is, the residual vote rate from 2000—but the fundamental approach here would be to focus on one point in time, the 2004 election.

While it is a common approach, it is seriously flawed. The biggest problem is that cross-sectional analysis relies on our accumulating a set of control variables that would satisfactorily account for all the confounding effects and changes in the residual vote rate—that is, the effects that influenced *both* the residual vote rate in 2004 *and* the choice of voting machines. The failure to do so creates a problem known as "omitted variables bias." The problem, briefly summarized, is that any variables that *are* included in the regression analysis will end up doing double-duty—they will explain their own influence on the residual vote rate *and* the influence that the omitted factors have on the residual vote rate. The main practical consequence is this: if we have measures of voting technology in the analysis but not good variables to control for the choice of technologies, then we will over-attribute reductions in residual vote rates to voting technologies.

Scholars doing cross-sectional analysis have tried to deal with the omitted variables problem by including a host of demographic controls in regressions. For instance, we know that residual vote rates are correlated with the fraction of African Americans in a county's population and that the choice of particular voting machines is also highly correlated with African-American populations. Hence, it is natural to include a measure of African-American population as a control when estimating the effects of voting machines on residual vote rates.

The problem with this approach still remains: once we have added all the demographic controls we can lay our hands on, we still cannot measure the most important factor that simultaneously influences the choice of voting machines and residual vote rates in counties—administrative practices (Ansolabehere and Stewart 2005). Locality-specific effects substantially influence residual vote rates, even after demographics

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TABLE 3. EFFECT OF VOTING MACHINE UPGRADES ON RESIDUAL VOTE RATE, 2000 AND 2004 (FIXED EFFECTS REGRESSION)

	(1)	*(2)*
Election year = 2004	−0.0098**	−0.0103**
	(0.0037)	(0.0038)
log (Turnout)	0.025	0.029
	(0.019)	(0.020)
County made a change:		
Any change	−0.0060*	—
	(0.0024)	
Punch cards to DREs	—	−0.0107*
		(0.0050)
Scanners to DREs	—	−0.0072**
		(0.0028)
Punch cards to scanners	—	−0.0045
		(0.0033)
Lever machines to scanners	—	−0.0027
		(0.0039)
Paper to scanners	—	0.0070
		(0.0043)
All other changes	—	0.0031
		(0.0043)
Constant	−0.27	−0.32
	(0.22)	(0.23)
N	8,716	8,716
R^2	0.63	0.64

*$p < 0.05$.
**$p < 0.01$.
Robust standard errors in parentheses.

have been controlled for; therefore cross-sectional regression has serious limitations in estimating the influence of voting machine choices on residual vote rates.

To address these problems, scholars have started turning to *panel studies* of residual vote rates. A panel study is simply a study of the same geographic units across more than one period of time. The specific regression technique used here is *fixed effects regression.* The dependent variable is the residual vote rate of county *c* measured at time *t*. In this case, we consider two time periods, 2000 and 2004.[10] The adoption of new voting machines is measured by a series of dummy variables that indicate whether county *c* followed upgrade path *p* between 2000 and 2004. All the other effects are measured by a series of dummy variables, one for each county, which soaks up a host of unmeasured (and often un-measurable) demographic and administrative factors that influence both residual vote rates and voting machine choices.

The major disadvantage of the panel approach is that it is impossible to use it to estimate the effects of independent variables that vary across counties, but which are relatively constant within a county for the time period being studied. Interesting demographic, administrative, and political factors often fit this description. As a result, many county-specific demographic effects, like average income or racial characteristics, are bound up in the thousands of county-specific dummy variables. If our interest were in these characteristics, *per se*, the analysis followed here would be of limited use. However, we are not examining the effects of demographics on the residual vote rate in this paper, and so this potential problem need not detain us here.

The first column of Table 3 reports the results from a baseline fixed effects regression. The only independent variables in the model are (1) a dummy variable equal to 1 if the observation is from 2004, 0 otherwise, (2) the logarithm of turnout in election year *t*, and (3) a dummy variable equal to 1 if the county adopted a new voting technology in 2004, 0 otherwise.[11] Counties are weighted by turnout in year *t*.[12] (Keep in mind that all county-spe-

[10] Ansolabehere and Stewart (2005) used a much larger panel, incorporating presidential election results from 1988, 1992, 1996, and 2000. I have chosen the shorter time period, for three reasons. First, the panel technique relies on the unmeasured, county-specific effects to be (relatively) constant during the period of study; that is a more reasonable assumption across two presidential elections than across five. Second, the analysis in this paper uses data gathered from a number of towns in the states where counties do not conduct elections; Asolabehere and Stewart (2005) contained a hodgepodge of counties and towns from these states. Thus, by taking a shorter, more recent panel, the units of analysis are not shifting in these states. (Including these states is important because they provide the leverage we need to estimate the effectiveness of traditional paper ballots.) Third, DREs have become much more common in recent years. The interfaces of the machines deployed before 2000 are quite different from those deployed more recently. If we stretch the time period back too far in time, the extreme heterogeneity of DREs will interfere with the precise estimation of what affect DREs have on residual vote rates.

[11] This variable is set to zero for all observations in 2000.

[12] Because we weight by turnout, we can interpret the dummy variable coefficients measuring equipment changes as the estimated change in probability that *an individual voter* who lived in a jurisdiction enacting that change would cast a residual vote.

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cific effects are accounted for by 4,400 dummy variables, one for each county.)

These results show that, as a whole, counties that adopted new voting technologies in 2004 experienced a drop in their residual vote rates an average of 0.60%, compared to counties that stood pat. This is virtually identical to the estimate we get without running the regression, reported in Table 2. Therefore, to a first approximation, it does not appear that the gains experienced by counties that changed voting technologies in 2004 were fundamentally due to the spurious effects of other reform efforts.

Before moving on, it is instructive to consider the other two independent variables in the analysis, logged turnout and the dummy variable for the year 2004. The dummy variable for the year 2004 indicates that the residual vote rate dropped in 2004 by 0.98%, controlling for county-specific effects and voting machine upgrades. The raw drop in the residual vote rate was 0.80%. With a standard error of 0.37%, this 0.98% estimate is not statistically distinguishable from 0.80%. Thus, it is reasonable to conclude that we would have experienced a similar-sized drop in residual vote rate in 2004 absent the factors in the model, namely, turnout surges, voting equipment changes, and changes in purely local political/demographic conditions. Stated another way, people involved in upgrading voting machines cannot take all the credit for reduced residual vote rates in 2004. At least as important was the heightened interest in politics in 2004, which reduced intentional abstentions significantly. These factors alone contributed to over one million new votes cast for president in 2004.

The variable measuring the (log) of turnout describes the effect of a surge in turnout, taking the average of the two years as a baseline. The positive coefficient shows that an increase in turnout led to an increase in the residual vote rate. This finding is consistent with Ansolabehere and Stewart (2005), who examined elections from 1988 to 2000. Keep in mind that the size of each county is already controlled for by the fixed-effects procedure, so that the only leverage that the direct measure of turnout provides is in estimating how much a *change* in turnout within a county affects the residual vote rate for that county. The substantive result, that local surges in turnout make residual vote rates go up, is consistent with previous formal and informal observation of local election administration. When turnout unexpectedly surges in a locality, long lines appear at the polls, voters get impatient, and poll workers become less attentive. Turnout surges also increase the number of inexperienced and less sophisticated voters. One result of all of this is that some votes get lost.

Column two of Table 3 replaces the single variable indicating a change in voting technology with six separate dummy variables corresponding to the major voting equipment upgrade paths explored in Table 2. The omitted category consists of counties that did not change their voting equipment from 2000 to 2004.

The coefficients associated with the equipment upgrade paths indicate that there were two paths that show statistically significant differences, compared to doing nothing: changing from punch cards to DREs and changing from scanners to DREs. The first change resulted in an average reduction of the residual vote rate of 1.07% and the second resulted in a reduction of 0.72%. The punch-card-to-scanner path shows a 0.45% reduction in residual vote rate, but the traditional $p < 0.05$ statistical hurdle is not exceeded.

If we compare these regression results with the raw percentage differences in Table 2, we see that the findings are similar. On the whole, the upgrades from punch cards and from optical scanners to DREs showed the only statistically significant gains in residual vote rates, among the common upgrade paths. On the margin was the path from punch cards to scanners, which produced small improvements in the residual vote rate—improvements that exceed statistical significance only if we use a very generous statistical standard.

This finding, which places the adoption of DREs at the top of voting technology reforms, is at odds with previous findings associated with the Caltech/MIT Voting Technology Project (2001a,b,c), which found the greatest residual vote rate gains prior to 2000 came when jurisdictions switched to scanners, and that DREs

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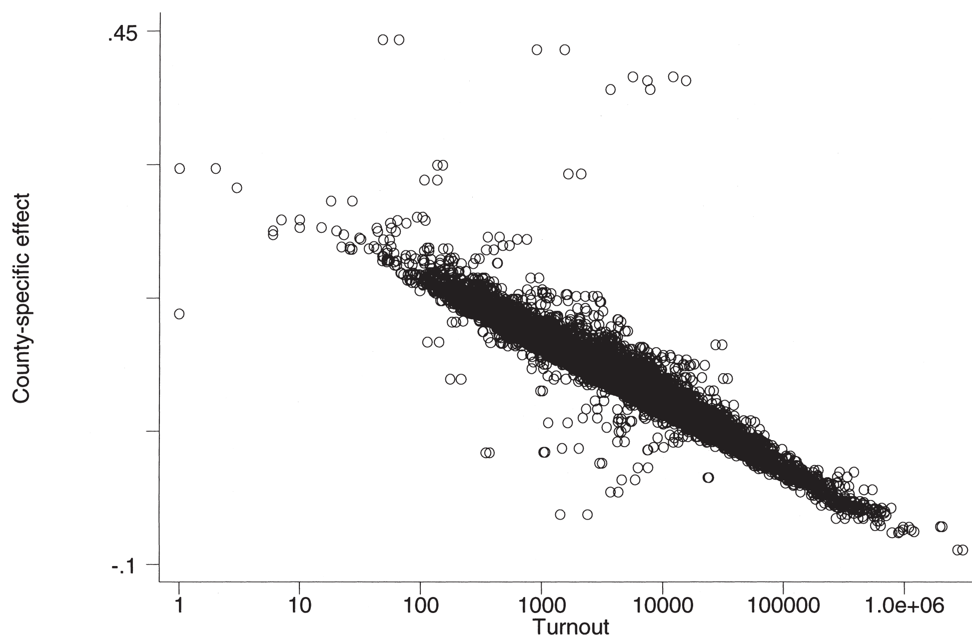

FIG. 1. County-specific dummy variables plotted against (log) of turnout.

were mediocre in this regard.[13] What explains this difference?

The most obvious difference is that the newest DREs are different from the older generation, and that greater attention has been paid to the ergonomic characteristics of these new machines. (For a similar argument, see Brady et al. 2001.) It is also the case that the newer DREs provide tighter integration of administrative activities associated with voting, which may have reduced confusion among poll workers. Finally, it is quite possible that the controversy associated with electronic voting machines in 2004 caused the users of these machines and the vendors who supplied them to be especially careful in using them.

We can make one final empirical point from the statistical estimation in Table 3. Because there are over 4,000 dummy variables—one associated with each county—in the estimation, it would be unwieldy to report all these coefficients. However, we can report them graphically. Figure 1 shows values of all the county-specific dummy variables, plotting them against the size of each jurisdiction's electorate. Note the strong negative correlation ($r = -.94$) between the coefficients and the log of the size of the electorate. This graph illustrates that bound up in the statistical controls are local factors that produce much higher residual vote rates in tiny jurisdictions than in larger ones.

This points to a factor that appears to be empirically robust, but rarely discussed in the literature: there is something about voting in small places that leads to more errors among the voters, reflected in higher residual vote rates. This regularity suggests that it is critical for researchers to understand better, at a micro level, how elections are run in communities of all sizes. In 2004, there was a surfeit of press coverage in American cities, examining the difficulties faced by voters who were struggling with long lines, understaffed voting places, and missing ballots. The results reported in this paper suggest that if similar coverage were afforded rural communities, even more difficulties (proportionately speaking) would be found.

Stated another way, differences in residual vote rate across geographic units are sometimes used to signal a potential equal protec-

[13] On the other hand, the finding here that moving from hand-counted paper to optical scanners actually makes residual vote rates worse is consistent with previous findings.

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tion issue in the administration of elections. If that is so, then smaller counties and towns deserve greater scrutiny than they have typically received by the press and voting rights activists, since they tend to have the largest residual vote rates, independent of voting machine type.

CONCLUSION

As Election Day 2004 came and went, much of the controversy that surrounded the election's conduct concerned the reliability and security of new electronic voting machines and the access that voters had to ballots themselves. It has become easy to forget that the urgency of election reform became evident in 2000 because of the manifestly poor performance of older voting machines, which led some to "lose" votes more easily than others. A major portion of the energy expended since 2000 in reforming elections has come in buying new voting machines and training new voters and poll workers how to use them.

The analysis in this paper shows that this effort produced results. Almost one million votes were "recovered" in 2000 because of the dramatic drop in the residual vote rate. Yet this paper also suggests a cautionary tale about placing too much faith in buying new machines alone. Even counties that used their old machines in 2004 experienced a reduction in the residual vote rate compared to 2000. The increased political heat generated by the 2004 presidential election was as important in reducing residual vote rates as changing voting machines.

One surprising finding in this paper is that two upgrade paths that involved the adoption of DREs turned out to produce the greatest drops in the residual vote rate. This finding contradicts previous statistical analysis that was performed on earlier generations of DREs. The current generation of DREs may, in fact, be better than the old ones.

If adopting DREs improved residual vote rates in 2004 more than other machine upgrade choices, then there are some important policy trade-offs at stake in the controversy over whether to require DREs to be equipped with "voter-verifiable paper trails" (VVPTs). The DREs being studied in this paper did not have VVPTs. It is likely that an attractive feature of the DREs—one that may have reduced residual vote rates—was the lack of mechanical moving parts. The addition of VVPTs to DREs risks adding mechanical devices that can break and confuse (Selker 2005). At the very least, it will be important to measure how residual vote rates change in the future in counties that add VVPTs to the DREs they already are using. It is possible, though by no means guaranteed, that we may discover that there is a trade-off between the peace-of-mind that VVPT devices bring against the cost of greater complexity in running elections (and eventually higher residual vote rates).

Finally, the results here show that the often-unmeasurable county-specific demographic, political, and administrative effects are strongly correlated with the size of the jurisdiction administering elections. Voters in small jurisdictions are more likely to cast ballots that are not counted on Election Day. Why this is so remains an unstudied aspect of election administration, but deserves more attention if all voters are to have an equal opportunity to have their voices heard at the ballot box.

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