Some Observations on Proportions of Uncounted Votes in the 2000 Presidential Election in Georgia

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1 Punch Card Ballots, Lever Machines, and Optical Scan Systems

In the wake of the 2000 presidential election, Americans were made aware of possible errors, inefficiencies, or inequities in the voting system in the United States. Voters have been wondering, perhaps for the first time, whether the vote they meant to cast was actually correctly tabulated in the election results. While the election results in Florida were the immediate focus, all over the country methods of tabulating votes were scrutinized. If some polling methods such as punch card ballots result in a higher proportion of uncounted votes than other methods such as optical scan, then voters in some polling areas may have a higher probability of their vote "counting," and others may feel relatively disenfranchised. This paper presents some interesting observations on the proportions of uncounted votes, by county, in the state of Georgia. The data used in this study, and some similar data from the state of Florida can be found on the web at

`www.stat.uga.edu/~mmeyer/absvote.html`

In Georgia, voters cast almost 2.7 million ballots in this election, but only about 2.6 million votes for the president were recorded. A press release from the office of the Georgia Secretary of State [1] reported that differences between the number of actual ballots cast and the number of votes recorded in the final, certified results may be generated in three ways: 1) the voter decided not to make a choice in the presidential race, 2) the voter attempted to make a choice but it was not read or computed by machines used, or 3) the voter inadvertently chose more than one candidate in a single race, which voided their (sic) choice. The statewide figures for uncounted votes are:

Number of Ballots: 2,691,314

Number of Votes: 2,596,633

Number of Uncounted Votes: 94,681

Percent Uncounted Votes: 3.50%

The Georgia Secretary of State is quoted [1]: "I find it difficult if not impossible to believe that so many citizens chose not to make a selection in the most important race on the ballot."

The 3.5% uncounted votes tops Florida's well-known 2.9%. However, the race was not close in Georgia; in fact, if all of the uncounted votes were assigned to Mr. Gore, Mr. Bush would have still carried the state's electoral votes.

The state has 159 counties and 5 different methods, or types of voting equipment, for tabulating votes in an election. The Secretary of State web page provided some statistics from the 2000 presidential election: the number of ballots cast in each county, the type of voting equipment used by that county, and the number of votes for the president that were counted. The response variable for the analyses in this paper is the proportion of uncounted votes, by county.

The first thing we want to determine is whether the voting equipment is a significant predictor of the proportion of uncounted votes. The five voting methods used in Georgia were "optical scan, precinct count" (OS/PC), "optical scan, central count" (OS/CC), "lever," "punch card," and "paper." The summaries of uncounted votes by voting method are listed in Table 1, along with the number of counties utilizing the method (in order of increasing proportion of uncounted votes). The data are depicted in Figure 1, where some of the counties with particularly high proportions of uncounted votes are indicated by name.

The horizontal lines in each column of points in Figure 1 indicate the overall proportion of uncounted votes for that method. This is not the average of the proportions since the counties with higher proportions of uncounted votes tend to be smaller counties, with fewer ballots cast. Therefore, the averages of the proportions are higher than the overall proportions for each voting method.

Voting Method	# Counties	Total Ballots	Total Votes	Percent Uncounted
OS/PC	22	807,526	790,280	2.1%
Paper	2	3,454	3,341	3.3%
OS/CC	44	628,633	606,786	3.5%
Lever	74	427,780	410,764	4.0%
Punch	17	823,921	785,459	4.7%

Table 1: Percent Uncounted Votes by Voting Method

If we use an unweighted ANOVA of the proportion of uncounted votes on voting method to analyze the data, we can not reject the null hypothesis that the mean proportion of uncounted votes does not differ by county (p-value is approximately 0.54). This is equivalent to comparing averages of proportions instead of overall proportions. This erroneous analysis seems to have been done by the office of the the secretary of state. In the press release [1] quoted above, a "new statistical analysis ... shows consistent rates of [uncounted votes] regardless of the type of voting equipment used," with none of the systems offering a "significant advantage." The proportions of uncounted votes given in this document by method are 4.6% for punch card, 4.5% for the optical scan methods, and 4.2% for the lever method; these are all higher than the statewide 3.5%. They are the averages of the proportions rather than the overall proportions.

The ANOVA weighted by number of ballots gives very different results, because it compares the overall proportions rather than the average proportions. Using this method, the voting method is a highly significant predictor of proportions of uncounted votes by county, with $p < 0.00001$. Further, a pairwise multiple comparison shows that punch card and lever methods are not significantly different, but both optical scan methods have significantly lower proportions of uncounted votes, compared with the punch card method. The paper ballot method has too few observations to determine if the overall proportion of uncounted votes is significantly different from other methods. The coefficient of determination, R^2, is 0.18, which means that about 18% of the variation in proportion of uncounted votes is explained by the voting method. The other 82% of the variation is due to other factors, or to "randomness."

A residual analysis shows some lack of fit to the model. A plot of the residuals against the predicted values of proportion of uncounted votes is shown in Figure 2. The values of the residuals and the predictors are multiplied by the square root of

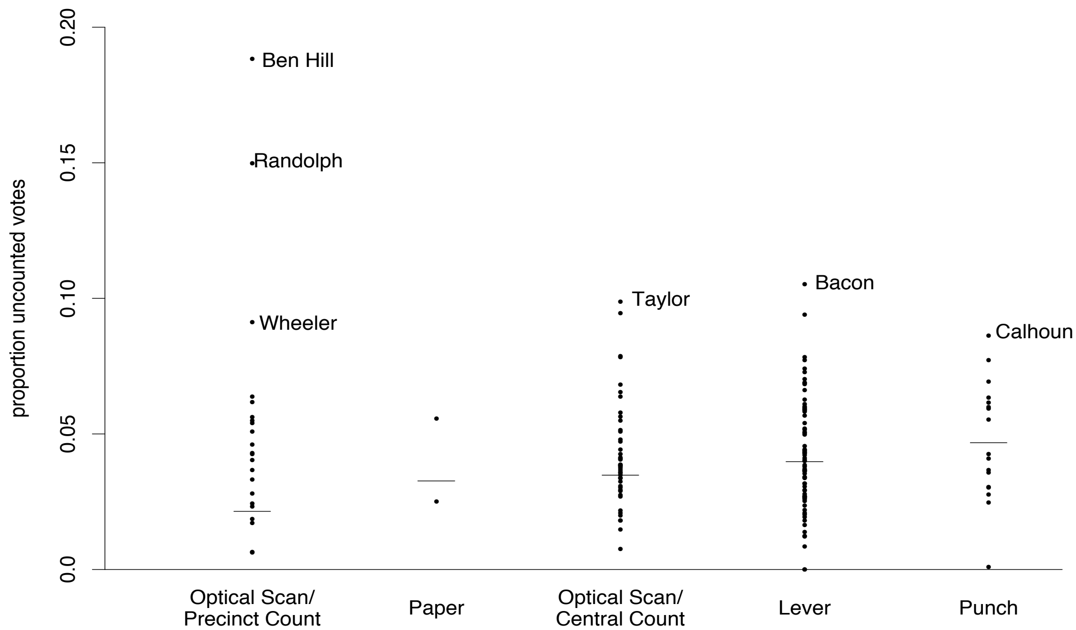

Figure 1: Proportions of Uncounted Votes by Method, for the 159 Counties in Georgia. Overall proportions for each voting method are shown by horizontal lines.

the number of ballots, since the assumptions for the distribution of the response variable of the linear model refer to the product of the response and the square root of the weighting variable. This plot shows a general negative trend: the larger values of predicted proportion of uncounted votes correspond to smaller (larger negative) residuals. We had some indication of this when we observed that larger counties (in terms of number of ballots cast) tended to have lower proportions of uncounted votes. We can try to correct this by adding a covariate to the model; there are several choices. The logarithm of the number of ballots is a significant predictor of the proportion of uncounted votes in the county; when this variable is added to the model, the R^2 increases to 0.32. Interestingly, a "county type" variable that is related to number of voters is more successful in predicting proportion of uncounted votes. If instead of the ballot variable, we add a rural/non rural indicator variable along with a metro Atlanta indictor, the R^2 for the model increases to 0.40. The number of ballots variable is no longer significant when the model contains these two county type indictors. Summaries of percent uncounted votes by county type are seen in Table 2.

County Type	# Counties	Total Ballots	Total Votes	% Uncounted
Metro-Atlanta	15	1,351,822	1,312,012	2.9%
Non-Rural, Non-Atlanta	28	609,857	587,366	3.7%
Rural	116	729,635	697,252	4.4%

Table 2: Percent Uncounted Votes by Type of County

We can find other county-specific data on the web, such as numbers of registered voters by race and gender. A variable representing the proportion of black voters in a county is also a significant predictor of proportion of uncounted votes, when the voting method and county type variable are included in the model, with larger proportions of black voters corresponding to higher proportions of uncounted votes. The R^2 for the (weighted) analysis with the voting method variable, the county type indicators, and the percent of black voters variable, increases to 0.44.

The county type variable and the proportion of black voters are both strongly related to the economics of the county. When an economic summary variable is added to the model, it is seen to be a highly significant predictor of proportion of uncounted votes. Further, both county type and proportion of black voters are no longer significant predictors in the presence of the economic variable. In other words, the proportions of uncounted votes are not signficantly different by county type or by proportion of black voters, for fixed economic levels.

2 The Economic Effect

The State Department of Community Affairs has grouped counties in Georgia according to economic status [2]. They created four "tiers," where Tier 1 contains the poorest counties in the state, and the most affluent are in Tier 4. The breakdowns of proportions of uncounted votes by tier are shown in Table 3. All six of the counties indicated by name in Figure 1 are in the poorest economic tier.

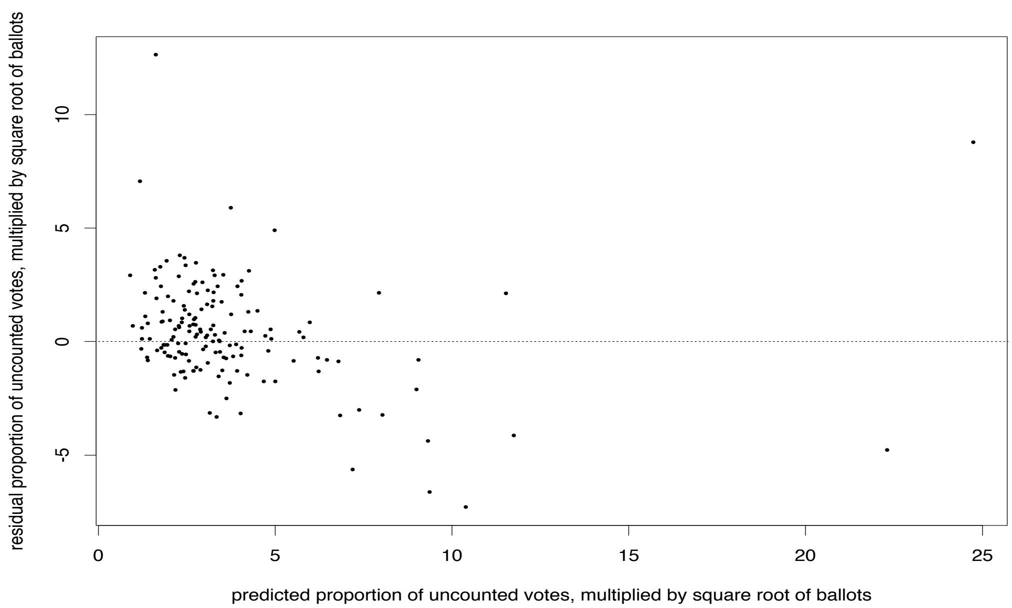

Figure 2: Residual plot for proportions of uncounted votes as a function of voting method

For the purpose of predicting uncounted votes, Tiers 2 and 3 are combined, to provide three levels: poorer, middle, and affluent. This economic variable could be a confounder with voting method, if more affluent counties use optical scan methods, for example, and more poor counties use the punch card method. Both the economic variable and the voting method variables need to be included in the same model. This two-way ANOVA weighted by the number of ballots produces an $R^2 = 0.52$, so that over half of the variation in proportion of uncounted votes is explained by these two predictor variables. Both the economic variable and the method variable are strongly significant predictors of proportion of uncounted votes ($p < 0.001$).

This ANOVA model does not include an interaction between voting method and economic level; the inclusion of such a term does not explain significantly more of the variation in proportion of uncounted votes. This means that the effect of voting method on the proportion of uncounted votes does not depend on the economic level of the county. For example, the predicted uncounted votes for punch card method

Economic Tier	# Counties	Total Ballots	Total Votes	% Uncounted
1	72	360,785	341,586	5.3%
2	34	422,691	405,327	4.1%
3	35	1,050,986	1,006,597	4.2%
4	18	856,852	843,120	1.6%

Table 3: Percent Uncounted Votes by Economic Tier of County

is about two percentage points above the predicted uncounted votes for the optical scan, precinct count method, for each of the economic groups.

The overall percentages of uncounted votes in each combination of voting method and economic level (not including the two counties using paper ballots) are depicted in Figure 3. These are the observed percentages rather than the percentages predicted by the model. The numbers of counties in each voting method and economic group combination is shown as the number in the parentheses. For each voting method, the proportion of uncounted votes decreases consistently with increasing affluence. Further, over all three economic levels, the lever method is slightly but consistently better than the optical scan/ central count method, which in turn is consistently better than the punch card method. This is an example of Simpson's paradox, since in the aggregate, the lever method has a larger proportion of uncounted votes than the optical scan/ central count method. The paradox can be understood by observing that the lever method is used by more poorer counties.

The proportion of uncounted votes using the lever method is not significantly different from those using either optical scan method, once economic level is controlled for. However, this model indicates that the punch card method is significantly worse than the optical scan and lever methods, and that all three economic levels have significantly different overall proportions of uncounted votes.

There are two residual plots shown in Figure 4. The first is a scatterplot of residuals against the predictor variables similar to that of Figure 2, except that we use the model with both predictor variables. The counties with five largest residuals (in absolute value) are marked on the plot. Ben Hill, Fulton, and Randolph counties have higher than expected proportions of uncounted votes, given their economic status and voting method, while Clayton and DeKalb counties have done better than expected. Ben Hill and Randolph counties have optical scan/ precinct count voting method and are both poorer counties, while the other three counties are middle economic level and use punch card method. The second plot in the figure

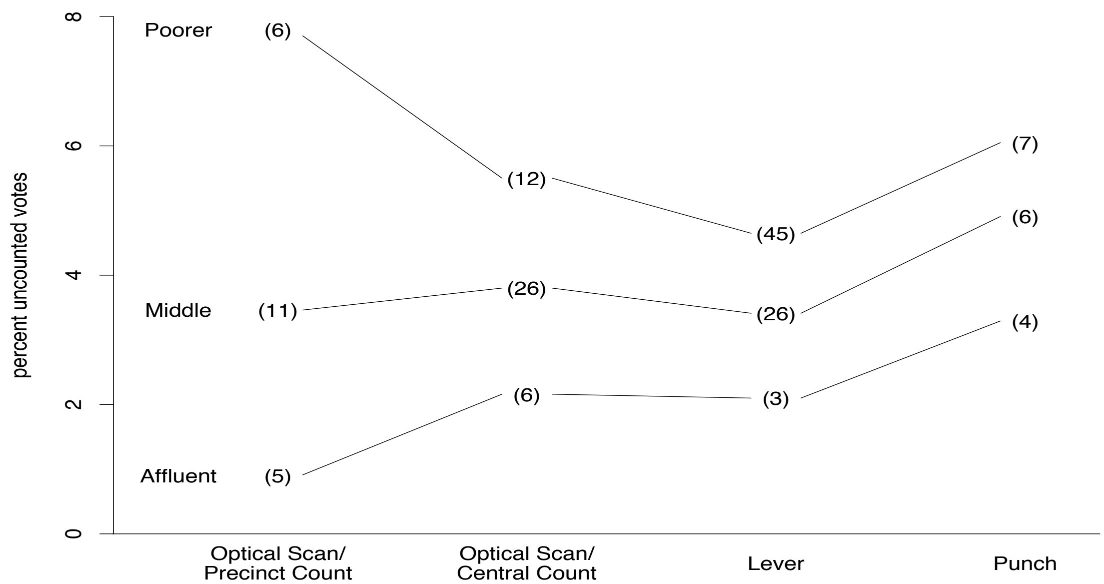

Figure 3: Overall proportions of uncounted votes by voting method and economic tier, for 159 Counties in Georgia. The numbers of counties in each method and economic combination are shown in parentheses.

shows a probability plot of the residuals against the normal quantiles. Aside from the five "outliers," the points lie roughly on a straight line, indicating that the error distribution is not far from normal. This is important since the response variable is actually a binomial proportion.

Observations which are outliers are typically removed from the dataset if they are "anomalous" observations in some sense, and certainly if they result from recording errors. When the observations seem "legitimate," they should be left in, and if the model assumptions are not met, a different model should be used. In the absense of more information about these counties, an analysis of the data with the outliers removed provides some insight into whether the results using the entire dataset are

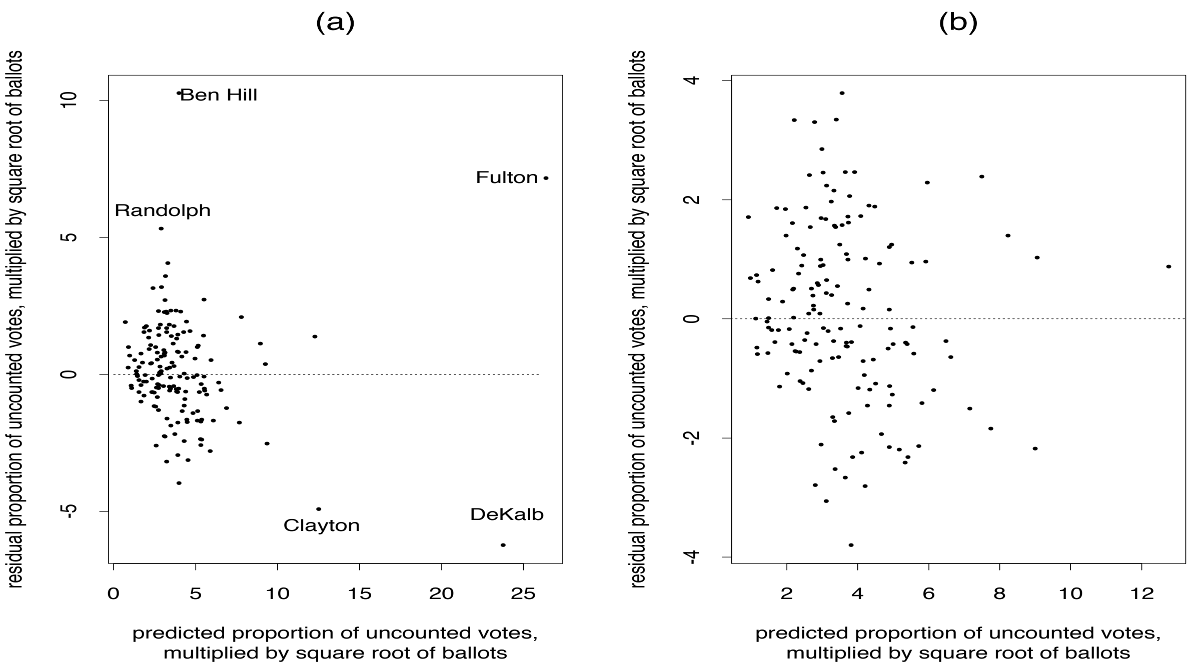

Figure 4: Residual plots for two-way ANOVA. Plot (a) uses data from all 159 counties, while plot (b) is from the analysis with the five outliers removed

valid. In this case, when the five identified counties are removed from the dataset, the conclusions about the effects of economic status and voting method are substantially the same, with $R^2 = 0.57$.

When the five outliers are removed from the dataset, the plot in Figure 3 changes in two places. The point representing poorer counties with OS/PC method moves down about two percentage points, and the point representing middle counties with punch card method moves down a bit, with the effect that the lines are "more parallel." The fit to the model is even better without these five counties. The residual plots for the analysis without the five outliers show that the usual assumptions for the ANOVA model are adequately met, though we know that the normal errors assumption is technically incorrect.

3 Discussion

The economic variable is the strongest predictor of the proportions of uncounted votes in the state of Georgia. By itself, it explains 41% of the variation in uncounted votes across counties. Pairwise comparisons show that each of the three economic levels has significantly different overall proportions of uncounted votes. When the voting method is added to the model, the punch card method has a significantly higher proportion of uncounted votes, but the lever method is not significantly different from the two optical scan methods. This effect was confounded with economic group, since more poor counties use the lever method. These significance results hold when the five identified outliers are removed from the dataset. More than half of the variation in proportion of uncounted votes, by county, can be explained by the economic level of the county and voting method.

These results point to significant discrepancies in proportions of uncounted votes, but do not necessarily support a specific cause for these discrepancies. One person who is reading this report might conclude that voters in poorer counties are treated unfairly, while another reader might conclude that voters in poorer counties are probably less educated than others, and make more mistakes voting, even if the conditions are the same as in more affluent counties. Both of these cause-and-effect interpretations are consistent with the data, although the lack of interaction effect between the voting method and the economic group might be said to refute the second reader. If the punch card method, for example, is believed to be more conducive to voter error, and voters in poorer counties are more likely to make mistakes, then we perhaps we should have seen a larger effect for punch card ballots in poorer counties than in more affluent counties. In fact, the gap between proportions of uncounted votes for punch card and other methods is not significantly different in poorer counties.

There are several examples of aggregation bias with these data. We have seen an example of Simpson's paradox in the comparison of proportions of uncounted votes using the lever and OS/CC methods, aggregated or disaggregated by the economic variable. Also, the economic variable is a confounder in the relation between proportion of uncounted votes and proportion of black voters. In the absense of the economic variable, there is a strong positive relationship between the two variables, but this appears to be due to the fact that poorer counties have higher proportions of black voters. Once economic level is controlled for by adding this variable to the model, the race variable is no longer a significant predictor of proportion of uncounted votes. The economic variable is also a confounder in the relationship between proportion of uncounted votes and county type. Here, rural counties tend to be poorer, and the metro Atlanta counties are on average among the most affluent.

Some of the discussion in the media has centered on the possible racial inequities. The Atlanta Journal and Constitution article "Study says racial disparity exists in state's voting system" [3] points out that higher proportions of black voters live in counties using the punch card system. Further, we know that higher proportions of black voters live in poorer counties, so that while there is no significant direct effect of proportion of black voters on proportion of uncounted votes when the economic and voting method variable are controlled for in the model, there could be an important indirect effect. If black voters went to the polls in the same proportions as they are registered, then approximately some 681,040 ballots were cast by black voters. If votes by black voters in a particular county are just as likely to be counted as votes by non-black voters in that county, then about 27990 of these votes, or 4.1%, were uncounted. Similarly, we can estimate that about 3.3% of votes by non-black voters went uncounted.

It seems clear that the economic class and voting methods have a strong impact on the proportions of uncounted votes. The statistical analyses can measure differences and determine significance, but it is up to the politicians and social researchers to determine the causes of these differences. These analyses suggest that focusing on the disparities due to economic class might have a greater impact for improving overall vote counts and creating a fairer voting system than a focus on voting methods.

References

[1] Press Release from the office of the Secretary of State of Georgia, December 28, 2000, "Optical Scan Systems Not Substantially Better Than Punch card in Assuring Accurate Vote Count - Data Underscores Need to Upgrade to Modern Electronic Systems, Cox says"

[2] News Article from the Atlanta Journal and Constitution, January 28, 2001, "Wealth Divides Two Georgias," by Peralte C. Paul.

[3] News Article from the Atlanta Journal and Constitution, February 2, 2001, "Study says 'racial disparity' exists in state's voting system." by Rhonda Cook.