Voting Machine Allocation in Franklin County, Ohio, 2004: Response to U.S. Department of Justice Letter of June 29, 2005

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This note reports analysis of the effects voting machine allocation had on voter turnout in precincts of Franklin County, Ohio, in the election conducted on November 2, 2004. The results here extend the analysis of voter turnout in Mebane (2005) to take into account facts presented in a report by the U.S. Department of Justice (DOJ), Voting Section, Civil Rights Division, released in a letter dated June 29, 2005 (Tanner 2005). I also respond to some of the facts and interpretations stated in the DOJ report.

Most of the data used in this analysis come from a spreadsheet file obtained directly from Franklin County. The file contains information about a number of variables for each voting precinct in the county. It was given to me with the name `FINAL JUSTICE DEPARTMENT ANALYSIS.xls` (received by me on January 29, 2006). The data in this file are the same as in a file supplied to the Democratic National Committee's team that was investigating the Ohio 2004 election. That file was originally supplied to Eric Greenwald, who gave it to me with the name `franklinMchWrkProPollClose.xls` (received by me on April 13, 2005). Among the variables in the file is one that counts the number of voting machines in each precinct ("2004 VOTING MACHINES"). Also available are variables that count the number of registered voters in each precinct as of April 1, 2004, and November 4, 2004 ("4/1/04 VOTER REGISTRATION" and "11/4/04 VOTER REGISTRATION") and the number of active voters as of April 27, 2004, and November 4, 2004 ("4/27/04 ACTIVE VOTERS" and "11/4/04 ACTIVE VOTERS"). The file also contains a variable reporting the official count of the number of ballots cast ("2004 OFFICIAL PUBLIC COUNT").

The racial composition of each precinct is measured using proprietary data, derived from the 2000 Census, prepared under contract for the DNC.

For discussion of the statistical methods used in this memo see Mebane and Herron (2005) and Mebane and Sekhon (2004a; 2004b).

Voting Machine Allocation and Voter Turnout

The analysis of Ohio precincts in the Democratic National Committee's report on Ohio 2004 (Mebane and Herron 2005) finds that in precincts across the state, as the ratio of voting machines per registered voter in each precinct increases, voter turnout increases. The mechanism conjectured in that report is that more machines per registered voter meant there were shorter lines, and that shorter lines meant that more people could take the time to vote. The report in this way connects official decisions to place different numbers of voting machines in different precincts with disparities in different voters' access to the polls.

Mebane (2005) reports evidence that tends to confirm that mechanism among precincts in Franklin County. The analysis in the current report refines the analysis by taking into account the racial composition of each precinct. Mebane (2005) estimates that the effect of inadequate provision of voting machines in Franklin County reduced voter turnout much more than was implied by the estimates presented in Mebane and Herron (2005). The DOJ report finds that voter

registration data from Franklin County are unreliable, due to failure to purge lapsed voters (Tanner 2005, 2). The current analysis shows that replacing voter registration with a measure of the number of voters active in each precinct produces estimates of the effect of inadequate machine provision on voter turnout that agree with the estimates Mebane and Herron (2005) present as typical throughout the state.

Figure 1 illustrates how providing an inadequate number of voting machines in precincts in Franklin County, Ohio, in 2004 produced long lines and caused voter turnout to decrease. Voter turnout in these figures is measured as the ratio of the official count of ballots cast to the number registered in November. The figure shows three scatterplots. The first plot shows the relationship between the voting machines per registered voter ratio and voter turnout across precincts. The lines in this and in the second plot are the ordinary least squares regression line where the natural logarithm of the machines per registered voter ratio is the regressor (using the natural logarithm fits the data better than using the ratio directly). Turnout is higher where the number of voting machines per registered voter is higher. The second plot shows the relationship between the voting machines per registered voter ratio and the elapsed time each precinct's polls were open. A longer elapsed time implies that there were more voters still waiting to vote at the end of election day. Many voters waited in long lines during the day, so this duration measure is not a perfect indicator for the long lines phenomenon. The durations are shorter (meaning lines at the end of the day were shorter) where the number of voting machines per registered voter is higher. The third plot shows the relationship between the elapsed time each precinct's polls were open and voter turnout. The line in this plot is the regression line using the polls open elapsed time as the regressor. Turnout is lower where the durations are greater (meaning lines were longer).

The DOJ report includes several statements that together may suggest that the observed relationships between voting machine allocations, polls open elapsed times and voter turnout simply reflect the fact that both low ratios of voting machines per registered voter and long polls open elapsed times occurred in precincts with many African American voters, voters who are already predisposed for other reasons to turnout to vote at lower rates.

The DOJ report observes that "voter turnout in Franklin County, as in much of the United States, varies significantly by race" (Tanner 2005, 2). A typical finding is that voter turnout is lower among African Americans. The DOJ report further states that "there were fewer voting machines in black precincts than in white precincts based on registration" (Tanner 2005, 3). I present evidence regarding this claim (which is correct) below.

The DOJ report also claims that there is a "tendency in Franklin County for white voters to cast ballots in the morning (i.e., before work), and for black voters to cast ballots in the afternoon (i.e., after work)" (Tanner 2005, 3). Data from a survey of 1,201 Ohio voters conducted January 30 through February 2, 2005, supports only the first part of this assertion (for a description of the survey methodology, see Feldman and Belcher 2005). As Table 1 shows, a higher proportion of voters who identified themselves as white rather than African American arrived at the polls to vote early in the morning: 49 percent of white voters arrived before 11 a.m. but only 41 percent of African American voters did so. And a higher proportion of African American voters than white voters arrived at the polls to vote during the middle of the day: 31 percent of African American voters but only 23 percent of white voters arrived between 11 a.m. and 3 p.m. But during the late afternoon and early evening period there is no disparity in the proportion of each group arriving at the polls: 27 percent of white voters and 28 percent of African American voters arrived at the polls to vote after 3 p.m. Across Ohio, at least, there is no support for the DOJ's claim that black

voters more than white voters tended to show up to cast ballots "after work."

The DOJ report also states that "the predominantly black polling places stayed open later than the predominantly white precincts in order to serve those voters who were in line at the normal 7:30 p.m. poll closing time" (Tanner 2005, 3). Figure 2 shows the relationship across precincts between the proportion African American and the polls open elapsed time. In addition to a scatterplot of the two variables, the figure also shows the ordinary least squares regression line. While there is slight tendency for the polls to be open longer as the proportion African American increases, the longest elapsed times in fact occur in precincts where the proportion African American is low.

Direct evidence against the suggestion that the relationship between voting machine allocations and voter turnout primarily reflects a general tendency for voter turnout to be low among African American voters may be seen by examining the relationshps shown in Figures 3, 4, 5, and 6. These figures show the same scatterplots as in Figure 1, except the precincts are separated based on the proportion of the voting age population in each that is African American. The precincts are grouped into quartiles. Figure 3 shows the scatterplots among the 25 percent of precincts that have the lowest proportion African American. These are precincts where less than 1.7 percent of the voting age population is African American. Figure 4 shows the middle half of precincts. These are precincts where more than 1.7 percent but less than 15.65 percent of the voting age population is African American. Figure 5 shows the scatterplots among the 25 percent of precincts that have the highest proportion African American. These are precincts where more than 15.65 percent of the voting age population is African American. Figure 6 shows the precincts in which more than half of the voting age population is African American.

In every one of the four subsets of Franklin County precincts, turnout is higher where the number of voting machines per registered voter is higher. In each of the subsets, as well, the polls open elapsed times are shorter (meaning lines at the end of the day were shorter) where the number of voting machines per registered voter is higher. The bivariate relationship between polls open elapsed times and voter turnout varies across the four subsets. Among the precincts with low and intermediate proportions African American, turnout is lower where the elapsed times are greater. But among the precincts with the highest proportions African American, the mean level of voter turnout is not correlated with the elapsed times.

Because the machines per registered voter ratio, the polls open elapsed time, the proportion African American and voter turnout are all correlated with one another, the simple pairwise relationships between them are difficult to interpret. To try to disentangle the relationships, let us first consider the conditional distribution of the polls open elapsed times given the machine per registered voter ratios and the proportions African American. Then we will look at the conditional distribution of voter turnout given the other variables.

Table 2 reports estimates of a Poisson regression model (allowing for underdispersion) that shows that the polls open elapsed time does tend to be significantly shorter in precincts where the voting machines per registered voter ratio is higher, and longer where the proportion African American is greater. Shortages of voting machines are a primary reason for poll closing times to be later.

Table 3 reports robust estimates of an overdispersed binomial regression model that has voter turnout in each precinct depending on the number of voting machines per registered voter, the polls open elapsed time and the proportion African American. The regression model uses dummy variables to allow the estimated base level of turnout and the estimated effects of the machine

allocations and the polls open elapsed times to vary across the three subsets of precincts. Specifically, using A_i to denote the proportion African American in precinct i, I define two dummy variables using the following rules:

$$\mathrm{LOW}_i = \begin{cases} 1, \text{ if } \mathrm{A}_i < 0.017 \\ 0, \text{ otherwise} \end{cases}$$

$$\mathrm{MED}_i = \begin{cases} 1, \text{ if } 0.017 \leq \mathrm{A}_i \leq 0.1565 \\ 0, \text{ otherwise} \end{cases}$$

$\mathrm{LOW}_i = 1$ only if precinct i is in the set of precincts that have the lowest proportion African American, and $\mathrm{MED}_i = 1$ only if precinct i is in the set of precincts that have an intermediate proportion African American. Using MR_i to denote the natural logarithm of the voting machines per registered voter ratio and P_i to denote the polls open elapsed time, the linear predictor in the model may be written as follows.

$$Z_i = b_0 + b_1\mathrm{P}_i + b_2\mathrm{MR}_i + \mathrm{LOW}_i(b_3 + b_4\mathrm{P}_i + b_5\mathrm{MR}_i) + \mathrm{MED}_i(b_6 + b_7\mathrm{P}_i + b_8\mathrm{MR}_i) + b_9\mathrm{A}_i \ .$$

With this formulation, the estimated effects for each set of precincts may be recovered as follows:

$$Z_i = \begin{cases} b_0 + b_3 + (b_1 + b_4)\mathrm{P}_i + (b_2 + b_5)\mathrm{MR}_i + b_9\mathrm{A}_i, & \text{low proportion African American} \\ b_0 + b_6 + (b_1 + b_7)\mathrm{P}_i + (b_2 + b_8)\mathrm{MR}_i + b_9\mathrm{A}_i, & \text{medium proportion African American} \\ b_0 + b_1\mathrm{P}_i + b_2\mathrm{MR}_i + b_9\mathrm{A}_i, & \text{high proportion African American} \ . \end{cases}$$

Clearly we expect that having more voting machines per registered voter should increase voter turnout, because having more machines should reduce each voter's expected waiting time (i.e., shorter lines). Hence we expect $b_2 + b_5 > 0$, $b_2 + b_8 > 0$ and $b_2 > 0$. If shortages of machines are the primary cause of delays in voting and consequently of reductions in voter turnout, then given the number of voting machines we expect that having a polling place be open longer should increase voter turnout (the counterfactual is obvious: imagine closing the polls while people are still standing in line waiting to vote). Therefore we expect $b_1 + b_4 > 0$, $b_1 + b_7 > 0$ and $b_1 > 0$. In this case the negative relationships between the polls open elapsed time and voter turnout that appears in Figures 3 and 4 would be explained as a reflection of the fact that shortages of voting machines caused long lines that forced the polls to be open longer. Finally, if African Americans are less likely than others are to vote, given the same number of voting machines per registered voter and the same polls open elapsed time, then we should observe $b_9 < 0$.

The estimates in Table 3 confirm all of these expectations except one.

Other things equal, having more voting machines per registered voter is associated with higher voter turnout, but the effects are larger among the precincts that have intermediate or high proportions African American. In the set of precincts with high proportions African American, the number of voting machines per registered voter is very strongly related to voter turnout. The point estimate for the coefficient is $\hat{b}_2 = 1.36$. The estimated effect of voting machines on turnout among the precincts with intermediate proportions African American is not significantly different: $\hat{b}_2 + \hat{b}_8 = 1.51$. The estimated effect of voting machines on turnout among the precincts with low proportions African American is positive but substantially smaller: $\hat{b}_2 + \hat{b}_5 = 0.67$. The display at the bottom of Table 3 translates these coefficient estimates into estimates of the

differences in voter turnout expected across the ranges of values for the ratio of voting machines per registered voter observed among each of the three sets of precincts. The results confirm that effects of voting machine allocations on voter turnout were less severe among precincts that had low proportions African American. Each expected turnout value is computed using the coefficient parameter estimates and the quartiles of the machines per registered voter ratio, the median polls open elapsed time and the median proportion African American among precincts in the referent subset. Moving from the first to the third quartile of the voting machines per registered voter ratio is associated with an increase of about nine percent in voter turnout in the precincts having high and intermediate proportions African American. But among the precincts having low proportions African American, moving from the first to the third quartile of the voting machines per registered voter ratio is associated with an increase of about three percent in voter turnout.

Also, as expected, voter turnout falls as the proportion African American increases, other things equal ($\hat{b}_9 = -0.34$).

The estimated effects of polls open elapsed times on turnout are as expected for the precincts that have intermediate or high proportions African American, but not for the precincts that have low proportions African American. For the precincts with the highest proportion African American, keeping the polls open longer is associated with higher turnout, other things equal ($\hat{b}_1 = 0.081$). The estimated effect among the precincts with intermediate proportions African American is not significantly different ($\hat{b}_1 + \hat{b}_7 = 0.072$). But for the precincts that have low proportions African American, keeping the polls open longer is associated with lower turnout, other things equal ($\hat{b}_1 + \hat{b}_4 = -0.104$). The display at the bottom of Table 3 translates the coefficient estimates into estimates of the differences in voter turnout expected across the ranges of values for the polls open elapsed times observed among each of the three sets of precincts. Each expected turnout value is computed using the coefficient parameter estimates and the quartiles of the median polls open elapsed times, the machines per registered voter ratio and the median proportion African American among precincts in the referent subset. Moving from the first to the third quartile of the polls open elapsed times is associated with an increase of about 3.4 percent in voter turnout in the precincts having high proportions African American, and with an increase of about two percent in the precincts with intermediate proportions African American. But among the precincts having low proportions African American, moving from the first to the third quartile of the voting machines per registered voter ratio is associated with a decrease of about 0.7 percent in voter turnout. In the precincts that have low proportions African American, delays that deterred voters from voting occurred for reasons that do not trace back to insufficient provision of voting machines in the same way as in the other precincts. Other unmeasured aspects of conditions in those precincts may have made a difference. Or it may be that the people in those precincts tended to respond differently when faced with similar conditions in the polling place.

The model reported in Table 3 describes the pattern of voter turnout among most of the precincts in the analysis. Among the 787 precincts, there are only four precincts that have voter turnout so different from the pattern observed among the other precincts that they are classified as outliers. Table 3 lists those precincts. In all of them the observed turnout is substantially smaller than expected according to the model that describes turnout throughout the rest of the county.

The DOJ report states that the rolls of registered voters in Franklin County are so unreliable that in making decisions about how to allocate voting machines to precincts, Franklin County election officials augmented them with information about turnout in previous elections. The DOJ report states, “the Board used the inflated voter rolls in the Fall of 2004 as one factor in its

allocation of voting machines, and it also used past voter turnout as another factor" (Tanner 2005, 2). In the data provided by Franklin County, the variable that most closely approximates the combination of these two kinds of information is the count of the active voters in each precinct. One may wonder whether the effects of voting machine allocation on voter turnout appear to be smaller if in the analysis the number of registered voters is replaced by the number of active voters.

As may be seen in Figures 7, 8, 9, 10, and 11, using active voters instead of registered voters does not greatly change the bivariate relationships among the machine allocations, the polls open elapsed times and voter turnout. Voter turnout in these figures is measured as the ratio of the official count of ballots cast to the number of active voters in November, and we now consider the ratio of voting machines per active voter in each precinct. Over all precincts in Franklin County, the relationships using active voters are nearly the same as they are using registered voters (compare Figure 7 with Figure 1). Likewise the relationships are more similar than not in each of the previously considered subsets of precincts grouped by the proportion of the voting age population in each that is African American (compare Figure 8 with Figure 3, Figure 9 with Figure 4, Figure 10 with Figure 5 and Figure 11 with Figure 6).

Table 4 reports estimates of a Poisson regression model (allowing for underdispersion) that shows that the polls open elapsed time does tend to be significantly shorter in precincts where the voting machines per active voter ratio is higher, and longer where the proportion African American is greater. The effect the ratio of voting machines per active voter has on the polls open elapsed time is about the same as the effect estimated for the ratio of voting machines per registered voter. If anything the effect estimated with respect to active voters is slightly larger than the one estimated with respect to registered voters.

Estimating an overdispersed binomial regression model that has voter turnout among active voters in each precinct depending on the number of voting machines per active voter, the polls open elapsed time and the proportion African American produces one noteworthy change from the model estimated using registered voters that was presented in Table 3. The estimates presented in Table 5 refer to a model having the same form as the one for turnout among registered voters. Using MA_i to denote the natural logarithm of the voting machines per active voter ratio, the linear predictor in the model may be written

$$Z_i = c_0 + c_1\mathrm{P}_i + c_2\mathrm{MA}_i + \mathrm{LOW}_i(c_3 + c_4\mathrm{P}_i + c_5\mathrm{MA}_i) + \mathrm{MED}_i(c_6 + c_7\mathrm{P}_i + c_8\mathrm{MA}_i) + c_9\mathrm{A}_i \ ,$$

and the estimated effects for each set of precincts may be recovered as follows:

$$Z_i = \begin{cases} c_0 + c_3 + (c_1 + c_4)\mathrm{P}_i + (c_2 + c_5)\mathrm{MA}_i + c_9\mathrm{A}_i, & \text{low proportion African American} \\ c_0 + c_6 + (c_1 + c_7)\mathrm{P}_i + (c_2 + c_8)\mathrm{MA}_i + c_9\mathrm{A}_i, & \text{medium proportion African American} \\ c_0 + c_1\mathrm{P}_i + c_2\mathrm{MA}_i + c_9\mathrm{A}_i, & \text{high proportion African American} \ . \end{cases}$$

If having more voting machines per active voter increases voter turnout among active voters less than having higher numbers of voting machines per registered voter increases registered voter turnout, then the coefficients that measure these effects should be of smaller magnitude in the current model. That is, we should observe $b_2 + b_5 > c_2 + c_5$, $b_2 + b_8 > c_2 + c_8$ and $b_2 > c_2$. If shortages of machines are the primary cause of delays in voting and consequently of reductions in voter active voter turnout, then we continue to expect that, given the number of voting machines,

having a polling place be open longer should increase voter turnout among those voters. Therefore we expect $c_1 + c_4 > 0$, $c_1 + c_7 > 0$ and $c_1 > 0$. Of course the model estimates for registered voters have already indicated that among the precincts with a low proportion African American, delays apparently had effects on turnout that were qualitatively different from the effects among the other precincts (recall that $\hat{b}_1 + \hat{b}_4 < 0$). And, finally, if African Americans are less likely to vote than other active voters are, given the same number of voting machines per active voter and the same polls open elapsed time, then we should observe $c_9 < 0$.

The estimates presented in Table 5 show that, other things equal, having more voting machines per active voter is associated with higher voter active voter turnout, even though the effects of the machine allocation on turnout are of smaller magnitude among active voters than they are among registered voters. Once again the effects are larger in the precincts that have high proportions African American than among the precincts that have low proportions African American. The effects on turnout among the precincts with intermediate proportions African American are smaller than among the high proportion precincts and greater than among the low proportion precincts. In the set of precincts with highest proportions African American, the coefficient that measures the effect on active voter turnout of the number of voting machines per active voter is estimated to be smaller than the corresponding coefficient estimate for registered voters: $\hat{c}_2 = 1.21$, while $\hat{b}_2 = 1.36$. The estimated effect of voting machines on active voter turnout among the precincts with intermediate proportions African American is slightly smaller than the estimate among the precincts with high proportions African American: $\hat{c}_2 + \hat{c}_8 = 1.04$. The estimated effect among the precincts that have low proportions African American is significantly smaller: $\hat{c}_2 + \hat{c}_5 = .41$.

The estimated differences in expected active voter turnout across the ratios of voting machines per active voter observed in each of the three sets of precincts are reported at the bottom of Table 5. The results confirm that the effects of voting machine allocations on active voter turnout are smaller than the effects on registered voter turnout (compare Table 3). The results also show that the effects are greatest among the precincts that have high proportions African American and least among precincts that have low proportions African American. Moving from the first to the third quartile of the voting machines per active voter ratio is associated with an increase of about 5.7 percent in active voter turnout in the precincts having high proportions African American and of about 3.5 percent in active voter turnout in the precincts with intermediate proportions African American. But among the precincts having low proportions African American, moving from the first to the third quartile of the voting machines per active voter ratio is associated with an increase of about 1.1 percent in voter turnout.

Voter turnout among active voters falls as the proportion African American increases, other things equal ($\hat{c}_9 = -0.54$).

Having polls be open longer is associated with increases in active voter turnout, other things equal, only for the precincts that have high proportions African American ($\hat{c}_1 = 0.042$). The estimated effect among the precincts with intermediate proportions African American is slightly negative ($\hat{c}_1 + \hat{c}_7 = -0.031$), and the estimated effect for the precincts that have low proportions African American is significantly negative ($\hat{c}_1 + \hat{c}_4 = -0.123$). The display at the bottom of Table 5 translates these coefficient estimates into estimates of the differences in voter turnout expected across the ranges of values for the polls open elapsed times observed among each of the three sets of precincts. Moving from the first to the third quartile of the polls open elapsed times is associated with an increase of about 1.6 percent in voter turnout in the precincts having high

proportions African American, with a decrease of about 0.7 percent in the precincts with intermediate proportions African American, and with a decrease of about 0.4 percent in voter turnout in the precincts having low proportions African American. These results again suggest that the delays that deterred active voters from voting in the precincts having lower proportions African American occurred for reasons that do not trace back to insufficient provision of voting machines in the same way as in the precincts that have high proportions African American.

The model reported in Table 5 describes the pattern of active voter turnout in most of the precincts. Among the 787 precincts, there are only four precinct outliers. Table 5 lists those precincts. In all of them the observed turnout is substantially smaller than exected according to the model that describes turnout throughout the rest of the county. One of the outlier precincts in the model for active voter turnout is also an outlier in the model for registered voter turnout. That precinct appears to be extremely anomalous whether one considers active voters or registered voters.

To summarize, while it is clear that shortages of voting machines in Franklin County caused delays in people waiting to vote that in turn reduced voter turnout, it is not clear why the relationship between voting machine allocation and turnout seems to take different forms depending on the racial composition of the precincts in question. Using the separation of precincts into quartiles based on the proportion of a precinct's voting age population that is African American, we find that in all the sets of precincts, having more voting machines per voter (either registered voter or active voter) is associated with higher voter turnout, given the polls open elapsed time and the proportion African American. But the estimate of the partial association between machines per voter and turnout is much smaller in the set of precincts with low proportions African American than it is in the other sets. And when we consider only active voters, the estimated partial association is larger in the set of precincts that have high proportions African American than it is in the set of precincts that have intermediate proportions. In addition, the partial association between polls open elapsed time and turnout is negative in the set of precincts with low proportions African American, and when only active voters are considered the partial association is negative as well in the set of precincts that have intermediate proportions African American. Because greater shortages of voting machines are a primary cause of longer polls open elapsed times, these negative partial associations are probably best seen as additional manifestations of the basic problem that there were not enough machines, but it is not clear why the effects take such different forms in the different sets of precincts.

Regardless of the differing appearances the relationship between voting machine allocations and voter turnout has in the statistical models, the estimates of the typical differences in turnout associated with the allocations suggests that the impact was much larger in areas that had higher proportions of African American voters. Even considering only the estimated effects on turnout among active voters, which are smaller than the estimated registered voter effects, the expected voter turnout estimates at the bottom of Table 5 show that the typical reduction in voter turnout—when comparing a precinct that has a machines per active voter ratio near the third quartile to a precinct having a ratio near the first quartile—is more than five times larger in the set of precincts with high proportions African American than it is in the set of precincts with low proportions. In the former set of precincts the reduction in turnout associated with such a difference in the provision of voting machines is about 5.7 percent while in the latter set the reduction is about 1.1 percent.

If we take into account the indirect consequences of the machine allocations that are

associated with the polls open elapsed times, the picture of more severe effects in precincts that have more African American voters does not change in any substantively important way. Because longer polls open times are in the regression model sense associated with higher voter turnout among precincts with high proportions African American but with lower voter turnout among precincts with low proportions, a crudely estimated combined effect of the two variables shows slightly less disparate impacts than the estimated effect of differences in the voting machine ratios alone. If, just to get a heuristic sense, we add together both sets of expected voter turnout effects from the bottom of Table 5—comparing the third to the first quartile for the machine ratio and the first to the third quartile for the polls open time—the crude result is a typical reduction of 4.1 percent in voter turnout in the precincts having high proportions African American and a typical reduction of 1.4 percent in the precincts having low proportions. By this crude measure the allocation of voting machines still is associated with reductions in turnout that are typically three times larger in the set of precincts with high proportions African American than they are in the set of precincts with low proportions. There is no merit to the DOJ report's suggestion that keeping the polls open longer fully mitigated the consequences of the initial disparity in the distribution of voting machines (recall the DOJ statement, "the predominantly black polling places stayed open later than the predominantly white precincts in order to serve those voters who were in line at the normal 7:30 p.m. poll closing time" Tanner 2005, 3).

Racial Biases in Voting Machine Allocation

So far we have seen that the allocation of voting machines among Franklin County's precincts affected different voters differently, and that the most severe effects in terms of reduced voter turnout were incident on voters in precincts that had high proportions of African Americans. Were the machine allocation decisions that produced such disparate impacts themselves racially biased?

The description of the methods used to allocate voting machines in the DOJ report is unspecific:

> "In any event, the Board used the inflated voter rolls in the Fall of 2004 as one factor in its allocation of voting machines, and it also used past voter turnout as another factor. Of course, any allocation—no matter how bipartisan—was inevitably going to be inelegant and imprecise given that the Board had to make allocation decisions well before the election and was constrained by the number of voting machines available (2,904), the number of precincts (788), and the Ohio practice of having at least two machines in each precinct so that voting can continue if one machine breaks down. As Elections Director Damschroder acknowledged, the process involved 'some math and some art.' " (Tanner 2005, 2)

The lack of specificity in the DOJ report's description is apparent, but its accuracy is also questionable. The spreadsheet file provided by Franklin County shows 2,800 voting machines assigned to precincts, not 2,904.

The DOJ report states plainly that "there were fewer voting machines in black precincts than in white precincts based on registration" (Tanner 2005, 3), but the report attempts to justify that as an appropriate response to the history of voter turnout in the different precincts: "the Board [of Elections] tended to allocate fewer machines to the 54 predominantly black precincts per registered voter because of the long history of lower black turnout" (Tanner 2005, 3). The DOJ

report goes on to state that when one looks at the voting machine allocation in relation to the ballots cast, the problematic disparity disappears:

> "But while there were fewer voting machines in black precincts than in white precincts based on registration, the disparity was reversed when compared to actual voter turnout in the 2004 election. In fact, voting machines in the white precincts were busier than the machines in the black precincts, and black persons who went to the polls were not at a disadvantage due to the number of machines." (Tanner 2005, 3)

In view of the disparities we have documented with respect to the effects the allocation of voting machines had on voter turnout, it should be obvious that it is not appropriate to take the relationship between the number of voting machines and the number of ballots cast as a measure of the fairness and adequacy of the machine allocations. Doing so, as the DOJ report does, ignores the people who went to the polls with the intention to vote but could not do so because of the great delays caused by the scarcity of machines.

It is true that the ratio of ballots cast per voting machine does not show the same pattern of disparities associated with the racial composition of precincts that are evident in the ratio of registered voters per voting machine. Using the previous discussion's separation of precincts into quartiles based on the proportion of a precinct's voting age population that is African American, the first column of Table 6 shows that in the set of precincts that have low proportions African American there were typically 262 registered voters per voting machine while in the set of precincts with high proportions African American there were typically 324 registered voters per voting machine. The second column shows that the balance changes when the number of ballots cast is considered. In the set of precincts with low proportions African American there were typically 170 ballots cast per voting machine while in the set of precincts with high proportions African American there were typically 164 ballots cast per voting machine.

Far from being a measure of the fairness of the voting machine allocation, however, the relationship between the number of voting machines and the number of ballots cast is primarily an indication of the length of time it took for each voter who did manage to vote to complete the ballot. Of the 792 precincts for which there are data in the file from Franklin County, 776 have a polls open elapsed time greater than 13 hours, which indicates that they were open past the scheduled poll closing time of 7:30 p.m.. Presumably each precinct remained open until the last voter in line as of 7:30 p.m. had voted, and no longer, and the universally acknowledged long lines in most places in the county throughout the day means that every voting machine was fully occupied throughout the day. So all we learn from the fact that typically there were 170 ballots cast per voting machine in the precincts with low proportions African American and 164 ballots cast per voting machine in the precincts with high proportions is that in the latter precincts each voter typically took slightly longer to vote than each voter did in the former set of precincts. That the time it took each person to vote is the main fact underlying the ballots per machine statistics is shown most clearly by the third column of Table 6, which shows the median value for each set of precincts of the number of ballots cast divided by the polls open elapsed time and the number of voting machines. In the set of precincts with low proportions African American typically 13 ballots were cast per voting machine per hour that the polls were open while in the set of precincts with high proportions African American typically 11 ballots were cast per voting machine per hour. Perhaps this is where the DOJ report's speculation about the effects of the length of the ballot come into play: "It is clear that there were long lines at polling places across Franklin

County, and it was not uncommon for voters to have to wait three or more hours to cast their ballots. This was especially true within the City of Columbus, where the ballot was exceptionally long" (Tanner 2005, 1).

The most relevant measure of whether there were racial biases in the allocation of voting machines is the relationship between the number of voting machines in each precinct and the measure of the number of voters Franklin County officials expected in each precinct for the November election as of the time the voting machine allocation decisions were made. We asked the Franklin County Board of Elections to supply the exact count of voters in each precinct that they used to make the machine allocations. In response to that query, on January 23, 2005, they sent three files via email (Brown 2006): the file named `FINAL JUSTICE DEPARTMENT ANALYSIS.xls`, a file named `SECOND LIST FOR DOJ 06.09.05.xls` and a file named `06.20.05 Purged Voters for DOJ.xls`. We then asked which of several alternative formulas matched the measure used to make the allocation decisions. Referring to columns in the three spreadsheet files, the question was "`Which numbers were used to make the machine allocation? (a) "4/27/04 ACTIVE VOTERS"; (b) "4/27/04 ACTIVE VOTERS" + "TOTAL NEWLY REGISTERED VOTERS 2004";(c) "4/1/04 VOTER REGISTRATION";(d) "4/1/04 VOTER REGISTRATION" + "TOTAL NEWLY REGISTERED VOTERS 2004";(e) any of the preceding - "PURGED VOTERS"; (f) other.`" The Director of Franklin County's Board of Elections, Matt Damschroder, responded as follows:

> "I have been quoted as saying the 11/04 allocation decision was calculated using 'a little bit of math and a little bit of art.' Because 90% of the allocation decision using the old machines had to be made well in advance of the election, there was not sufficient time to take into full account the significant change in registration. Therefore, mid-summer, post primary active voter numbers were used as an objective baseline and then changed based upon subjective evaluations such as past turnout, new construction (which would indicate more provisional ballot demand), and local contests or issues that may drive turnout beyond what was expected for the balance of the county (i.e., school tax levy)." (Damschroder 2006)

Evidently the allocation decisions were not a simple function of any particular measure of the number of voters.

Nonetheless we can use the information sent in response to our query to assess whether the machine allocations appear to be racially biased when compared to the count of voters in each precinct near the time the bulk of the allocation decisions were made. Damschroder's statement suggests that most but not all of the allocations were made in "mid-summer." His mention of "post primary" voters refers to the primary election of March, 2004. Two columns in the `FINAL` spreadsheet file may bear on the concept of "post primary active voters": "4/1/04 VOTER REGISTRATION" and "4/27/04 ACTIVE VOTERS." The fact that the "4/1/04 VOTER REGISTRATION" count for each precinct is always larger than the "4/27/04 ACTIVE VOTERS" count implies that the latter reflects some voters having been purged from the former. The `SECOND` file contains a column entitled "TOTAL NEWLY REGISTERED VOTERS 2004" and the `Purged` file contains a column entitled "PURGED VOTERS," but these numbers do not appear to be useful for recovering the status of each precinct as of "mid-summer." We asked the Franklin County officials to clarify the temporal scope of the "NEWLY REGISTERED" numbers.

Our question was, "In SECOND LIST FOR DOJ 06.09.05.xls there are columns "TOTAL NEWLY REGISTERED VOTERS 2004" and "NEWLY REGISTERED VOTERS CASTING BALLOTS IN 2004." What is the time span for "newly" here? Newly registered since when? Does that mean between 4/27/2004 (or 4/1/2004) and 6/9/2004 (I assume 06.09.05 is June 9, 2005)? That would suggest I should add the "newly" counts to the "4/27/04 ACTIVE VOTERS" counts to get the total number of voters used to allocate the machines. Is this correct?" Damschroder responded as follows:

> "For the spreadsheet you reference, 'TOTAL NEWLY REGISTERED VOTERS 2004' means any qualified elector registering to vote in Franklin County for the first time during the time period between the March primary election and the November general election. Newly registered voters, by NVRA definition, are considered active voters and would be included in the final total active voters numbers." (Damschroder 2006)

Regarding the "PURGED VOTERS" values, Damschroder gave a response that included the following:

> "In 1999, the Board of Elections changed voter registration systems (database software application) and in the transition lost all of its electronic data "proving" that the Board had followed the law and issued the confirmation notices. Therefore the Board chose to reset all inactive voters to active status and began the NVRA process over. It is hard to determine precisely how many inactive voters in 2004 should have been purged from the rolls in 2001 and 2003, but the bottom line is that the 2004 rolls were bloated due to the abnormally high number of inactive voters. Note here that not all inactive voters were then purged in 2005 (because not all had reached the fullness of their NVRA timetable). Once a voter is purged (cancelled) the voter no longer appears on the rolls of the election jurisdiction as a registered voter. The future purge status of an inactive voter was not considered in the 2004 voting machine allocation decision making process." (Damschroder 2006)

An exact reconciliation in the spirit of Damschroder's statements between all the numbers contained in the files supplied by Franklin County is not possible, but it is clear that the "TOTAL NEWLY REGISTERED VOTERS 2004" and "PURGED VOTERS" information cannot be used to approximate "mid-summer" voter counts. Precinct by precinct, the sum of "4/1/04 VOTER REGISTRATION" and "TOTAL NEWLY REGISTERED VOTERS 2004" is moderately close to the value of "11/4/04 VOTER REGISTRATION" from the FINAL file. The median percentage difference between them is 0.16 percent and the largest difference is 26.9 percent. The sum is greater than "11/4/04 VOTER REGISTRATION" in 367 precincts and less in 406 precincts. If the "PURGED VOTERS" values are subtracted from the sum then the result is less than "11/4/04 VOTER REGISTRATION" in all but two precincts. The sum of "4/27/04 ACTIVE VOTERS" and "TOTAL NEWLY REGISTERED VOTERS 2004" is always less than "11/4/04 VOTER REGISTRATION."

The information provided by Franklin County does not allow us to recover the information or the decision rules Franklin County officials used to allocate voting machines to precincts for the

2004 general election. The closest we can come to measuring the number of voters as of "mid-summer" 2004 is to use the number of active voters in each precinct as of April 27, 2004.

The active voter counts used in the analysis reported in the preceding section are dated November 4, 2004, two days after the election. The November active voter count is the best measure to use for comparing the allocation of voting machines to the electorate as it existed on election day. Allocation decisions made using "mid-summer" information would of course have ignored the surge in voter registration that took place between July and October. According to the file provided by Franklin County, there was a net increase of 15 percent in voter registration in the county between April 1, 2004, and November 4, 2004. Between April 27, 2004, and November 4, 2004 the number of active voters in the county increased by 27.4 percent.

The fifth and sixth columns of Table 6 show that, in terms of racial disparities, the November count of active voters and the April-June count of active-newly-purged voters present divergent pictures of the voting machine allocation. Using the November active voter counts, there are on average more active voters per voting machine in the precincts that have high proportions African American (242 voters per machine) than in the precincts with low proportions (213 voters per machine). In percentage terms, this disparity is smaller than the one observed using the counts of registered voters. Using the registered voter counts there are on average 23.7 percent more voters per machine in the precincts with high proportions African American than in the precincts with low proportions, but using the November active voter counts there are 13.6 percent more. The disparity is nonetheless still large. Using the April active voter counts, however, there are more active voters per voting machine in the precincts that have low proportions African American (189 voters per machine) than in the precincts with high proportions (177 voters per machine), a difference of 6.8 percent.

The allocation of voting machines in Franklin County was clearly biased against voters in precincts with high proportions of African Americans when measured using the standard of the November, 2004, electorate. Measured against the active electorate in April, the machine allocations on average favored voters in precincts with high proportions African American. If we had reason to believe that the "mid-summer" information about the voters in each precinct was similar to the active voter counts in late April, then it might be plausible to argue that Franklin County election officials should be exculpated for the November disparities because the large increase in the active electorate from April to November simply caught them by surprise.

Beyond the fact that we have no reason to believe that the number of active voters in each precinct in "mid-summer" was close to the number on April 27 (new registrants are considered active voters), at least two considerations argue against deciding that the officials should be considered blameless. First, the total number of voting machines was inadequate even when compared to the size of the estimated active electorate in June. To reach an average of 100 voters per machine in the April electorate, the county needed 5,023 working voting machines, not 2,800. The DOJ report states that the county plans to increase the number of voting machines to 5,000 (Tanner 2005, 4). If the size of the active electorate in November, 2004, is used, the number of working machines needed to reach 100 voters per machine is 6,404. It appears that Franklin County election officials are making plans that will again produce shortages of voting machines in future elections.

Second, to say that it was appropriate for Franklin County officials to rely on an assessment of the size of the active electorate made in "mid-summer" would be to say it was appropriate for them to ignore the clear signs during the late summer and fall that the November electorate would

be substantially larger. If nothing else, the surge of applications from new registrants should have been a clear indicator that plans made based on the earlier information would not be sufficient.

Conclusion

The allocation of voting machines in Franklin County was clearly biased against voters in precincts with high proportions of African Americans when measured using the standard of the November, 2004, electorate. In precincts with high proportions of African American voters there were 13.6 percent more active voters per voting machine than in precincts having low proportions of African American voters. While shortages of voting machines caused long delays in voting throughout the county, the allocation of voting machines among the county's precincts affected different voters differently. The most severe effects in terms of reduced voter turnout were incident on voters in precincts that had high proportions of African Americans. The most conservative estimate—based on the reported size of the active electorate in November—is that typically the shortages of machines reduced voter turnout by slightly more than four percent in precincts in which high proportions of the voters were African American, while shortages in precincts where very few voters were African American reduced voter turnout by slightly less than 1.5 percent.

If the allocation of voting machines is compared to information about the size of the active electorate that was available to Franklin County election officials at the end of April, 2004, then the allocation of machines is not biased against voters who were active at that time in precincts having high proportions of African Americans. But if we use the April information to evaluate the allocation plans, then we must note that the plans involved using a total number of machines that was nearly 45 percent too small. Using the April measure of the size of the active electorate, 5,023 working voting machines were needed, not 2,800 machines as data supplied by the county indicate were actually deployed on election day.

Using plans made in "mid-summer" meant that Franklin county officials ignored information during the late summer and fall that should have showed them that the November electorate would be substantially larger. Between April and November, the active voter population in the county increased by more than 15 percent. If nothing else, the surge of new registrants should have indicated that their plans made in mid-summer would prove woefully insufficient.

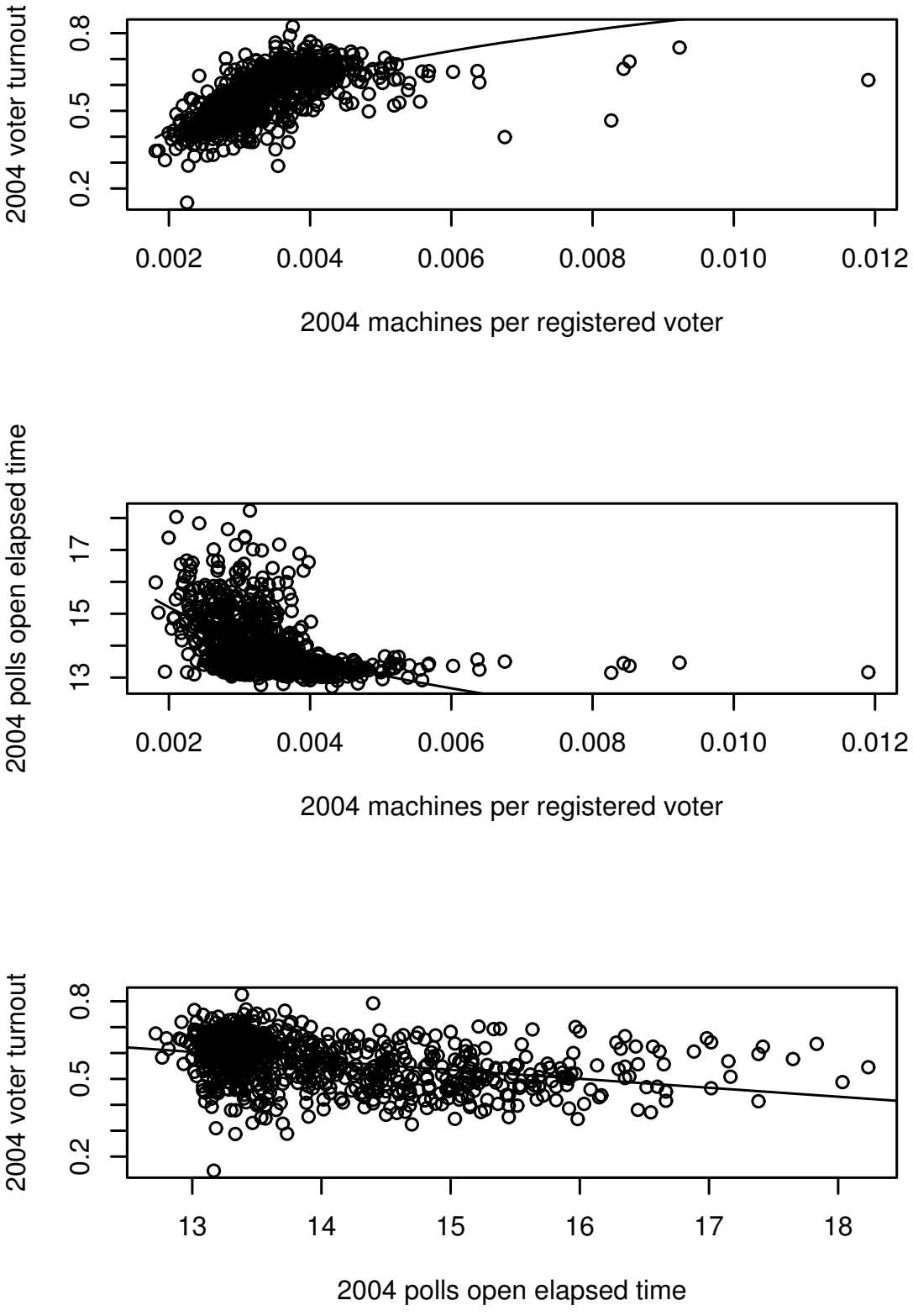

Figure 1: Number of Voting Machines, Turnout and Poll Closing Times in Franklin County

Table 1: Voter Ethnicity and Time of Day Arrived at Polls

	Ethnicity	
Time	White	Afr. Am.
Before 8 a.m.	21	18
8 a.m.–11 a.m.	28	23
11 a.m.–3 p.m.	23	31
3 p.m.–5 p.m.	13	15
After 5 p.m.	14	13

Notes: Each column shows the percentage of voters self-identifying as having the referent ethnicity (question wording: "Could you please tell me your race?") who arrived at the polls to vote during the indicated time interval (question wording: "What time of day did you get to the polls to vote?").

Source: Voter Experience Survey. The sample is a random telephone sample of 1,201 people interviewed throughout Ohio during January 30 through February 2, 2005, "who voted (or went to the polls with the intention of voting) in the 2004 general election" on November 2, 2004 (Feldman and Belcher 2005, 1).

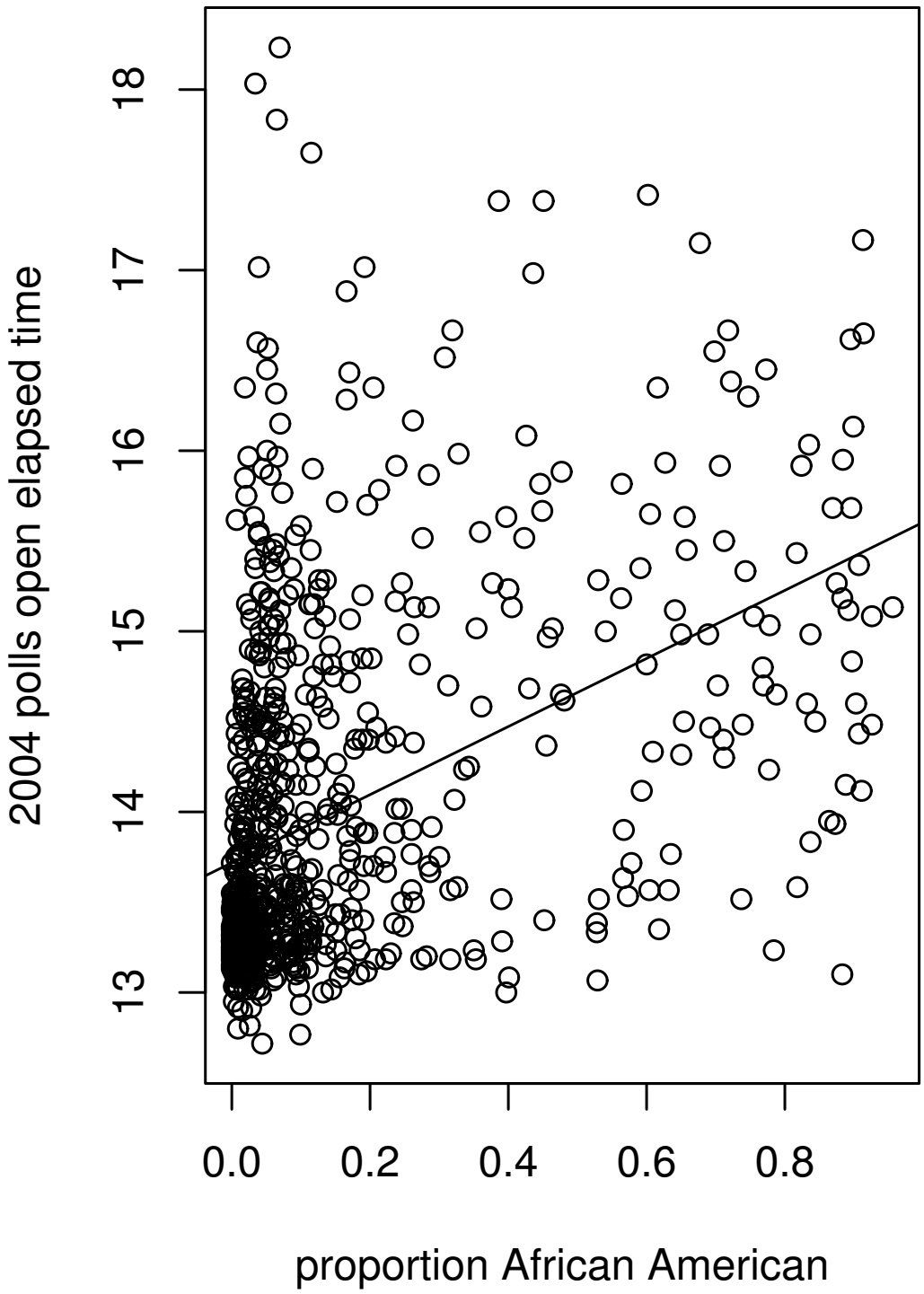

Figure 2: Polls Open Elapsed Time by Proportion African American

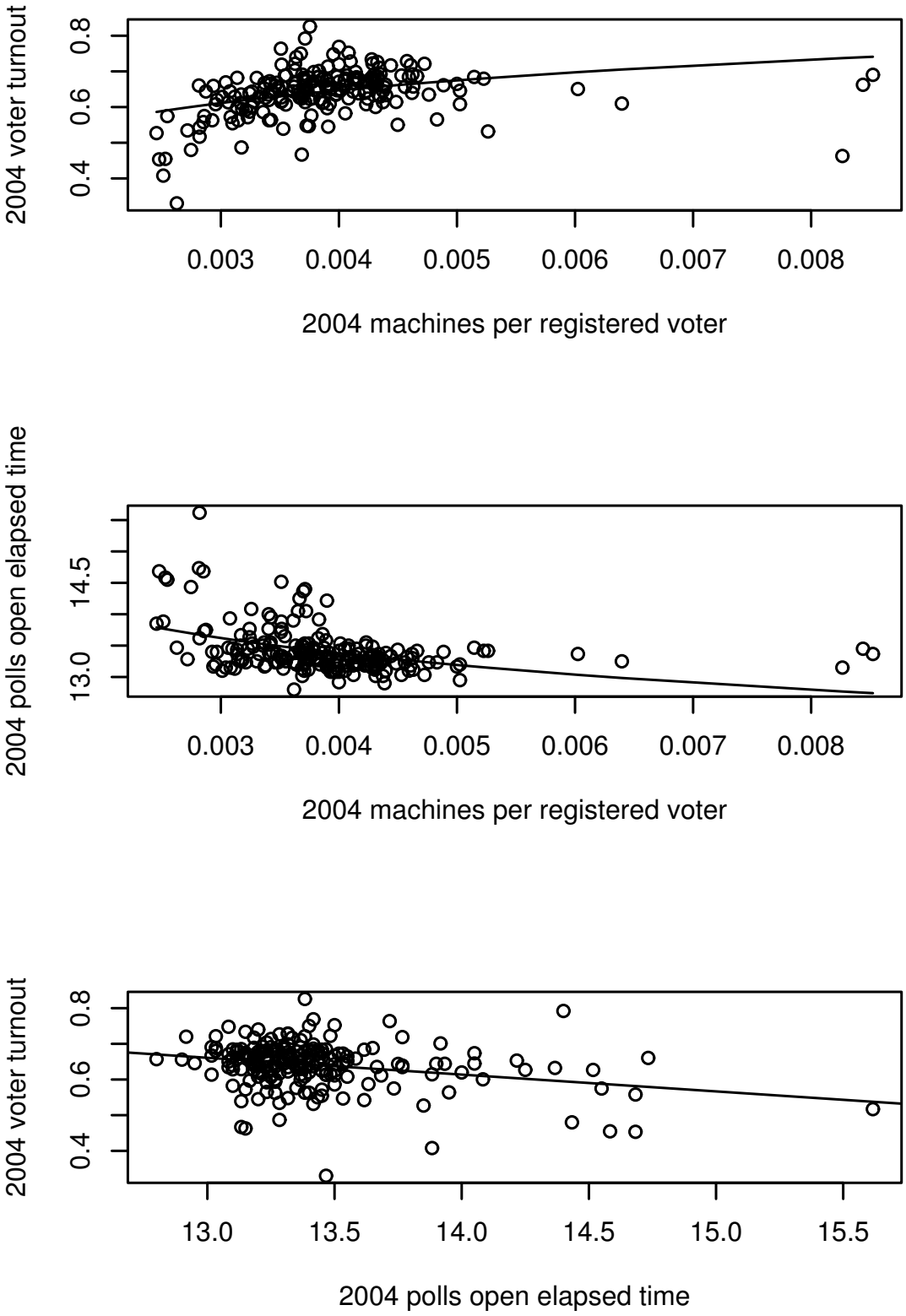

Figure 3: Number of Voting Machines, Turnout and Poll Closing Times in Franklin County: 25 Percent of Precincts with Lowest Proportions African American

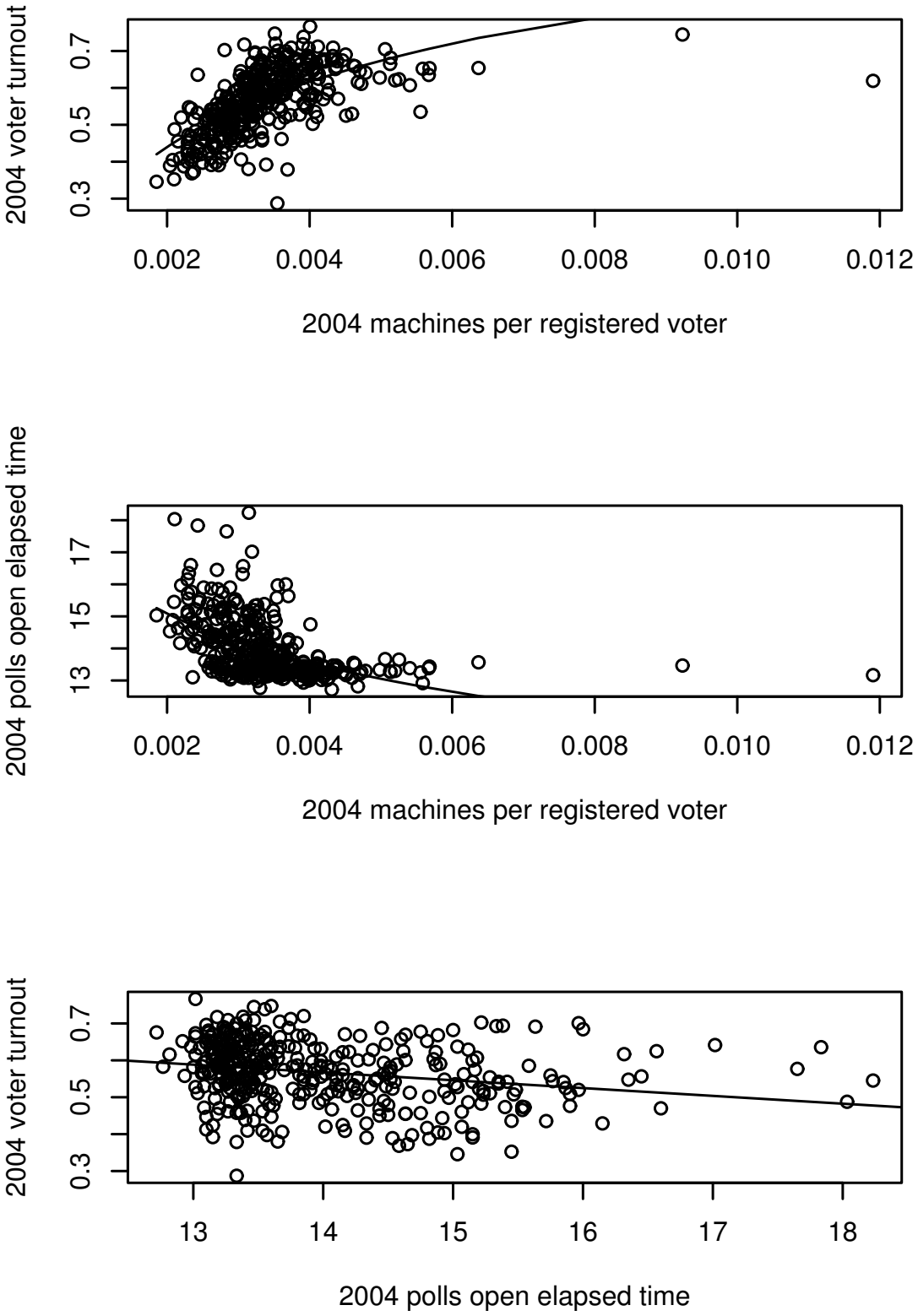

Figure 4: Number of Voting Machines, Turnout and Poll Closing Times in Franklin County: 50 Percent of Precincts with Middle Proportions African American

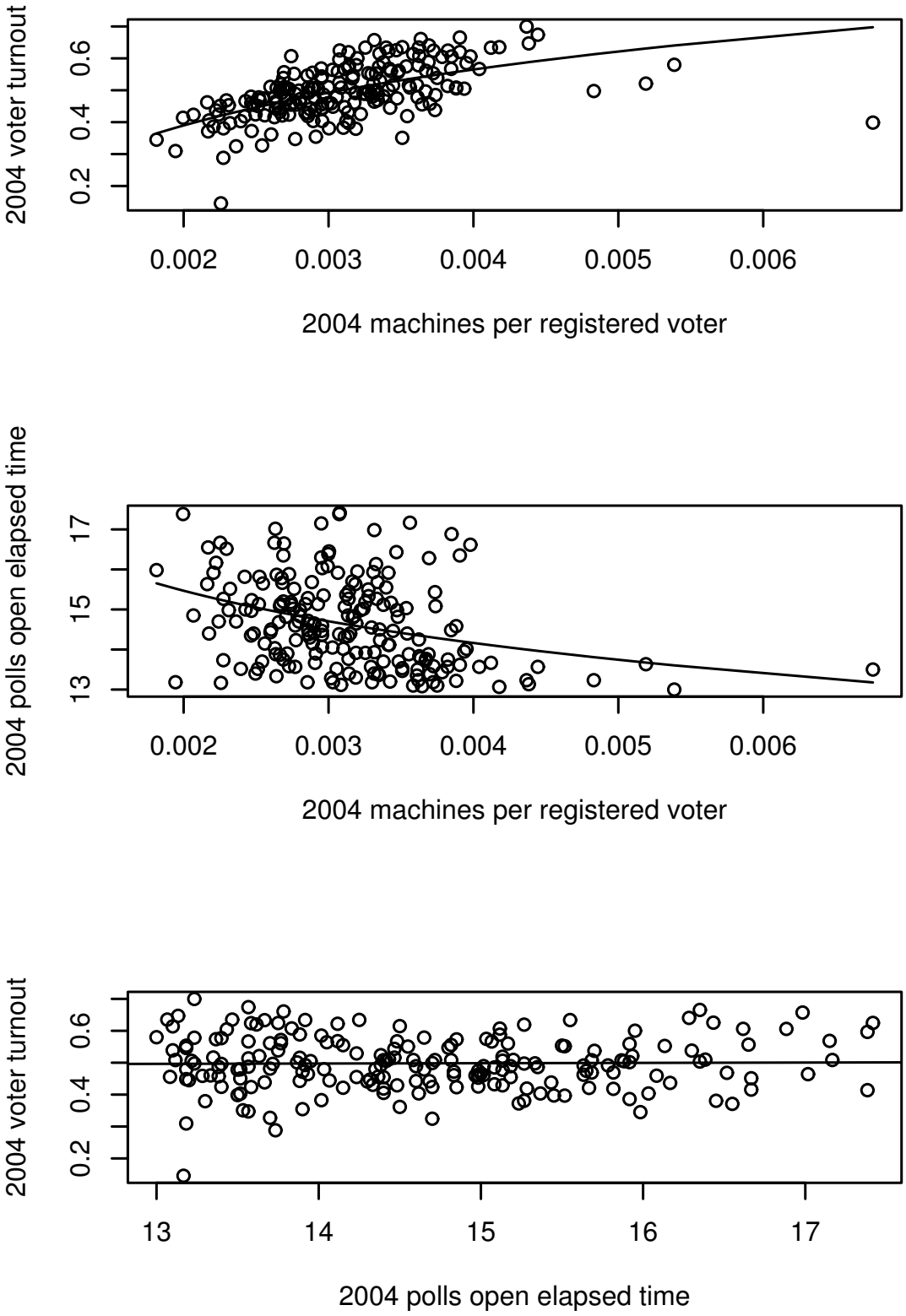

Figure 5: Number of Voting Machines, Turnout and Poll Closing Times in Franklin County: 25 Percent of Precincts with Highest Proportions African American

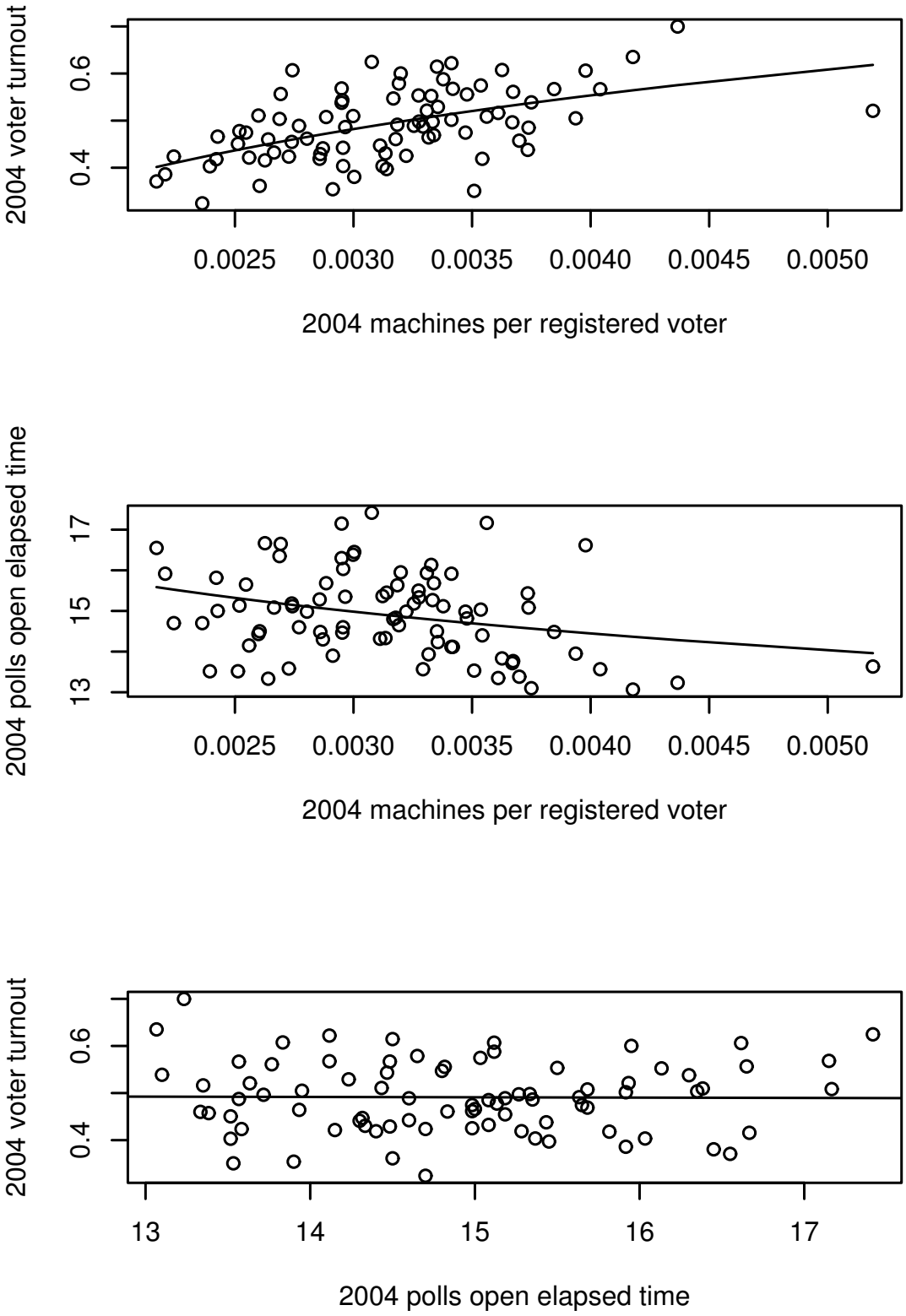

Figure 6: Number of Voting Machines, Turnout and Poll Closing Times in Franklin County: Precincts with More than 50 Percent African American

Table 2: Polls Open Elapsed Time Given Machines per Registered Voter and Proportion African American Regressors

Variable	Coef.	SE	t-ratio
(Intercept)	1.818847	0.053773	33.83
Log(Machines per Registered Voter)	−0.141308	0.009480	−14.90
Proportion African American	0.099189	0.008725	11.37

Notes: Underdispersed Poisson regression model estimates (dispersion estimate is 0.043). Polls open elapsed time is the dependent variable. $n = 787$.

Table 3: Voter Turnout: Polls Open Elapsed Time, Machines per Registered Voter and Proportion African American Regressors

Variable	Coef.	SE	t-ratio
(Intercept)	6.8400	0.4780	14.300
Polls Open Elapsed Time	0.0817	0.0148	5.510
Log(Machines per Registered Voter)	1.3600	0.0851	16.000
Low Proportion African American Dummy	−1.1200	0.8870	−1.260
Low AA Dummy × Polls Open Elapsed Time	−0.1860	0.0485	−3.830
Low AA Dummy × Log(Machines per Registered Voter)	−0.6930	0.1450	−4.800
Medium Proportion African American Dummy	1.0800	0.6040	1.790
Medium AA Dummy × Polls Open Elapsed Time	−0.0101	0.0207	−0.489
Medium AA Dummy × Log(Machines per Registered Voter)	0.1460	0.1140	1.280
Proportion African American	−0.3410	0.0632	−5.390

Notes: Robust ($\tanh$) overdispersed binomial regression estimates. For each precinct, the dependent variable counts the number of registered voters voting versus the number of registered voters not voting. LQD $\sigma = 3.73$; $\tanh\ \sigma = 3.40$; $n = 787$; 2 outliers.

Outliers

Code	Precinct	Precinct Name	SRes
01059E	COLS 59-E	Columbus City Fifty-Ninth Ward Precinct E	−4.69
06000E	FRANKLIN-E	Franklin Township Franklin E	−3.96

	Expected Voter Turnout at Quartiles of the					
	Machine Ratio			Polls Open Time		
Proportion African American	25%	50%	75%	25%	50%	75%
Low	0.635	0.650	0.666	0.653	0.650	0.646
Medium	0.516	0.565	0.608	0.560	0.565	0.581
High	0.460	0.506	0.546	0.490	0.506	0.524

Notes: Each expected turnout value for the machine ratio quartiles is computed using the coefficient parameter estimates reported in the top part of this table and, for each subset of precincts, the quartiles of the machines per registered voter ratio, the median polls open elapsed time and the median proportion African American in the referent subset. The values for the polls open time quartiles are computed using the quartiles of the polls open elapsed time, the median machines per registered voter ratio and the median proportion African American in the referent subset.

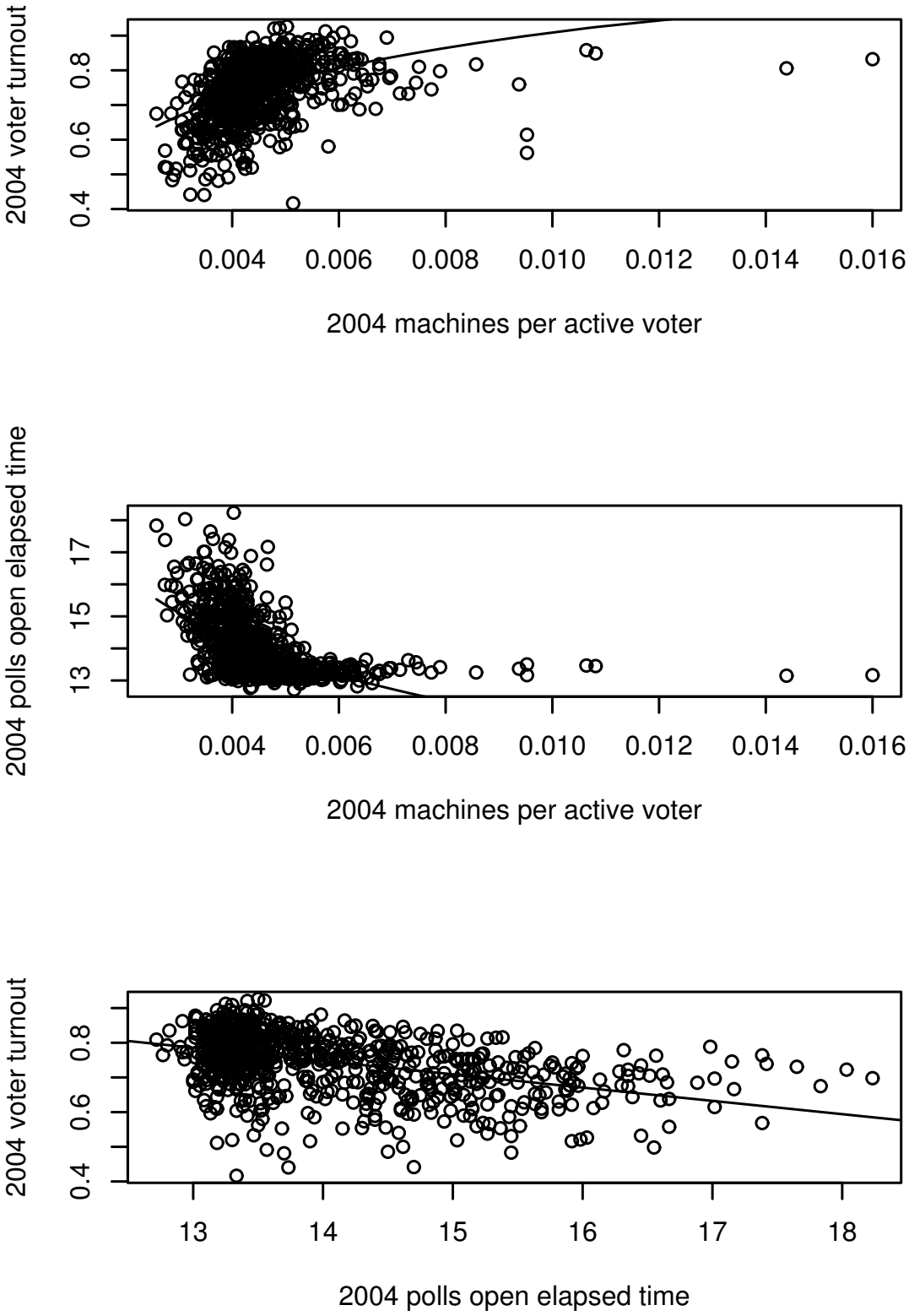

Figure 7: Number of Voting Machines, Turnout among Active Voters and Poll Closing Times in Franklin County

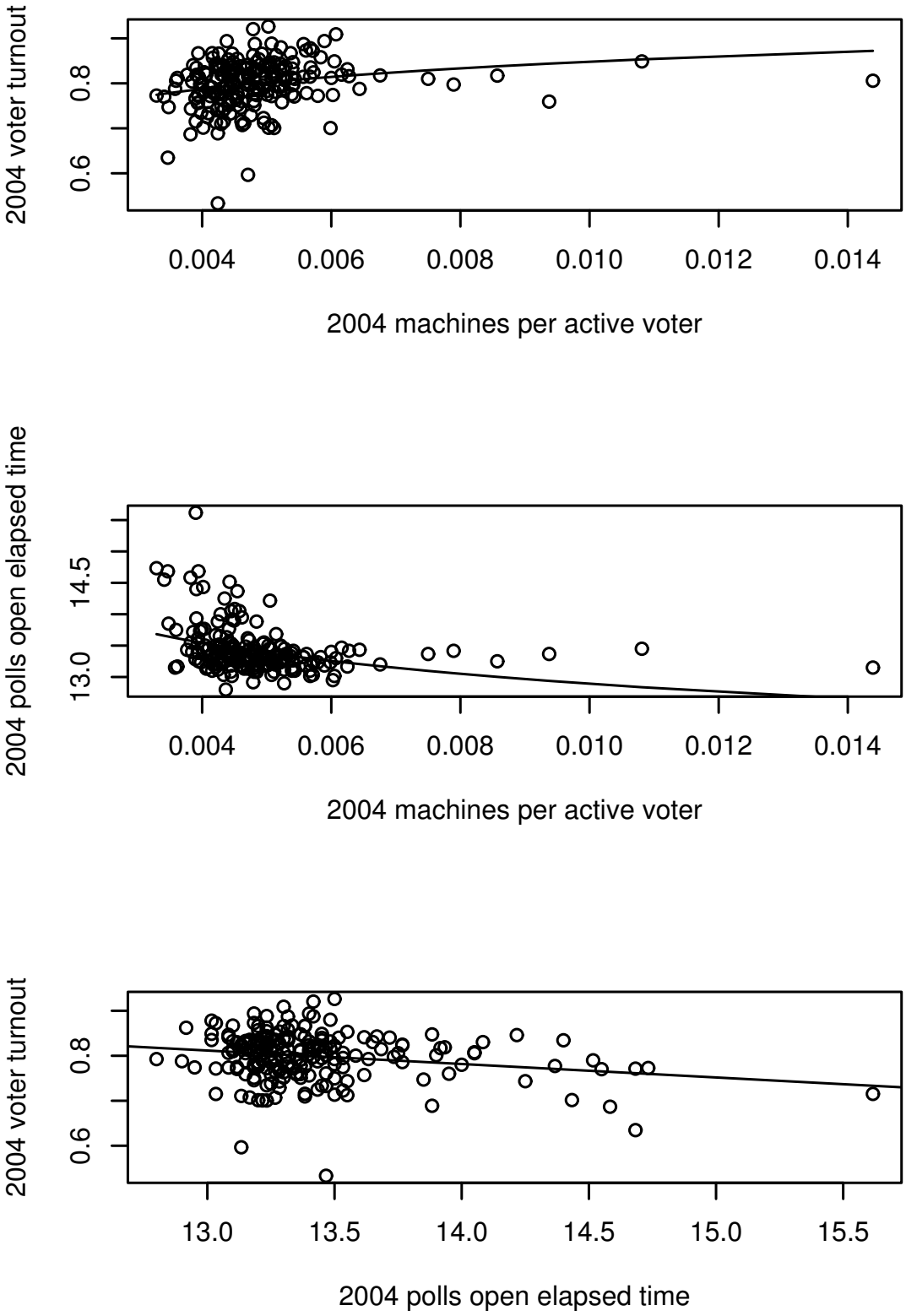

Figure 8: Number of Voting Machines, Turnout among Active Voters and Poll Closing Times in Franklin County: 25 Percent of Precincts with Lowest Proportions African American

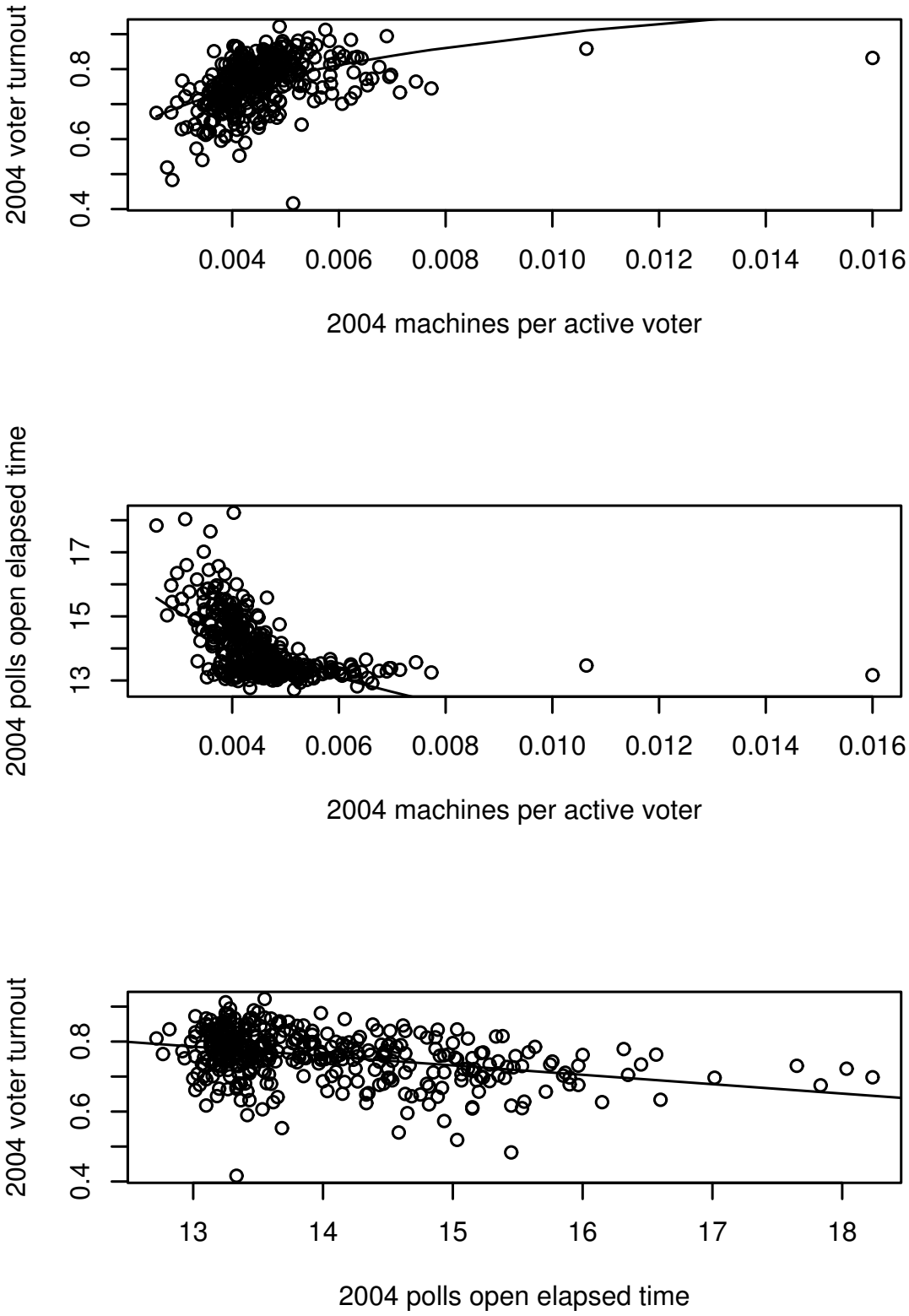

Figure 9: Number of Voting Machines, Turnout among Active Voters and Poll Closing Times in Franklin County: 50 Percent of Precincts with Middle Proportions African American

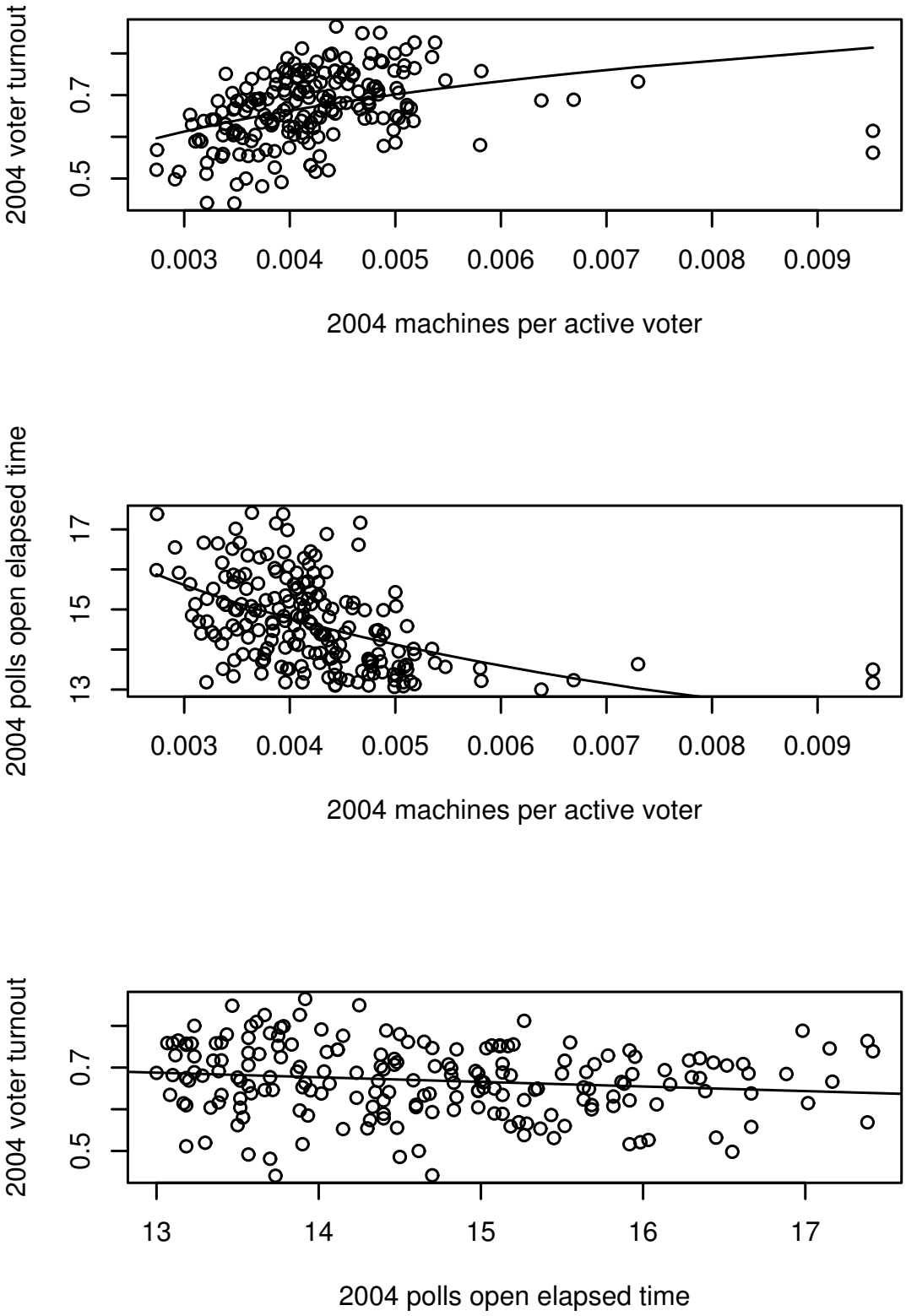

Figure 10: Number of Voting Machines, Turnout among Active Voters and Poll Closing Times in Franklin County: 25 Percent of Precincts with Highest Proportions African American

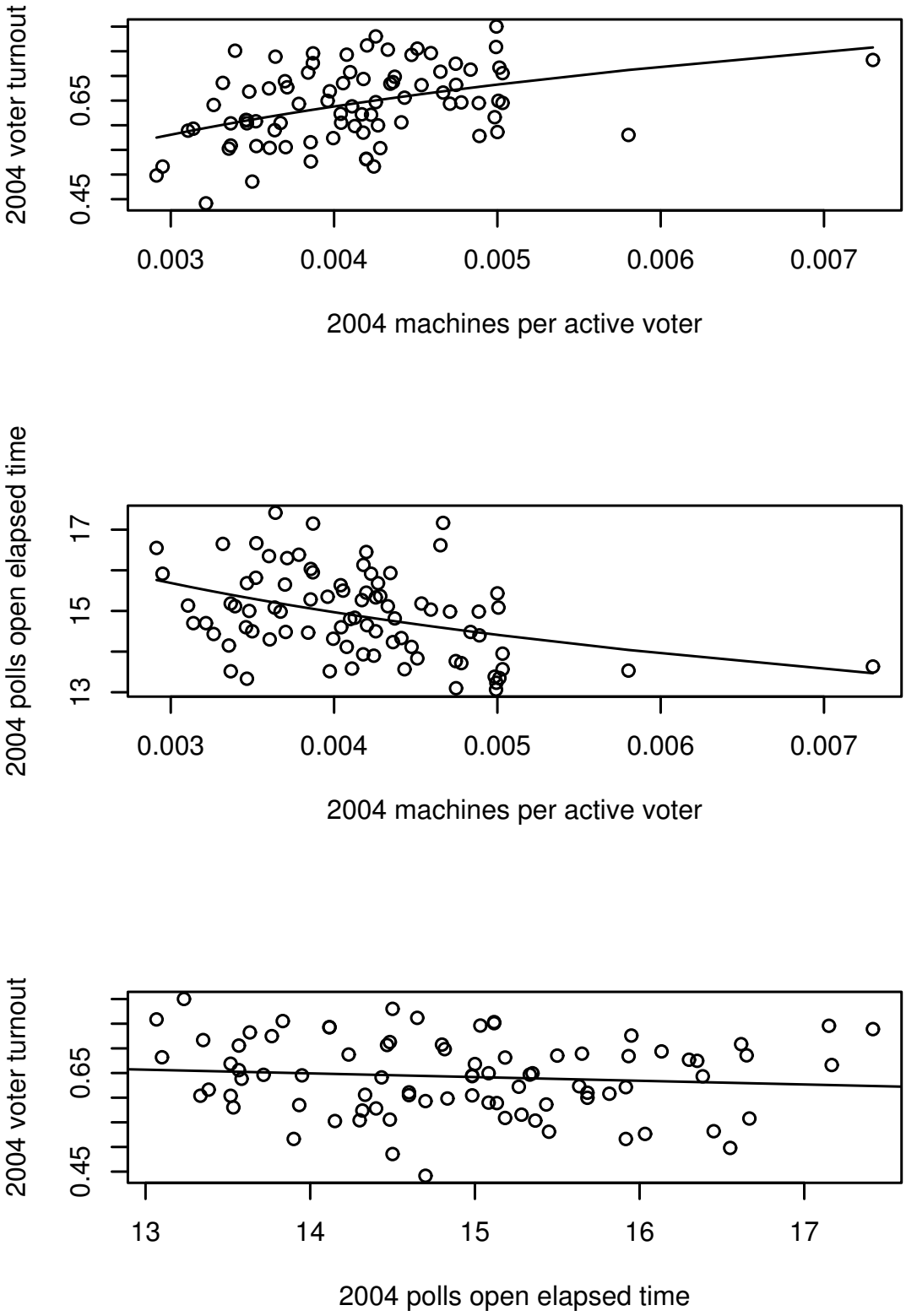

Figure 11: Number of Voting Machines, Turnout among Active Voters and Poll Closing Times in Franklin County: Precincts with More than 50 Percent African American

Table 4: Polls Open Elapsed Time Given Machines per Active Voter and Proportion African American Regressors

Variable	Coef.	SE	t-ratio
(Intercept)	1.670601	0.057828	28.89
Log(Machines per Active Voter)	−0.176063	0.010720	−16.42
Proportion African American	0.096276	0.008495	11.33

Notes: Underdispersed Poisson regression model estimates (dispersion estimate is 0.041). Polls open elapsed time is the dependent variable. $n = 787$.

Table 5: Voter Turnout among Active Voters: Polls Open Elapsed Time, Machines per Active Voter and Proportion African American Regressors

Variable	Coef.	SE	t-ratio
(Intercept)	7.0000	0.7360	9.510
Polls Open Elapsed Time	0.0424	0.0215	1.970
Log(Machines per Active Voter)	1.2100	0.1500	8.070
Low Proportion African American Dummy	−1.7400	1.1100	−1.570
Low AA Dummy × Polls Open Elapsed Time	−0.1650	0.0563	−2.930
Low AA Dummy × Log(Machines per Active Voter)	−0.7970	0.2000	−3.980
Medium Proportion African American Dummy	0.2570	0.9530	0.270
Medium AA Dummy × Polls Open Elapsed Time	−0.0736	0.0282	−2.610
Medium AA Dummy × Log(Machines per Active Voter)	−0.1750	0.2030	−0.863
Proportion African American	−0.5390	0.0764	−7.050

Notes: Robust ($\tanh$) overdispersed binomial regression estimates. For each precinct, the dependent variable counts the number of active voters voting versus the number of active voters not voting. LQD $\sigma = 3.61$; $\tanh\ \sigma = 3.44$; $n = 787$; 4 outliers.

Outliers

Code	Precinct	Precinct Name	SRes
01009A	COLS 09-A	Columbus City Ninth Ward Precinct A	−4.77
01009B	COLS 09-B	Columbus City Ninth Ward Precinct B	−4.22
01010B	COLS 10-B	Columbus City Tenth Ward Precinct B	−5.02
01059E	COLS 59-E	Columbus City Fifty-Ninth Ward Precinct E	−4.73

	Expected Voter Turnout at Quartiles of the					
	Machine Ratio			Polls Open Time		
Proportion African American	25%	50%	75%	25%	50%	75%
Low	0.798	0.804	0.809	0.806	0.804	0.802
Medium	0.750	0.768	0.785	0.770	0.768	0.763
High	0.652	0.682	0.709	0.674	0.682	0.690

Notes: Each expected turnout value for the machine ratio quartiles is computed using the coefficient parameter estimates reported in the top part of this table and, for each subset of precincts, the quartiles of the machines per active voter ratio, the median polls open elapsed time and the median proportion African American in the referent subset. The values for the polls open time quartiles are computed using the quartiles of the polls open elapsed time, the median machines per active voter ratio and the median proportion African American in the referent subset.

Table 6: Voting Machine Allocations by Precinct Racial Composition

	Counts per Voting Machine				
Precinct Racial Composition	Registered Voters	Ballots Cast	Ballots Cast per Hour	Active Voters November	Active Voters April
Low Proportion African American	262	170	13	213	189
Medium Proportion African American	305	173	12	226	180
High Proportion African American	324	164	11	242	177

Notes: Each entry is the median value of the referent ratio in the referent subset of Franklin County precincts. “Ballots cast” refers to the official count of the number of ballots cast.

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