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MACHINES VERSUS HUMANS: THE COUNTING AND RECOUNTING OF PRE-SCORED PUNCHCARD BALLOTS

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Machines Versus Humans: The Counting and Recounting of Pre-scored Punchcard Ballots*

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The counting of ballots, especially punchcard ballots, has received a great deal of attention in the years following the 2000 presidential election in Florida. Much of the research literature has focused on various measures of how accurately voting machines record voter intentions, with studies of the relative accuracy rates across voting machines (e.g., Caltech/MIT Voting Technology Project 2001), studies of voting accuracy across groups of the electorate (Alvarez and Sinclair 2003), and studies that examine the variability in voting machine accuracy across both machine types and voter types (Alvarez, Sinclair and Wilson 2002; Ansolabehere 2002; Tomz and Van Houweling 2003).

This literature has analyzed voting machine accuracy in the context of the reliability of vote intention recording, either through the prism of the "residual vote," or through the study of over- and undervotes (Caltech/MIT Voting Technology Project 2001; Ansolabehere and Stewart 2004; Hanmer and Traugott 2004; Alvarez, Ansolabehere and Stewart 2005). Recent research has made much progress studying voting machine accuracy but continually runs into a simple measurement problem: how can the researcher be certain that observed residual votes, overvotes, or undervotes result from problems introduced into the balloting process by the voting machines themselves and not from errors made by the voters? Equally problematic, how certain can the researcher be that a residual vote, overvote, or undervote was not the result of a deliberate decision by a voter herself to not cast a vote in some race (a deliberate undervote) or to intentionally vote for more than the allowed number of candidates (a deliberate overvote)?[1]

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[1]For example, in Herron and Sekhon (2003) study of ballot image data from two Florida counties from the now infamous 2000 presidential election found 412 ballots that included votes for all 10 choices for president. It is hard to imagine that these were mistakes, but more likely some sort of protest vote.

Yet another dimension of potential error in vote counting regards tabulation. That is, voters might mark their intentions on a ballot correctly, but when the ballot is initially tabulated the device used to count ballots might fail to record the voter's intention. This type of tabulation error may be especially prevalent when voters use ballots on which they can make common errors, like overvotes or undervotes, and thus punchcard or optical scanning voting systems seem particularly prone to these problems. In these situations the voter may attempt to indicate a vote intention, only to do so in such a way that the tabulation device may fail to record the intended vote.

As the public became aware in November 2000, this type of tabulation error can easily happen in election jurisdictions using pre-scored punchcard voting systems. If for some reason the so-called "chad" is not cleanly removed from the punchcard, the chad's presence can block the vote intention from being recorded when the ballot is machine-tabulated. Or, a "loose" chad could lead to the recording of an incorrect vote or possibly an overvote. Unless these ballots are then recounted accurately, it might be difficult for these vote intentions to be recorded correctly.[2]

In this paper we study the potential extent of these types of machine tabulation errors arising from the use of pre-scored punchcard ballots. We take advantage of a unique aspect of California election law and the good will of the election official in California's largest election jurisdiction (Los Angeles County). California election law requires that election officials recount ballots from 1% of precincts after every election. We have obtained the results of the mandatory 1% recount from three recent general elections in Los Angeles County, and we use that data to estimate the rate at which there are tabulation differences when votes are counted by machine and by hand.

As far as we are aware, there is little literature that uses data like ours to assess the difference between machine and manual tabulation for punchcard voting systems. There is, of course, a lively literature on the Florida recount itself (e.g. Dershowitz (2001), Gillman (2003), and Posner (2001)). And now that the current litigation over the disputed 2004 gubernatorial election in Washington state is concluded, we suspect there will be a literature that discusses that case. But the only extant research papers that we have found are two recent papers using recount data from New Hampshire. The first paper is from Ansolabehere and Reeves (2004), who use data from New Hampshire recounts from the 1946 - 2002 period to study the accuracy of voting technologies. In their study, Ansolabehere and Reeves examine complete ballot recounts, done either by hand or more recently by optical scanning devices, and find that the differences between initial and recount tabulation rates are much lower if the ballots are counted using an optical scan device than if they were counted twice by hand. The second paper, by Herron and Wand (2004), focuses on 2004 New Hampshire recount data from local election jurisdictions and evaluates claims of election irregularities in areas using optical scan voting devices.

[2]Problems like these can easily arise when different voting systems are used. Recently, the City of Los Angeles utilized Los Angeles County's "InkaVote" voting system (essentially a punchcard-style ballot, but one that the voter makes a small ink mark on, instead of removing a chad, to indicate vote intention) for the first round of voting in their 2005 citywide elections. According to media reports from the May 2005 citywide runoff elections, the Los Angeles City Clerk election workers used markers to "re-ink" ballots where the voter's mark was thought to be too faint for the machine tabulation to count (Anderson and Orlov 2005).

Our analysis differs from both the Ansolabehere and Reeves' study and the Herron and Wand paper in a number of ways, the most important difference being that we study a situation where the ballots are first counted by machine and then a subset of all ballots cast is counted by hand. This critical difference allows us to estimate the extent to which the initial machine tabulation of the ballots differs from the hand count, which in turn allows us to gauge the accuracy of the tabulation process.[3]

In the next section of this paper we discuss the methodology we use, and we then proceed to discuss the results of our analysis. Based on the results of the 1% manual recounts, we extrapolate the potential aggregate effect of the difference between machine and manual counts in selected races. We find generally that the number of votes counted is higher when the pre-scored punchcard ballots are counted manually rather than by machine tabulation; however, the increase in the number of votes counted is typically quite small, and given that there are relatively few close contests in Los Angeles County, we estimate that the machine undercount will rarely have a substantive impact on election outcomes. We conclude by discussing the recounting of ballots, the 1% manual recount procedures in use in California, and the implications of our study for the current debate about the auditing of elections.

1 Manual Recounts in Los Angeles County

The data used in this analysis are the original machine counts of votes and the subsequent manual recounting of a subset of votes from Los Angeles County for the 2000 presidential general election, 2002 gubernatorial general election, and 2003 statewide special election. After each election the county is required to perform a manual recount of ballots in a sample of 1% of randomly-drawn precincts in the county.[4] Procedurally, the chief election official in the county determines which precincts will be selected for the 1% manual recount, and then all of the ballots cast from each of the selected precincts are retrieved for the recounting process.

We had the opportunity to observe the 1% manual recount following the 2003 recall election in Los Angeles County. During that 1% recount, ballots were manually recounted

[3]We say "possibly" here because it is certainly true that the manual counting process itself is not error-free and that hand-counting of paper ballots introduces the possibility of error into the process that might generate deviations in the number of tabulated votes between a machine and manual count. Having directly witnessed the manual tabulation of ballots during the 2003 recall election, our intuition is that the methodology used to manually recount those ballots may be a more accurate baseline than the initial machine tabulation, and we discuss the precise methodology of the manual recount we witnessed later in this paper. However, much more research is necessary as to what errors are introduced into ballot tabulation by both people and machines as we have little research on point at this time.

[4]The requirement for California counties to perform the 1% manual recount is in Section 15360 of the state election code, which states "During the official canvass of every election in which a voting system is used, the official conducting the election shall conduct a public manual tally of the ballots tabulated by those devices cast in 1 percent of the precincts chosen at random by the election official." California election code (Section 15620) allows any citizen of the state to file a request for a complete recount, within a certain period. The citizen must deposit sufficient funds to cover the costs of the process with the election official doing the recount, though these funds will be returned to the citizen if the recount reverses the initial results (an excellent summary of these procedures is available from http://www.lavote.net/voter/recount.htm).

for each of the four contests on the ballot (the two recall questions and two ballot measures) in each of the selected precincts. A team of county employees would be provided one precinct's ballots, and this team would then count the total number of ballots. The team would then examine each punchcard ballot for indications of a voter's intention for one of the four contests on the ballot; one individual would call out her assessment of the voter's intention on the contest, and a second individual would verify that assessment while the other two team members would record each assessment of voter intent manually on paper. In cases where there was disagreement or uncertainty in the assessment, a senior election official would be asked to adjudicate. When finished, the team would move to another precinct's ballots for that same contest until all of the precincts for that contest were recounted.

Our interest is in comparing the initial machine counts of ballots against these manual recounts. The machine and manual vote counts from the precincts in the 1% manual recount were aggregated for each state or county level race in the three elections.[5] The average difference between the number of votes in the machine and manual counts in each precinct was then computed for each of these races (that is, the difference in votes is equal to the manual count minus the machine count). The average percent difference was calculated by dividing the difference between the manual and machine counts by the manual count of votes in each precinct. Based on the data provided to us, we have no way of verifying whether the same ballots are not recording votes in both the machine and manual recount, though we suspect that generally this should be the case given the underlying reasons for prescored punchcard ballots to not record a vote in both tabulation procedures.[6] Table 1 shows the data as well as the calculations for each race.[7]

[Table 1 Goes Here]

There are a number of interesting points that are made apparent by Table 1. First, the manual count is almost always greater than the machine count of votes. In fact, we only find five instances in the 57 candidate races or ballot measures in our data where the total number of votes counted manually is lower than the total number of votes counted in the initial machine tabulation. That is, in approximately 92% of the cases we find that the manual recount reveals *more* votes cast than were counted in the initial tabulation.

Given the nature of pre-scored punchcards and the differences between the machine and manual counting procedures, this finding is not that much of a surprise. In all likelihood some ballots have hanging chads of various sorts — for example, a so-called "swinging" chad. These hanging chads can block the card opening and the machine tabulator can fail to record a vote in the race. In such cases, by individually examining the ballot by hand, the hanging

[5]In this analysis we concentrate only on the candidate races or ballot measures that all voters in the entire county saw on their ballot. This excludes from our analysis a number of municipal candidate races and ballot measures.

[6]Stephen Graves pointed out to us in personal communication (August 5, 2005) that if one assumes that both tabulation procedures are failing to record vote, we are getting an accurate understanding of the potential differences between the two tabulation methods. But as Graves pointed out to us, if the two tabulation methods are actually not recording votes for the identical set of ballots, then there are potentially different consequences for tabulation differences than we can estimate with the data we have.

[7]For the 2002 election there were 57 precincts included in the manual recount. In the governor's race the recount data were only reported for 54 of these precincts, and for each of the statewide measures the recount data were reported for 58 precincts.

chad may be found and the individuals recounting the ballots can attempt to divine the voter's actual intention.

Second, we see in Table 1 that the percent difference between the machine and manual counts is fairly small. The largest average percent difference (in absolute value) in any race is 0.76% (with a variance of 0.000149), and the overall average percent difference is 0.24% (with a variance of 0.000170).[8] We find that important, top-of-the-ticket races generally have small differences. For example, in the 2000 presidential race there were a total of 38 more votes counted in the manual recount than in the original machine tabulation, or a difference of 0.29%. This is roughly in line with the difference observed in the 2002 governor's race where in total 0.20% more votes were counted in the manual recount than in the original machine recount. Therefore, the initial machine tabulation misses the vote intention only in a small number of ballots.

Next, we summarize the findings graphically. Figures 1 and 2 are histograms of the differences between each counting method. The vertical line on each chart is at zero in order to emphasize that the percent difference is generally positive and, therefore, that the manual count is typically larger than the machine count. Figure 1 presents a histogram of the percent difference between the machine and manual counts pooling the data for all three elections. Figure 2 presents a histogram of the percent differences between the machine and manual counts for just the 2002 election, isolating this one election as a representative case.

[Figures 1 and 2 go here]

The graphical presentations in these two figures underscore our two basic findings with these data. The first is that the differences are largely positive — notice in both figures that much of the mass of the distributions are positive (to the right of zero). Again, the manual recounting of these punchcard ballots typically produces a higher count of votes. The second result also clear from the figures is that the deviation between the original machine and later manual tabulations are typically very small.

The consistent difference between the machine and manual counts of votes naturally raises the question of whether the difference in the counts might ever be substantial enough to possibly change the outcome of an election. Obviously only a complete manual recounting of votes could ever actually show the precise extent of the problem, but our data allow us to determine the potential effects of the errors in machine tabulation we have documented in this simple analysis. The key question is how often are races in Los Angeles County ever close enough (in this set of elections) that we might be concerned that the tabulation errors found from manual recounting errors might have been of sufficiently great magnitude to sway the outcome of some elections.

To understand more completely whether the types of differences we see in the data are consequential, we focus on the five closest races in Los Angeles County in the three elections for which we have data. These five close races are listed in Table 2. We note that these are only the results in Los Angeles County, not results for the entire state of California. Recall that the greatest average deviation that we observed across all of the races in these three election cycles was 0.76% — so the first counterfactual question we pose here is whether *any*

[8]The reported variance is for the actual decimal value of the calculated vote differences rather than the percentages.

elections in our sample were decided by less than a percentage of votes cast. The second counterfactual, then, considers a more reasonable scenario: were any of these close races decided by what would be a statistician's "best guess" tabulation difference, 0.24%, the overall average difference of the recounts for which we have data?

Examination of Table 2 shows that the closest race in our sample was the special election of 2003 on the question of whether Gray Davis should be recalled as Governor of California. In Los Angeles County as a whole this race would have been decided by a margin of 2.00%, much greater than the 0.76% that was found to be the greatest average percent difference between the machine and manual counts of votes, even assuming the worst case that all these mis-tabulated votes were for the recall. All of the other races in Los Angeles County were, of course, decided by even great vote margins, and so the outcomes were unlikely to have been changed had there been a manual recount of votes for the entire county. Thus, it is clear that in our sample there never was a race that was even as close as the worst-case scenario of tabulation deviations, which certainly implies that no race was as close as our "best guess" tabulation difference.[9]

Another question that could be asked, however, is how often are there *any races* in Los Angeles County that are within this margin of differences between machine and manual counts of votes, including the vast array of local and municipal races? These are the races for which there would most likely be differences in the winners of the machine and manual counts of votes. In order to address this question, all races in Los Angeles County during the time period of 2000 to 2002 were examined, not only the races that were county or statewide. These races include party primaries, city positions, school district boards, and all manner of local elections.

During this time period, there were a total 919 races in Los Angeles County. We could identify clear winners in 848 of these races.[10] In this set of election, 648 races were actually contested. The average wining vote margin across these contested races was 20.63%.[11] Look-

[9]Stephen Graves (personal communication, April 7, 2001) noted that an approximation for how spoiled or fraudulent ballots could influence close election outcomes Graves noted that one way to approximate the probability that a candidate wins an election, given a certain margin of votes by which they lost (M) and the number of spoiled ballots (N) is:

$$P = 1 - \Phi(M/\sqrt{N}) \tag{1}$$

assuming that spoiled ballots are distributed equally between the two candidates. As applied to our example, consider the 2003 recall vote, where a margin of 40,119 votes separated yes on the recall (984,222 yes votes in Los Angeles County) and no votes (1,024,341 no votes). Using the maximum difference estimate of 0.76% and the number of votes initially tabulated by machine in this race (13,362), we estimate that as many as a 102 vote difference might have arisen in this situation under the worst-case scenario. Substituting 102 for N and 40,119 for M in the Graves approximation, we find that the probability that the "loser" might have actually won is zero. It is only when we literally change the margin of victory to handfuls of votes that we see any positive probability that the "loser" might have actually won; for example, had the margin of victory only been 10 votes in Los Angeles County for this race with the maximum tabulation difference there would have been a .16 probability of "loser" potentially winning.

[10]A winner could not be determined, for example, in elections for delegates to national party conventions.

[11]The calculations for computing the margins vary depending on the characteristics of the particular race. For example, for a board of directors in which three people are elected, the vote difference between the

ing at these contested races, 57 were decided by a margin of 0.76% or less of the votes cast in that race. Thus, of the races for which winners could be determined, 6.72% were decided by a margin of 0.76% or less. That is, slightly less than 7% of the races in Los Angeles county in a three year period had vote margins within the range where the difference between a machine a manual count of votes could potentially alter the outcome of the election. Additionally, of those races for which winners could be determined, 15, or 1.77%, were decided within the margin of the observed average percent difference between the original and manual recount of 0.24%.

Figure 3 presents a histogram of the vote margins for the 648 contested races. As shown in the histogram, the vote margins drop off quickly after four percent. Thus many of the local races in Los Angeles County are being decided by a fairly small margin of votes. It is worth noting that many of these close races are contests in which multiple candidates are elected. For example, in a race in which seven people are elected, it is the difference between the seventh and eighth most popular candidates that decides the final election outcome. In such a race the vote margin would be expected to be quite close, and the outcome of a machine count could fairly easily be different from the outcome determined by a manual count.

Does this analysis suggest that all pre-scored punchcard ballots should be manually counted in all situations? Or is the 1% manual recount procedure sufficient to document substantial problems, situations so outrageous that a full recount should be required? This of course can be considered a simple question of statistical power where we can draw upon what we know from the large literature on sampling to determine if a procedure like the 1% manual recount is sufficient to document substantial problems. However, for us to be able to apply sampling theory to this question we need to make one important assumption (that we are sampling precincts to be recounted randomly) and to know at least two important parameters (how certain we want our test to be and how large the potential differences are likely to be). The latter two parameters are simple ones that can be determined by election officials or policymakers. The assumption is also a simple one, but it cannot be overlooked in the use of this data to make substantive conclusions or methodological recommendations.

Thus, we undertook an analysis to see if the precincts used in these three 1% manual recounts are indeed being drawn randomly from the larger population of precincts in each election. Unfortunately, our analysis leads us to believe that these precincts are not a random draw from a larger population. We found that there appears to be a selection bias in the precincts that are included in the 1% manual recount. There were ten races in the analysis for which it was possible to determine the party affiliation of the candidates, and a paired t test indicates that the top Democratic candidates in these races received a significantly lower aggregate vote share in the precincts included in the recount than in Los Angeles County as a whole. This result is consistent across all three elections. This bias simply indicates that the precincts included in the recount are not (statistically) representative of Los Angeles County, most likely because the precincts are not chosen completely at random. Because

candidate receiving the third most votes and the candidate receiving the fourth most votes was used to calculate the vote margin. Also, on bond issues in which 2/3 of the voters must pass the bond, the difference between the percent of votes cast "yes" and 2/3 was used as the vote margin.

this analysis looks at the absolute change in the vote count for each race independent of vote shares for individual candidates, it is not clear that this bias will have an appreciable impact on the findings in this paper, but it does prevent our ability to make strong methodological recommendations based on this particular dataset.

2 Conclusions

It is now widely known by researchers and the public that pre-scored punchcards can yield significant errors; the precise extent to which these errors are due to voter error or due to machine error has been a question that has eluded previous researchers. In our analysis, we have taken advantage of a unique dataset and have shown that election jurisdictions using pre-scored punchcard voting systems might be systematically undercounting vote intentions. The problem posed by undetached paper chads could lead to incorrect election results.

However, our analysis has also shown that in this set of elections the machine undercounting of ballots is relatively slight and that it does not appear to systematically impact any particular candidates or choices on ballot measures. This does alleviate some concern about the machine under counting of pre-scored punchcard votes, but in situations where races are extremely close there might be reason for concern.

We must point out, though, that we are not arguing that all ballots should always be tabulated by hand, nor that hand-tabulated ballots are necessarily counted more accurately than those tabulated by machine. First, our results are limited to the specific case of pre-scored punchcard ballots, and we do not know if our results would generalize to any other cases (like optical scanning ballots); studies similar to ours should be conducted on the discrepancies between initial tabulation and recounting of ballots from other voting systems. Second, we also realize that the size of election jurisdictions and the complexity of election administration today make the use of mechanical, optical, or electronic tabulation inevitable; thus we see the pressing need for machine tabulation of ballots. Third, detailed studies are needed that compare manual counts of ballots to machine tabulation to determine where errors arise with each method of tabulation and how to best catch and mitigate such tabulation errors.

We also acknowledge that we are studying this problem in a specific contest that might limit the generalizability of our results. Granted, we have data from only Los Angeles County which has a specific contextual framework (the unique size of this election jurisdiction, demographic diversity, and the County's unique election administration practices, procedures, and technologies). Thus extrapolation from our specific results to other election jurisdictions must be done with care.

Despite these caveats, we see that our analysis of this specific case highlights the need for strong post-election auditing procedures, one of which might be a manual recounting of some fraction of ballots cast to estimate the potential tabulation error rate. This fraction could be set as a fixed threshold (like the current California practice of manually recounting ballots from 1% of precincts), it could be a variable threshold (say dependent upon the total number of ballots cast), or it could be a requirement that would be followed for only some races (say races where a margin of 1% or less separated the top two vote getters). An

additional question to raise is how the ballots should be sampled; should election officials randomly sample a set threshold of precincts, or should they systematically sample from precincts that appear to have had some type of problems? Obviously, different sampling strategies are necessary for studying different questions, and more research is needed to better inform these sampling decisions.

Clearly more research is necessary on how existing recount procedures help insure the integrity of elections and whether better procedures can be developed and implemented. There are some starts in this direction, for example a recent paper by Neff (2003) that compares manual recount procedures to a "vote receipt" methodology, and we hope for additional research on this important question as well as more research on recounts generally in the near future.

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Table 1. Difference Between Machine Count and Manual Count in 1% Recount

Year	Race	Machine Count of Votes	Manual Count of Votes	Difference in Vote Count	Average Percent Difference in Vote Count across Precincts	Variance of Percent Difference in Vote Count across Precincts
2000	President-Vice President	13,175	13,213	38	0.33%	0.000122
2000	United States Senator	12,818	12,887	69	0.60%	0.000115
2000	State Measure 32	12,122	12,173	51	0.44%	0.000118
2000	State Measure 33	11,760	11,817	57	0.56%	0.000150
2000	State Measure 34	11,842	11,939	97	0.73%	0.000178
2000	State Measure 35	11,978	12,059	81	0.71%	0.000176
2000	State Measure 36	12,245	12,322	77	0.68%	0.000123
2000	State Measure 37	11,589	11,654	65	0.58%	0.000191
2000	State Measure 38	12,746	12,820	74	0.65%	0.000089
2000	State Measure 39	12,323	12,369	46	0.37%	0.000095
2000	Assessor Term Ends 12/02	10,294	10,347	53	0.46%	0.000237
2000	District Attorney	10,958	11,028	70	0.60%	0.000120
2000	County Measure A	11,614	11,702	88	0.76%	0.000149
2002	Governor	10,223	10,244	21	0.08%	0.000128
2002	Lieutenant Governor	10,734	10,753	19	0.13%	0.000094
2002	Secretary of State	10,509	10,507	-2	-0.08%	0.000098
2002	Controller	10,650	10,642	-8	-0.12%	0.000137
2002	Treasurer	10,560	10,578	18	0.05%	0.000129
2002	Attorney General	10,528	10,564	36	0.32%	0.000085
2002	Insurance Commissioner	10,420	10,428	8	0.04%	0.000110
2002	Associate Justice, Supreme Court, Carlos R. Moreno	7,958	7,985	27	0.21%	0.000229
2002	Associate Justice, Supreme Court, Marvin R. Baxter	7,447	7,451	4	-0.03%	0.000127
2002	Associate Justice, Supreme Court, Kathryn M. Werdegar	7,739	7,761	22	0.21%	0.000098

Table 1, continued. Difference Between Machine Count and Manual Count in 1% Recount Continued

Year	Race	Machine Count of Votes	Manual Count of Votes	Difference in Vote Count	Average Percent Difference in Vote Count across Precincts	Variance of Percent Difference in Vote Count across Precincts
2002	Associate Justice, 2nd Appellate Court Division 1, Miriam A. Vogel	7,231	7,254	23	0.20%	0.000128
2002	Associate Justice, 2nd Appellate Court Division 1, Robert M. Mallano	7,373	7,395	22	0.24%	0.000184
2002	Associate Justice, 2nd Appellate Court Division 2, Judith M. Ashmann	7,215	7,229	14	0.24%	0.000171
2002	Associate Justice, 2nd Appellate Court Division 2, Kathryn Doi Todd	7,250	7,261	11	0.10%	0.000209
2002	Presiding Justice, 2nd Appellate Court Division 3, Joan Dempsey Klein	7,290	7,296	6	0.01%	0.000143
2002	Associate Justice, 2nd Appellate Court Division 4, Gary Hastings	7,127	7,146	19	0.22%	0.000151
2002	Presiding Justice, 2nd Appellate Court Division 5, Paul A. Turner	7,103	7,142	39	0.44%	0.000207
2002	Associate Justice, 2nd Appellate Court Division 5, Richard M. Mosk	7,230	7,253	23	0.22%	0.000181
2002	Presiding Justice, 2nd Appellate Court Division 6, Arthur Gilbert	7,233	7,260	27	0.30%	0.000151
2002	Associate Justice, 2nd Appellate Court Division 6, Kenneth R. Yegan	7,078	7,096	18	0.19%	0.000192
2002	Associate Justice, 2nd Appellate Court Division 6, Steven Z. Perren	7,242	7,250	8	0.01%	0.000176
2002	Presiding Justice, 2nd Appellate Court Division 7, Mildred L. Lillie	7,200	7,220	20	0.19%	0.000158
2002	Associate Jusitce, 2nd Appellate Court Division 7, Dennis M. Perluss	7,079	7,122	43	0.44%	0.000327

Table 1, continued. Difference Between Machine Count and Manual Count in 1% Recount Continued

Year	Race	Machine Count of Votes	Manual Count of Votes	Difference in Vote Count	Average Percent Difference in Vote Count across Precincts	Variance of Percent Difference in Vote Count across Precincts
2002	Presiding Justice, 8th Appellate Court Division 8, Candace D. Cooper	7,229	7,255	26	0.25%	0.000207
2002	Associate Justice, 8th Appellate Court Division 8, Laurence D. Rubin	7,229	7,260	31	0.39%	0.001440
2002	Associate Justice, 8th Appellate Court Division 8, Paul Boland	7,161	7,162	1	-0.10%	0.000162
2002	Superintendent of Public Instruction	9,088	9,095	7	-0.03%	0.000170
2002	State Measure 46	10,827	10,844	17	0.09%	0.000052
2002	State Measure 47	10,979	11,003	24	0.15%	0.000082
2002	State Measure 48	10,162	10,161	-1	0.02%	0.000070
2002	State Measure 49	10,733	10,747	14	0.07%	0.000103
2002	State Measure 50	10,795	10,796	1	-0.05%	0.000106
2002	State Measure 51	10,511	10,527	16	0.12%	0.000136
2002	State Measure 52	10,845	10,865	20	0.07%	0.000085
2002	Judge Superior Court, Office No. 2	7,738	7,724	-14	-0.21%	0.000223
2002	Judge Superior Court, Office No. 39	7,412	7,427	15	0.12%	0.000099
2002	Judge Superior Court, Office No. 67	7,198	7,219	21	0.26%	0.000136
2002	Judge Superior Court, Office No. 100	7,515	7,537	22	0.20%	0.000183
2002	County Measure A	10,438	10,498	60	0.53%	0.000148
2002	County Measure B	10,516	10,534	18	0.14%	0.000104
2003	Shall Gray Davis Be Recalled	13,362	13,359	-3	0.05%	0.000054
2003	Governor	13,177	13,199	22	0.24%	0.000115
2003	State Measure 53	13,086	13,107	21	0.18%	0.000091
2003	State Measure 54	13,690	13,765	75	0.55%	0.000027

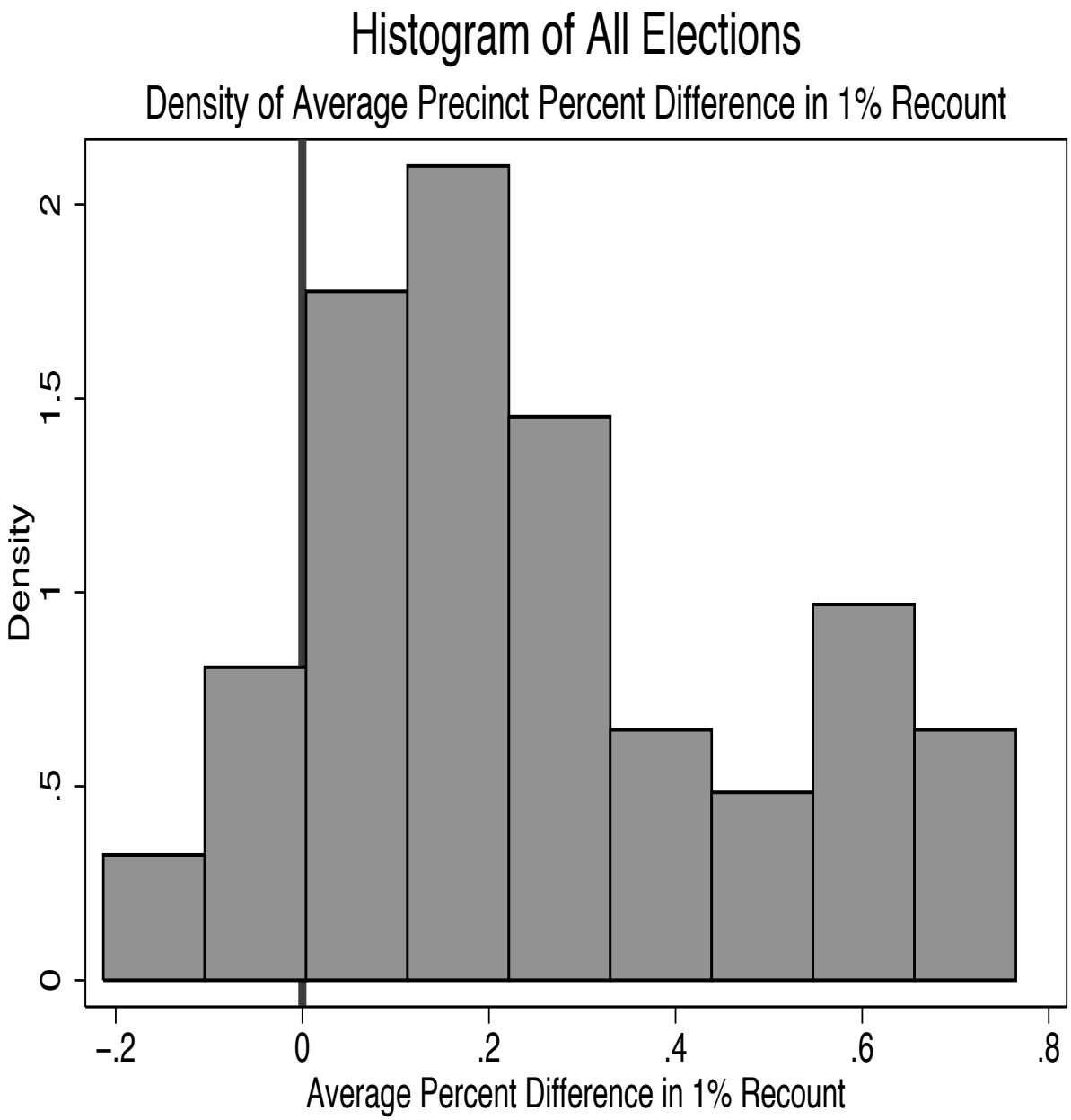

Figure 1: Histogram of All Elections

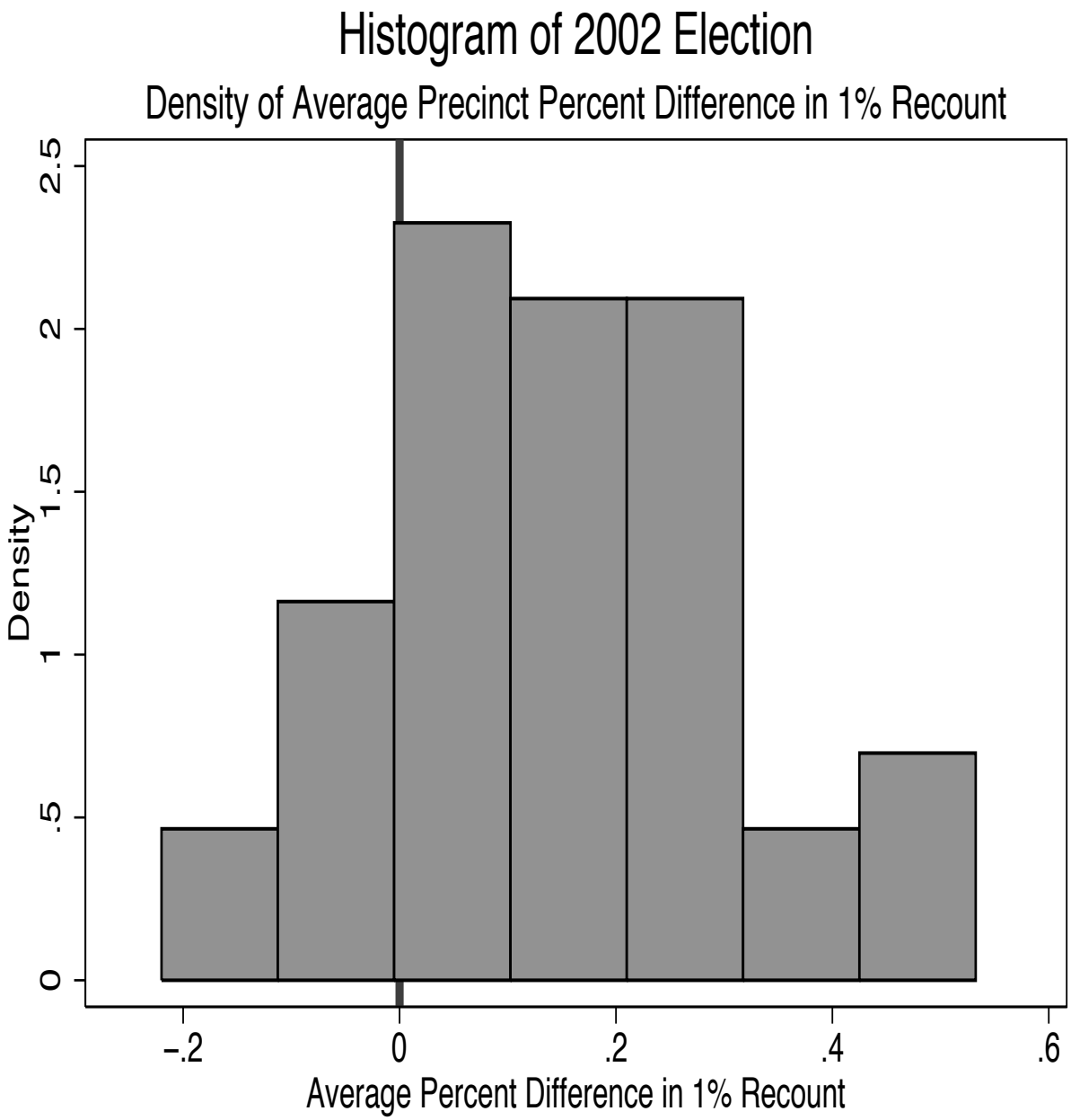

Figure 2: Histogram of 2002 Election

Table 2. Closest Races in LA County for Analyzed Elections

Year	Race	Candidates	Machine Counted Votes	% of Votes	Difference in % of Votes
2003	Shall Gray Davis Be Recalled	Yes	984,222	49.00%	2.00%
		No	1,024,341	51.00%	
2002	Judge Superior Court, Office No. 100	Richard F. Walmark	577,203	51.57%	3.14%
		John C. Gutierrez	542,081	48.43%	
2000	State Measure 35	Yes	1,245,447	51.78%	3.56%
		No	1,159,709	48.22%	
2002	State Measure 52	Yes	763,794	47.43%	5.14%
		No	846,544	52.57%	
2002	Judge Superior Court, Office No. 39	Richard E. Naranjo	581,617	52.75%	5.50%
		Craig A. Renetzky	521,021	47.25%	

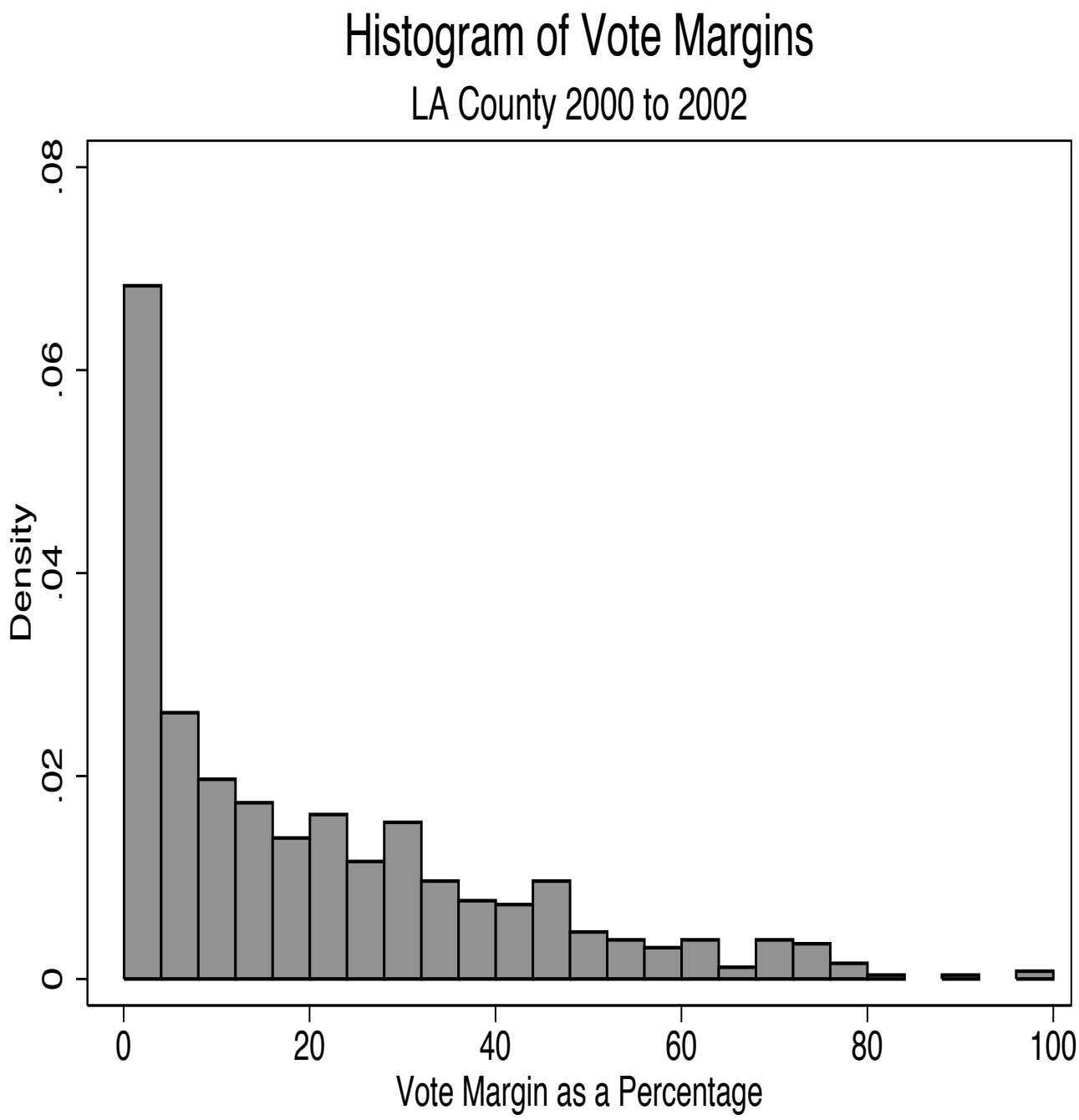

Figure 3: Histogram of Vote Margins as Percentages