Assessing Voting Methods in 2002

David C. Kimball

University of Missouri-St. Louis
Department of Political Science
8001 Natural Bridge Rd.
St. Louis, MO 63121-4499

dkimball@umsl.edu

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Abstract

In the wake of the controversial 2000 presidential election, several reforms have been proposed to improve election administration and reduce the number of unrecorded votes in future elections. Many counties upgraded to new voting equipment before the 2002 midterm elections, and many more are poised to follow suit in response to recent federal legislation. This paper documents changes in voting technology around the country and assesses their impact on unrecorded votes in the 2002 gubernatorial elections. The results indicate that not all "new" equipment performs the same. Touch-screen electronic voting machines and precinct-count optical scan systems significantly reduce the number of unrecorded votes in top-of-the-ballot contests. In contrast, full-face electronic voting machines and central-count optical scan systems have a much weaker impact and may not reduce the frequency of unrecorded votes.

As the presidential election in 2000 made clear, sometimes voters fail to cast a valid vote even in contests at the top of the ballot. Roughly 2 million voters (almost one in every 50 to cast a ballot) failed to record a valid choice for president in the 2000 elections. These unrecorded votes are the result of "undervotes" (where voters make no selection) and "overvotes" (where too many selections are recorded). In Florida, where George W. Bush defeated Al Gore by 537 votes, more than 175,000 ballots failed to record a vote for president (most were overvotes), and the disposition of those unrecorded ballots stoked a month-long election controversy.

In the wake of the 2000 elections, the phrase "we don't want another Florida to happen here" has become a common refrain for state and local election officials. Public officials have considered several election reforms to reduce the number of unrecorded votes in future elections. A common proposal is to replace older voting methods (punch cards, lever machines, and paper ballots) with newer equipment (optical scan systems or electronic voting machines). After the 2000 elections, over 370 counties upgraded their voting technology and many more jurisdictions are poised to follow suit in response to the recently passed Help America Vote Act of 2002.

This paper documents these changes in voting technology and provides a preliminary assessment of the impact of new voting methods and other ballot features on unrecorded votes in the 2002 gubernatorial elections. It appears that not all new voting technologies reduce unrecorded votes. Precinct-count optical scan systems and newer touch-screen electronic voting machines produce significantly lower rates of unrecorded

votes than central-count optical scan systems, full-face electronic machines, or other voting methods.

Waiting for the Feds to Act

Election reform has received a considerable push from the federal government in the past year. The Help American Vote Act of 2002 (HAVA) imposes several new requirements on state and local election officials. For example, the law requires each state to develop a statewide voter registration database and institute provisional voting procedures. In addition, the law requires election officials to provide access to voters with disabilities in each precinct and to adopt "second-chance" voting methods that allow voters to identify and correct mistakes.[1] The latter requirements may force many jurisdictions to replace older voting equipment. Furthermore, the law authorizes almost $4 billion to implement these requirements and improve election administration in the United States (although most of the money has not yet been appropriated). Some of the funds are specifically designated to help local governments replace punch card voting methods and lever machines. Finally, the recently passed federal appropriations for fiscal year 2003 includes roughly $1.5 billion to begin the HAVA election reform efforts.

To be sure, the recent economic downturn has lessened the appetite for election reform in many states, and the recent federal appropriation falls short of what was authorized by HAVA for fiscal year 2003. Furthermore, the money authorized by HAVA for new voting equipment (roughly $4,000 per precinct) does not come close to meeting the actual cost of new voting technologies. Nevertheless, there will be real money

[1] HAVA allows states to avoid the "second chance" requirement by adopting voter education programs to help reduce voting errors.

coming soon to make election changes, and most states are attempting to make the necessary legislative and regulatory changes to make sure they qualify for federal election reform funds. Thus, the pace of election reform and upgrading voting technology quickens.

In addition, several local governments switched to new voting equipment between the 2000 and 2002 general elections. It is worthwhile to examine the impact of these changes to inform the more sweeping changes in election administration that are likely to occur in the next few years. In particular, it is important to estimate the ability of new voting methods to reduce unrecorded votes, as compared to other ballot and election features.

Theory and Evidence on Unrecorded Votes

There are two general explanations for unrecorded votes: (1) lack of voter interest in a particular contest, and (2) voter confusion. Evidence from several elections indicates that both processes help account for unrecorded votes.

One common explanation of unrecorded votes is that voters intentionally abstain from making a selection in contests that do not interest them. This may reflect a failure of political parties and organized groups to mobilize voters (Burnham 1965), or it may reflect a strong incumbency advantage and other forces that reduce competition in elections (Pothier 1987; Crain, Leavens, and Abbot 1987). The "voter fatigue" phenomenon is a common example. That is, voters grow weary of having to make numerous selections on a long ballot and thus abstain (or undervote) in contests

appearing farther down the ballot (Bullock and Dunn 1996; Bowler, Donovan, and Happ 1992).

In addition, unrecorded votes are more common in contests where voters have little information about the competing alternatives, often because of negligible media coverage or low visibility campaigns (Burnham 1965; DuBois 1979; Bowler, Donovan, and Happ 1992; Magleby 1994; Mueller 1969; Pothier 1987; Stiefbold 1965; Bullock and Dunn 1996; Wattenberg et al. 2000). Unrecorded votes seem to be more common in nonpartisan contests than in equivalent partisan races (Schaffner, Streb, and Wright 2001). Similarly, unrecorded votes are more common in contests that lack appealing candidates or controversial issues (Vanderleeuw and Utter 1993; Harris and Zipp 1999; Vanderleeuw and Engstrom 1987; Engstrom and Caridas 1991). Finally, unrecorded votes are more common in states that restrict write-in voting, thus limiting the voter's ability to register disapproval of the choices listed on the ballot (Kimball, Owens and Keeney n.d.).

Voter confusion is another potential cause of unrecorded votes. Accidental undervotes and overvotes may occur due to faulty equipment or confusing ballot designs (Knack and Kropf 2003; Kimball, Owens, and Keeney 2003; Darcy and Schneider 1989; Shocket *et al.* 1992; Nichols and Strizek 1995; Caltech/MIT Voting Project 2001a, 2001b). Several studies conclude that unrecorded votes are more common with Votomatic punch cards than any other type of voting equipment, probably because punch card voting involves several steps that can malfunction or cause confusion (Saltman 1988; Caltech/MIT Voting Project 2001a; Brady et al. 2001; Knack and Kropf 2002, 2003; Kimball, Owens, and Keeney 2003). In contrast, voting methods that prevent

overvotes (electronic and lever machines) or allow voters to detect and correct errors (such as precinct-count optical scan systems) tend to have fewer unrecorded votes than other methods (Tomz and Van Houweling 2003; Kimball, Owens, and Keeney n.d.). As another example, when candidates for the same office are listed in multiple columns or on multiple pages of the ballot, voting errors and unrecorded votes are more common (Darcy and Schneider 1989; Wand et al. 2001; Jewett 2001; Kimball, Owens, and Keeney n.d.).

There are additional correlates of unrecorded votes that may reflect a combination of voter confusion and lack of interest. Studies indicate that ballot designs that facilitate straight-party voting (the straight-party punch and the party-column layout) reduce the number of unrecorded votes (Kimball, Owens, and Keeney 2003; Walker 1966). Such features minimize ballot fatigue but they also reduce the impact of voting technology and other ballot features that may confuse voters.

In addition, several demographic variables are correlated with higher levels of unrecorded votes. For example, unrecorded votes are more frequent in smaller counties than in large urban counties (Knack and Kropf 2003; Caltech/MIT 2001b; Brady et al. 2001; Kimball, Owens, and Keeney n.d.). Since candidates have an incentive to concentrate their efforts on the heaviest concentrations of voters, little campaign activity is directed toward small rural counties in national and statewide elections. It is also possible that large counties have more professionalized election administration (as well as other government functions) than smaller counties.

Unrecorded votes are also more common in counties or precincts with large populations of racial and ethnic minorities, low-income residents, less-educated citizens,

or elderly voters (Walker 1966; Vanderleeuw and Engstrom 1987; Darcy and Schneider 1989; Sheffield and Hadley 1984; Nichols and Strizek 1995; Herron and Sekhon 2003; Knack and Kropf 2003). It may be that each of these groups faces a higher degree of difficulty during the voting process (due to language differences, discrimination, or disabilities, for example). Alternatively, many of these groups may be alienated from the political process and thus less interested in many of the contests on the ballot.

It appears that voter confusion accounts for some of the demographic differences because some voting methods and ballot features appear to minimize the socio-economic disparity in unrecorded votes. Some studies indicate that the elevated rate of unrecorded votes associated with confusing ballots and voting technology (such as Votomatic punch cards) falls disproportionately on racial and ethnic minorities and the poor (Darcy and Schneider 1989; Nichols 1998; Tomz and Van Houweling 2003; Knack and Kropf 2003; Kimball, Owens, and Keeney n.d.). Similarly, the straight-party ballot option significantly reduces the effect of race and income as predictors of unrecorded votes (Kimball, Owens, and Keeney 2003).

Data

Since elections are administered at the county level in all but six states, the data collection includes the number of ballots cast, vote totals for specific contests, voting technology, and demographic characteristics for each American county in the 2000 and 2002 general elections. In states where elections are administered by municipalities or townships, I aggregate the vote totals and voting technology data to the county level. In four states (Illinois, Missouri, Maryland, and Virginia), some cities have separate election

administration authorities. These cities are treated as separate "counties" in this dataset.[2] Adding the District of Columbia as another "county" produces a total of 3148 geographic units that cover the entire country.

Voting Technology: What has Changed

Part of the data collection includes the voting technology used in each county, gathered from state and local election officials. Table 1 provides a short description of each type of voting technology and summary data on the prevalence of each voting method in the 2000 and 2002 elections. Generally, five different methods of voting are used in the United States: paper ballots, lever machines, punch card machines, optical scan ballots, and direct recording electronic (DRE) machines.[3] Within each of these general categories, further distinctions can be made. Punch card methods are divided between Votomatic varieties (in which the punch card is separate from the booklet listing the offices and issues up for election) and the Datavote system (in which offices and candidates are printed directly on the punch card).

[Table 1 about here]

Optical scan systems and electronic machines are currently the newest voting technologies. Optical scan systems vary depending on where ballots are counted: at a central location (like the county courthouse) or at the voting precinct. One advantage of

[2] The state government administers elections in Alaska. Alaska's boroughs are treated as counties for this analysis.
[3] One can find a detailed description of each type of voting equipment in a variety of sources (Fischer 2001; Caltech/MIT Voting Technology Project 2001a, 2001b; Brady et al. 2001).

the precinct-count optical scan systems is that they give voters a chance to discover and correct potential mistakes (overvotes and undervotes). The central-count systems do not have such an error-correction feature.[4] DRE machines can be divided into older and newer varieties. Older DREs (such as the Shouptronic 1242, which was designed to mimic lever machines) present the entire full-faced ballot at once and typically use a push-button interface (Caltech/MIT Voting Project 2001a). The newer generation of DREs (such as the E-Slate and Accuvote-TS machines) typically use a touch-screen interface and allow voters to scroll through the offices and issues on the ballot (as in Votomatic punch card ballots).

Finally, in some counties, not all ballots are cast using the same technology. In those cases, I code the voting technology as the equipment used by at least 75% of the voters. If no single method was used by at least 75% of the voters, the county's voting technology is coded as a "mixed" system. Most of the counties with mixed systems are in states where elections are administered by municipalities or townships.

Slightly more than 14 million voters cast ballots on new voting equipment in the 2002 general elections. As Table 1 shows, punch cards saw a steeper decline in usage in 2002 than lever machines (the other voting method targeted by HAVA). Over ninety counties replaced punch card balloting after the 2000 election, and the share of ballots cast on punch cards dropped from 30% in 2000 to 21% in 2002. Although over 100 counties replaced lever voting machines, most of these were small counties in Georgia, so the change did not have a dramatic impact on overall usage of lever machines in the United States.

[4] Some counties have precinct-count optical scan balloting but do not activate the error correction feature when scanning the ballots. These counties are coded as central-count systems.

While optical scan systems were the most commonly used voting method in recent elections, they did not see an overall increase in usage between 2000 and 2002. The percentage of ballots cast on precinct-count systems increased from 23% in 2000 to 27% in 2002 while use of central-count systems decreased. Among counties that switched to optical scan systems in 2002, 92 adopted precinct-count varieties while only 34 adopted central-count versions. In addition, while central-count optical scan systems are used in more counties than the precinct-count version, substantially more ballots are cast on the precinct-count version. Central count systems tend to be used in smaller, rural counties while precinct count systems tend to be used in more heavily populated counties.

Most of the counties that adopted new voting technology in 2002 switched to an electronic voting machine. Recent elections mark some new designs in electronic voting machines. Most of the DREs adopted after 2000 have a touch-screen interface and a scrolling format. These newer DREs saw their use rise from 1% of voters in 2000 to 10% in 2002. In contrast, almost all of the electronic machines in use before 2000 are full-face, push-button machines that tend to resemble lever machines when viewed from a distance. Among counties that upgraded to electronic voting machines before the 2002 elections, 195 adopted newer touch-screen DREs while only 20 switched to the older full-face DREs.[5]

The most dramatic changes in voting technology after 2000 took place in Florida and Georgia. Motivated by the 2000 presidential election controversy, the Florida legislature passed a reform bill requiring the replacement of punch card ballots, lever

[5] Another 25 counties switched to a mixed system in 2002. These counties tested new voting equipment in several, but not all, voting precincts. Finally, the city of Chicago and Cook County, Illinois upgraded their punch card voting to include ballot counters at each precinct that alerted voters when their ballots contained overvotes or undervotes (an error-correction mechanism similar to precinct-count optical scan systems).

machines, and paper ballots. As a result, 41 of the state's 67 counties were required to adopt new voting technology for the 2002 election (MacManus 2003). Counties were able to choose optical scan systems or electronic voting machines. Twenty-six counties in Florida upgraded to precinct-count optical scan systems and fifteen switched to electronic touch-screen voting machines.

While Florida garnered most of the media attention after the 2000 election, Georgia had a higher percentage of unrecorded votes in the 2000 presidential election than Florida. With a strong push from Secretary of State Cathy Cox, a Democratically-controlled Georgia state government adopted a uniform voting method for the entire state, requiring all 159 counties to replace existing voting methods with a touch-screen system (Strahan and Gunning 2003). Voting technology upgrades in the rest of the country were more scattered, but large urban counties in several states (such as California, Colorado, Maryland, Pennsylvania and Texas) also switched to new voting methods in 2002.

How Much Does Voting Equipment Matter?

I assess the impact of new voting technology by examining unrecorded votes in the 2002 gubernatorial elections. To measure the number of unrecorded votes for governor in each county, I calculate the difference between the total number of ballots cast and the number of votes cast for governor. In most cases, election results were collected from the official canvass provided by each state. However, some states do not maintain data on ballots cast for every county. For several states, I contacted individual counties to gather data on the total number of ballots cast in the county. Even so, there

are some missing observations, as some counties did not have reliable information on the number of ballots cast in recent elections. I have complete data for 1,846 counties (out of 2184 counties with a governor's race in 2002), which covers slightly less than 96% of the votes cast for governor in 2002. Demographically, the counties with missing data are very similar to the counties in the sample, with the exception that missing counties tend to be smaller in population and have a higher average percentage of Hispanic residents. Among the counties in the sample, there were 1,227,774 unrecorded votes cast in gubernatorial contests (2.0% of ballots cast). The distribution of unrecorded gubernatorial votes across counties is skewed, with outliers at the high end. Residual vote percentages range from .1% to 19.8%, with a median of 1.9%, a mean of 2.3%, and a standard deviation of 1.6%.

At first glance, it appears that new voting equipment can dramatically reduce the frequency of unrecorded votes. After having two of the highest rates of unrecorded votes in the presidential election of 2000, Florida and Georgia had two of the lowest rates of unrecorded votes in the 2002 gubernatorial elections. Unrecorded votes in Florida dropped from 2.9% of ballots cast in 2000 to 0.8% in 2002. In Georgia, unrecorded votes dropped from 3.5% in 2000 to 1.0% in 2002.

Table 2 provides another preliminary assessment of voting equipment and unrecorded votes in the 2002 gubernatorial elections. As in many studies, Table 2 indicates that punch card ballots (especially Votomatics) are associated with higher rates of unrecorded votes than other voting technologies. In addition, Table 2 suggests that precinct-count optical scan systems and touch-screen DREs have noticeably lower levels of unrecorded votes than all other voting methods, while full-face DREs and central-

count optical scan systems do not perform much better than paper ballots and lever machines.

[Table 2 about here]

The figures in Table 2 and the comparisons of Florida and Georgia are suggestive, however. Both states had very competitive contests for governor in 2002, which should increase voter interest and minimize unrecorded votes. In addition, Florida's problems in 2000 are partly attributed to decisions by election officials in eighteen counties to list the ten presidential candidates in multiple columns or on more than one page (Cauchon 2001; Jewett 2001; Kimball, Owens, and Keeney n.d.). None of the Florida ballots in 2002 had such a design flaw. Finally, there are several other factors that need to be controlled to increase confidence in the conclusion that new voting equipment reduces unrecorded votes.

Multivariate Analysis

To get a more reliable assessment of the impact of new voting technology, I estimate a multivariate model of unrecorded votes in the 2002 gubernatorial elections. The model includes voting technology, state-specific characteristics, and demographic measures as explanatory variables.

Optical scan balloting is the most commonly used voting technology, and some recent studies (Caltech/MIT Voting Technology Project 2001a, 2001b; Knack and Kropf 2003) conclude that it produces lower residual vote rates than most alternatives, including electronic machines. Consequently, the regression model uses the central-count optical

scan system as the baseline for comparison. The regression model includes separate dummy variables for each type of voting technology in Table 1 (including mixed systems) except centrally counted optical scan methods.

I control for several state election features that affect unrecorded votes. Previous research suggests that unrecorded votes should be less common in states with a straight-party ballot option (Bullock and Mishou 1999; Kimball, Owens, and Keeney 2003). In the 2002 elections, 17 states had a straight-party punch on the ballot. These states are identified by a dichotomous variable.

There is also evidence that laws regarding the treatment of write-in votes influence the number of unrecorded votes, since voters may use the write-in option to express disapproval of the candidates listed on the ballot (Kimball, Owens, and Keeney 2003). In 2002, thirty-four states either did not include space on the ballot for write-in votes or only counted write-ins cast for candidates who had filed a declaration of write-in candidacy (a requirement few candidates fulfill). Some voters in these states made write-in selections that were not counted as valid votes. Another 15 states allow and count all write-in votes. The regression model includes a dummy variable for states that count all write-in votes for governor. I also include a dummy variable for Nevada, the only state to include a ballot line for "None of These Candidates" in federal and statewide races.[6] This is certainly a more conspicuous outlet for a protest vote than the write-in option, so I expect unrecorded votes to be less common in Nevada.

It is also reasonable to expect that unrecorded votes are less common in competitive elections that feature vigorous two-party campaigns and high-quality

[6] In the 2002 Nevada gubernatorial election, "None of These Candidates" received 23,674 votes, almost as many as the combined totals of all four third-party candidates.

candidates. I use the final governor race ratings from the Cook Political Report (Cook 2002) to code the level of competition in each governor's race. The ratings variable has four categories: "toss up" (coded as 3), "lean" (coded as 2), "likely" (coded as 1), and "solid" (coded as 0). I expect unrecorded votes to be more common in states with the least competitive campaigns for governor (those rated "solid" for one party or the other).

Finally, the regression model includes a number of demographic variables that are often correlated with unrecorded votes. I include the percentage of a county's population that is black (which ranges from 0% to 98% with a mean of 8% in our sample), the percentage that is Hispanic (which ranges from less than 1% to 84& with a mean of 6%), and the percentage 65 years of age or older (which ranges from 2% to 35% with a mean of 15%). I expect a positive relationship between residual votes and each of these three demographic variables. In addition, I include the percentage of people over age 25 that hold a college degree (which ranges from 4% to 53%, with a mean of 14%) and the natural log of median household income (which ranges from 9.4 to 11.3 with a mean of 10.4). Both should be negatively correlated with residual votes. Median income is logged because the raw data are skewed with outliers at the high end and I hypothesize that beyond some point, increased income does not increase one's familiarity with the voting process. Finally, I include the natural log of each county's population (which ranges from 6.1 to 16.1, with a mean of 10.4) because several studies find a negative relationship between population and unrecorded votes.[7]

[7] Data on each county's median household income (a 1997 estimate) come from the U.S. Census Bureau's State and County QuickFacts web site (http://quickfacts.census.gov/qfd/). Data on each county's population, as well as the percent black, the percent Hispanic, and the percent 65 years or older (based on the 2000 census) come from the U.S. Census Bureau's State and County QuickFacts web site (http://quickfacts.census.gov/qfd/). Finally, data on the percentage of people over age 25 with a college degree (based on 1990 census data) come from the 1994 County and City Data Books (http://fisher.lib.virginia.edu/ccdb/).

The choice of a statistical model for the multivariate analysis requires some explanation. In analyzing unrecorded votes, it is common to use a least squares regression model, with the percentage of unrecorded votes serving as the dependent variable. However, there is some concern that least squares regression does not adequately capture the data generating process for unrecorded votes. The percentage of unrecorded votes must be between 0 and 100, and most observations clusters near 0. However, least squares regression models do not constrain the expected value to the 0-100 range.

I estimate a negative binomial regression model, using the number of unrecorded votes in each county as the dependent variable.[8] One of the statistical properties of the negative binomial model is that the expected value of the dependent variable cannot fall below zero.[9] The negative binomial is a variant of the Poisson regression model when there is "overdipsersion" in count data (Long 1997). Overdispersion means that there is more variation in the dependent variable than expected by the Poisson distribution and it can occur in count data if events are clustered in particular locations or time periods. For example, an unrecorded vote in a particular precinct or county may lead to more unrecorded votes in that same voting location (because of faulty equipment, for example). The negative binomial estimates an extra parameter (alpha) to account for overdispersion.

I also use a couple of modifications to the generic negative binomial regression model. Since the number of voters in each county varies dramatically, I weight each county by the number of ballots cast. Most counties have small populations, and relatively few voters, and weighting the data gives greater credence to the large counties

[8] Bullock and Hood (2002) estimate a negative binomial model to examine unrecorded votes.
[9] Some studies use a grouped logit equation to model unrecorded votes (Wand et al. 2001; Herron and Sekhon 2002).

where most voters cast their ballots. In addition, I estimate robust standard errors to correct for heteroskedasticity likely in data with a skewed dependent variable (White 1980). Finally, the model is modified to account for the fact that the count of unrecorded votes in a county is a function of the total number of ballots cast.[10] Even with the greatest voting equipment and the most helpful poll workers, a county with 100,000 voters will probably have more unrecorded votes than a county with 1,000 voters.

Results

Table 3 provides the estimated coefficients of a negative binomial regression of unrecorded votes in the 2002 gubernatorial elections. The estimate for alpha is roughly ten times larger than its standard error, indicating overdispersion in the data. More importantly, the estimates show that voting methods and several state election features are associated with unrecorded votes in 2002. To begin with some of the state characteristics, unrecorded votes are significantly less common in states with a straight-party ballot option. According to the model estimates in Table 3, having a straight-party device on the ballot reduces the expected number of unrecorded votes in a county by 20 percent, holding all other variables constant.[11]

[Table 3 about here]

[10] I use the *nbreg* command in Stata version 8 to estimate the model. The total number of ballots cast is specified with the "exposure" option. Long and Freese (2001, 241-250) describe the negative binomial model and the exposure concept.

[11] I use the *listcoef* suite of commands developed for Stata by Long and Freese (2001) to calculate the percent changes in expected values reported in this section.

While the handling of write-in votes appears to have no effect, unrecorded votes are significantly less common in Nevada, the only state with a "None of These Candidates" ballot line in the 2002 election for governor. Based on the regression model, the "None of These Candidates" ballot feature reduces the expected number of unrecorded votes by 46 percent, even after controlling for other factors. Nevada produced an unrecorded vote rate (1.8%) below the national average (2.0%) in 2002, even though Nevada featured one of the least competitive gubernatorial races in the country. Finally, as expected, unrecorded votes are less common in states with more competitive contests for governor. Increasing the four-category competition variable by one unit reduces the expected number of unrecorded votes in a county by 16 percent.

The estimates in Table 3 reveal substantial voting technology effects as well. Confirming other studies, Votomatic punch card balloting produced higher rates of unrecorded votes than any other voting method in the 2002 gubernatorial elections. Based on the model estimates, Votomatic punch card balloting increases the expected number of unrecorded votes by 58 percent over a county with central-count optical scan balloting. The results suggest that counties replacing punch card balloting with optical scan ballots counted centrally can expect to reduce the frequency of unrecorded votes. However, the results also indicate that paper ballots, lever machines, and Datavote punch cards perform no worse than central-count optical scan systems.

Among "new" voting technologies, touch-screen DREs perform best in the 2002 gubernatorial elections while full-face DREs perform the worst. Touch-screen DREs reduce the expected number of unrecorded votes by 41 percent when compared to

central-count optical scan systems.[12] However, older full-face DREs actually perform worse than some voting methods, including lever machines. Older DREs only perform statistically better than Votomatic punch cards. Counties with older DREs have an expected number of unrecorded votes 19 percent higher than counties with central-count optical scan systems. Whether it is the interface (push-button versus touch-screen), the ballot format (full-facing versus scrolling), or something else, the newer generation of electronic voting machines clearly produces lower levels of unrecorded votes than older electronic voting machines.

As expected, the results in Table 3 also indicate that precinct-count optical scan systems produce lower rates of unrecorded votes than central-count systems. Wald tests indicate that precinct-count optical scan systems perform better than every other method except touch-screen electronic machines. The error-correction feature in precinct-count systems clearly seems to help reduce the number of unrecorded votes.

Finally, demographic variables overall are not very closely associated with unrecorded votes in the 2002 gubernatorial elections. Race, ethnicity, and age are the demographic variables with statistically significant effects on unrecorded votes. Unrecorded votes are more common in counties with larger percentages of black, Hispanic, or elderly voters. These effects are consistent with previous research. On the other hand, education, income, and population are not correlated with unrecorded votes in the 2002 gubernatorial elections.

The results suggest that counties looking to upgrade voting technology may want to pay close attention to different varieties of optical scan systems and electronic voting

[12] Wald tests reveal that unrecorded votes are significantly less common in counties using touch-screen DREs than in counties using any other voting equipment, including precinct-count optical scan methods.

machines. Touch-screen DREs and precinct-count optical scan methods may reduce unrecorded votes more than full-face DREs and central-count optical scan systems.

A final analysis examines the change in unrecorded vote rates from the 2000 presidential election to the 2002 gubernatorial election in each county. This will help determine whether upgrading to new voting technology significantly reduced unrecorded votes, after controlling for some other relevant factors. The dependent variable is the percentage of unrecorded ballots in the 2002 gubernatorial election minus the percentage of unrecorded ballots in the 2000 presidential election. Positive values indicate that unrecorded votes increased in 2002, while negative values indicate that unrecorded vote rates decreased. On average, unrecorded vote rates did not change dramatically from 2000 to 2002, but there was quite a bit of variation. More than one quarter of the counties in the sample saw unrecorded vote rates increase more than 1 percent from 2000 to 2002. Similarly, more than one quarter of the counties saw unrecorded vote rates drop more than .5 percent in 2002.

I estimate a linear regression model with five explanatory variables to account for changes in unrecorded vote rates. Three voting technology variables are created to estimate the effect of new equipment. One dichotomous variable identifies counties that upgraded from Votomatic punch card ballots to a new voting method after the 2000 elections. In table 3 and in other studies (Brady et al. 2001; Kimball, Owens, and Keeney n.d.), Votomatic punch cards stand out as the equipment producing the highest levels of unrecorded votes. Thus, the first explanatory variable will test whether counties that replaced Votomatic punch cards saw a greater improvement in unrecorded votes than counties that replaced Datavote punch cards, lever machines or paper ballots.

A second dummy variable identifies counties that upgraded to touch-screen DREs or precinct-count optical scan systems (the two methods that represent the newest generation of equipment for each system and performed the best in previous analyses). A third dummy variable identifies counties that upgraded to full-face DREs or central-count optical scan methods in 2002 (older generation systems for these methods). These two variables will test whether there is a difference in the ability of the new generation of voting methods to reduce unrecorded vote rates observed in previous elections.

The regression model includes two control variables. One is a dummy variable identifying nineteen counties known to have listed presidential candidates in more than one column in 2000 (18 counties in Florida and one in Louisiana). The multiple-column layout caused unusually high levels of overvotes in the 2000 presidential contest (Wand et al. 2001; Jewett 2001; Kimball, Owens, and Keeney n.d.). Since each county corrected the ballot design flaw in 2002, I expect unrecorded vote rates to drop substantially in these counties. All other counties, with one exception, listed candidates in a single column in 2000 and 2002.[13] Finally, I include the competition rating variable used in Table 3 as a control. I expect that unrecorded vote rates may increase in states holding relatively uncompetitive gubernatorial elections in 2002.

The results are presented in Table 4, and they generally support expectations. On average, unrecorded vote rates dropped 4.5 percent in counties that had listed presidential candidates in multiple columns in 2000. This is a very large change and is seen in each of the affected counties. For example, the unrecorded vote rate in Duval County, Florida dropped from 9.1% in 2000 to 0.5% in 2002.

[13] Kewaunee county, Wisconsin is the only county I am aware of that went in the opposite direction, using the two-column ballot format for the 2002 governor's race after not using it in the 2000 presidential contest. Kewaunee is given a code of –1 on the two-column variable described above.

[Table 4 about here]

In addition, the level of competition in the 2002 gubernatorial elections is associated with changes in unrecorded vote rates. On average, unrecorded vote rates increased substantially in states with uncompetitive contests for governor in 2002, but rates changed little in states that had very competitive races for governor. For example, in Connecticut, unrecorded votes jumped from 1.0% in 2000 to 2.0% in 2002, when incumbent John Rowland cruised to reelection by a comfortable margin.

Most importantly, the results in Table 4 suggest that changes in voting technology help explain increasing or decreasing levels of unrecorded votes in 2002. Counties that replaced punch card balloting with any other voting method in 2002 saw unrecorded votes drop by an average of 1.7 percentage points. Simply eliminating punch card ballots dramatically reduced the rate of unrecorded votes in 2002.

In addition, the type of new voting equipment chosen in 2002 made a substantial difference. Upgrading to touch-screen DREs or precinct-count optical scan systems significantly reduces unrecorded vote rates, beyond the effect of simply eliminating punch card ballots. In contrast, upgrading from paper ballots, lever machines, or Datavote punch cards to full-face DREs or central-count optical scan methods slightly increased unrecorded votes. Counties that switched to touch-screen DREs or precinct-count systems in 2002 saw unrecorded vote rates drop almost 1 percent on average. In contrast, counties that switched from non-Votomatic voting methods to full-face DREs or central-count optical scan systems in 2002 saw, on average, a statistically significant .5 percent increase in unrecorded votes.

Conclusion

Several counties installed new voting equipment after the 2000 elections, and many more are preparing to do so in the near future. The evidence in this paper suggests that replacing Votomatic punch card ballots and adopting touch-screen DREs or precinct-count optical scan balloting will significantly reduce the number of unrecorded votes in future elections. In contrast, adopting full-face DREs and central-count optical scan systems may slightly increase unrecorded votes if they replace paper ballots or lever machines. Election officials purchasing new voting equipment should pay close attention to what they are buying.

Finally, while voting technology clearly deserves notice as election reforms move forward, other ballot features also merit consideration for those interested in reducing the frequency of unrecorded votes. The straight-party option and Nevada's "None of These Candidates" ballot line significantly reduce unrecorded votes. There may be other ballot design elements (such as the multiple column layout) that increase or decrease voter confusion and thus deserve closer scrutiny (Niemi and Herrnson 2003).

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Table 1
Voting Methods Used in 2000 and 2002

Technology	Description	Counties		% of Voters	
		2000	2002	2000	2002
Punch Card – Votomatic	Punch card is inserted behind booklet with ballot choices – voter uses stylus to punch out holes in card. Ballots counted by card reader machine.	513	436	27%	19%
Punch Card – Datavote	Ballot choices are printed on punch card – voter punches out hole next to chosen candidate. Ballots counted by card reader.	44	26	3%	2%
Lever Machine	Candidates listed by levers on a machine – voter pulls down the lever next to chosen candidate. Machine records and counts votes.	401	292	16%	13%
Paper Ballot	Candidates are listed on a sheet of paper – voter marks box next to chosen candidate. Ballots counted by hand.	331	297	1%	<1%
Older DRE (full-face)	Candidates listed on a full-face computerized screen – voter pushes button next to chosen candidate. Machine records and counts votes.	304	321	11%	12%
Newer DRE (touch-screen)	Candidates listed on a scrolling computer screen – voter touches screen next to chosen candidate. Machine records and counts votes.	29	224	1%	10%
Optical Scan – Central Count	Voter darkens an oval or arrow next to chosen candidate on paper ballot. Ballots counted by computer scanner at a central location.	902	837	15%	12%
Optical Scan – Precinct Count	Voter darkens an oval or arrow next to chosen candidate on paper ballot. Ballots scanned at the precinct, allowing voter to find and fix errors.	540	616	23%	27%
Mixed	More than one voting method used.	84	99	4%	5%

Table 2
Unrecorded Votes in the 2002 Gubernatorial Elections by Voting Technology

Voting Technology	Unrecorded Votes in 2002
Punch Card – Votomatic	3.5%
Punch Card – Datavote	2.8%
Paper Ballot	2.3%
Lever Machine	2.2%
Mixed	1.5%
Optical Scan – Central Count	2.0%
Optical Scan – Precinct Count	1.3%
Older DRE (full-face)	2.2%
Newer DRE (touch-screen)	1.2%
Number of Counties	1847

Table 3
Multivariate Analysis of Unrecorded Votes in the 2002 Gubernatorial Elections

Explanatory Variable	Coefficient	Robust Standard Error
State Variables		
Straight-Party Ballot Option	-.23***	.06
Level of Competition	-.18***	.03
State Counts all Write-In Votes	.02	.06
"None of These Candidates" (Nevada)	-.63***	.09
Voting Technology		
Votomatic Punch Card	.45***	.08
Datavote Punch Card	.22	.15
Paper Ballot	.03	.10
Lever Machine	-.01	.08
Older Electronic Machine (full-face)	.17*	.09
Newer Electronic Machine (touch-screen)	-.52***	.11
Optical Scan – Precinct Count	-.28**	.09
Mixed	-.09	.10
Demographic Controls		
Percent Black	.0026*	.0015
Percent Hispanic	.013***	.002
Percent 65 or older	.022**	.007
Median household income (natural log)	-.13	.15
Percent with a college degree	-.005	.004
Population in 2000 (natural log)	-.03	.02
Constant	-2.13	1.52
Alpha	.21***	.02
Number of Cases	1847	
Model Chi-Square	780.8***	

The dependent variable is the number of ballots cast that failed to record a valid vote for governor. Cell entries are negative binomial regression coefficients and robust standard errors.
Observations (counties) are weighted by the number of ballots cast in the 2002 election.
Central-count optical scan systems are the comparison category for voting technology.
*** p < .001, ** p < .01, * p < .1, two-tailed

Table 4
Multivariate Analysis of Change in Unrecorded Vote Rates from 2000 to 2002

Independent Variable	GLS Coefficient
Candidates Listed in Multiple Columns in 2000	-4.55*** (.94)
County Upgraded from Votomatic punch card ballots	-1.64*** (.47)
County Switched to New Generation Technology (touch-screen DRE or precinct-scan)	-.82** (.33)
County Switched to Old Generation Technology (full-face DRE or central-scan)	.47** (.21)
Level of Competition in 2002 Gubernatorial Contest	-.31*** (.05)
Constant	1.30*** (.14)
Number of Cases	1765
Root of Mean Square Error	1.29
R^2	.44

The dependent variable is the change in unrecorded vote rates (2002 unrecorded vote rate minus 2000 unrecorded vote rate). Cell entries are regression coefficients with robust Huber/White standard errors in parentheses. Each county is weighted by the number of ballots cast in the 2002 general election.
***$p < .01$, two-tailed test
**$p < .05$, two-tailed test
*$p < .1$, two-tailed t test