More Evidence on the Effects of Voting Technology on Election Outcomes

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Abstract

We present new empirical evidence on the relationship between voting technology and election outcomes. First, using data on nine elections in the Netherlands, we distinguish between the introductory and the more permanent effects of electronic voting. Second, we distinguish between national and municipal elections, which have different incentives to fraud given the Dutch system of proportional representation. Third, we test for a possible asymmetry between the effect of moving from paper ballots to electronic voting, and the effect of reverting to paper ballots. Fourth, we control for the density of polling stations. This is crucial as the introduction of voting machines usually goes along with a reduction in the number of polling stations. Using two different data sources – municipality-level data on actual voting behavior and a panel survey among eligible voters – we find small positive effects of electronic voting on voter turnout, a substantial negative effect on the fraction of residual votes, and no effect on the share of left wing parties.

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1. Introduction

After having served democracies for decades, the paper ballot is being replaced by technologically more advanced ways of casting a vote in many countries. But the trend toward voting by touching a screen, pushing a button, or clicking a mouse is not uncontroversial. Problems regarding electronic voting have been reported for Belgium, Brasil, Estonia, France, Germany, India, Ireland, the Netherlands, United Kingdom, United States, Switzerland, and other countries; see *New York Times* (2007) for a recent example. While vulnerability to fraud is a central concern, electronic voting has also been criticized for not sufficiently protecting the legal right to cast a vote confidentially. Shortly before the Dutch parliamentary elections in November 2006, it was found that votes cast with voting machines of a specific make could be traced from a distance with specialized equipment. As a response, a number of municipalities, including Amsterdam, decided to revert to paper ballots for casting votes.

These events stress the need for insight into the possible effects of voting technologies on election outcomes. The most notable paper that measures these potential impacts is Card and Moretti (2007) (CM from hereon), who analyze the effects of touch-screen voting using data on the 2000 and 2004 US presidential elections. CM conclude that this has had a negative effect on voter turnout, and a small but statistically significant positive effect on electoral support for George Bush. Because the effect was not larger in swing states, or in states with a Republican Secretary of State, the authors conclude that it was probably not the result of irregularities or fraud.

The present paper supplements previous work in a number of ways. First, by considering a sequence of nine different Dutch elections during the period 1994-2006, we can distinguish between the impact of the introduction of electronic voting and its more permanent impact. Since the introduction of electronic voting usually goes along with informational campaigns and extra media attention, these two effects are likely to be different. Second, we distinguish between national and municipal elections. The distinction is of interest since in a system of proportional representation (as is the case in the Netherlands) incentives to fraud are larger in municipal elections than in elections for the national Parliament. Thus, if we would find that the effect of electronic voting is larger in municipal elections than in national

elections, this might be interpreted as an indication of irregularities. Third, while previous empirical results exclusively relied on one-time changes from paper ballots to electronic voting, our data also includes a number of reverse changes as a result of the November 2006 events. This additional variation helps to address earlier criticism that a significant effect of electronic voting technology might merely pickup county (or municipality) specific trends. Fourth, as voting machines are expensive, their introduction usually goes along with a reduction in the number of polling stations. Since this increases individuals' average distance to a polling station – and hence costs of voting - the polling station density is crucial to control for in establishing the causal impact of electronic voting on elections outcomes, in particular voter turnout.

Using two different data sources – municipality-level data on actual voting behavior and a panel survey among eligible voters – we estimate the effects of voting technology on voter turnout, the share of left wing parties, and the share of residual votes. We find a small positive effect of electronic voting on voter turnout, in particular when used for the first time, and a strong negative effect on the share of residual votes. We do not find an effect on the share of left wing parties, neither in municipal, nor in national elections.

2. Voting technology in the Netherlands and data

In the Netherlands, municipalities are responsible for organizing both the municipal and national elections, and decide on what voting technology to use. In the past two decades, virtually all municipalities replaced paper ballots by electronic voting machines. There are two competing firms that provide the electronic voting machines, with one of them (*Nedap)* having by far the largest market share. Election dates are uniform in all municipalities, with the exception of local elections in merged municipalities, which we exclude from our study. Other election regulations are uniform across the country.

We collected data on voting technology by contacting all individual municipalities. For some municipalities we failed to establish exactly when electronic voting equipment was introduced, as local officials find it more difficult to provide this information the farther this moment lies back in history. We therefore decided to focus on the municipal council elections in 1994, 1998, 2002, and 2006, and the

national elections (for parliament) in 1994, 1998, 2002, 2003, and 2006. Data on election outcomes and on demographic control variables were obtained from Statistics Netherlands.[1] Another complication is the ongoing process of municipal mergers. We constructed a panel dataset of all 319 municipalities that existed in the same form during the period 1994-2006. This leaves us with a sample of that covers about two thirds of eligible voters.[2] As mentioned, a small number of municipalities reverted to paper and pencil ballots just prior to the November 2006 national elections. See table 1 for details.

As a robustness check, we also analyze data on self-reported voting behavior from a survey among 1632 eligible voters.[3] For both the 2003 and the 2006 national elections, respondents were asked whether they voted and, if so, for which party. In the survey, the fraction of respondents reporting to have voted is higher than the actual observed turnout (0.93 versus 0.80, both numbers averaged over 2003 and 2006), possibly because of respondents' tendency to give socially desirable answers. However, this bias is unlikely to be related to voting technology. The shares of left wing votes in both data sources are closer to each other (0.49 versus 0.45). Zip code information in the survey identifies a respondent's municipality and hence the corresponding voting technology in both years.

3. Empirical analysis

An important issue in our analysis is what predicts the use of electronic voting.[4] Table 2 investigates how electronic voting is related to time varying municipality characteristics, year dummies, and previous elections outcomes. In municipal as well as national elections the year dummies are large and significant, and dominate the explanation of electronic voting. Moreover, as shown in the second and fourth column, the use of electronic voting is unrelated to the outcomes of the

[1] Data on the number of polling stations per municipality previous to 2006 are from Statistics Netherlands. For 2006, we collected these data ourselves.
[2] Our sample for municipal elections is smaller for two reasons. First, municipalities that were about to merge in 2007 did not hold local elections in 2006. Second, municipalities that were merged in 1993 did not hold local elections in 1994.
[3] The data are from the CentERpanel, a representative sample of the Dutch population, except the institutionalized; see www.centerdata.nl.
[4] Ideally, we would like to instrument electronic voting, but suitable instruments are unavailable. The cost of voting machines, a potential instrument, does not vary across municipalities.

previous election. In sum, table 2 strongly suggests that the introduction of electronic voting has been a largely autonomous process. Note that virtually all municipalities introduced electronic voting, but at different points in time.

Using the municipality data on actual voting behavior, we estimate separate linear probability models for three types of election outcomes: voter turnout, the share of left wing parties, and the share of residual (including blank) votes.

We use three types of explanatory variables. First, we control for variables describing the voting technology that was used (dummies for electronic voting, for first-time electronic voting, and for reversal to paper ballots). The inclusion of the first-time electronic voting dummy allows us to assess whether the effects of electronic voting technology are temporary or permanent. For example, some people might find new technology confusing and therefore not vote, but such an effect could disappear as soon as once-new technology has become familiar. By the same token, the *introductio*n of electronic voting machines is typically accompanied by extra publicity (as the municipality informs voters how to use the new equipment). We also include a number of variables related to the (time) costs of voting: a dummy for whether voters were allowed to vote at the poling station of their own choice (a new option introduced in the November 2006 elections by about half of the municipalities), and the number of polling stations per 1000 eligible voters. We include the latter variable since municipalities appear to substantially reduce the number of polling stations upon introduction of electronic voting machines in order to save costs. A lower number of polling stations not only increases the average travel costs of voting, but may also result in longer lines at the remaining stations. For the present data set, the coefficient in a regression of the number of polling stations per 1000 inhabitants on a dummy for electronic voting dummy (controlling for municipality fixed effects and year dummies) is -0.114 (*t*-value –15.0), implying a strong and highly significant reduction in the average number of polling stations by 11 percent. Given this strong correlation, failure to control for the number of polling stations will induce a downward bias in the effect of electronic voting.[5] Second, we control for time-varying demographic indicators (fraction of women, aged 18-30, aged 65+, divorced, single, and the number of inhabitants per square kilometer).

[5] There are several reports of precincts not being allocated enough voting machines during the 2004 Presidential election in the United States; see for example http://copperas.com/machinery. CM do not control for voting machine density.

Finally, we include municipality specific fixed effects (Hausman tests strongly reject the random effects specification in all cases) and year dummies.

Like CM, we estimate by weighted least squares. We use the number of eligible voters in each municipality in 1998 as weights. Estimating a linear probability model on the basis of aggregate data complicates the calculation and interpretation of standard errors. The error term in the linear probability model at the individual level has variance $p_i(1-p_i)$, where p_i is individual i's probability to vote (or another outcome). The error term in the model at the municipality level has variance $(1/n^2)\Sigma_i p_i(1-p_i)$, where n is the number of eligible voters. Thus the appropriate weighting factor would be $n/\sqrt{\Sigma_i p_i(1-p_i)}$ rather than n, and using n as an approximation introduces heterogeneity in the aggregate error terms. Also, in the present setting, standard errors within municipalities are likely to exhibit autocorrelation; cf. Bertrand *et al*. (2004). We therefore report robust standard errors clustered by municipality, which are typically larger than uncorrected standard errors.

4. Results

Electronic voting has a small positive effect on voter turnout in municipal elections, but no significant effect in national elections; see table 3. In municipal elections, about two thirds of the effect is permanent. The introductory effect in national elections is significant, but this is based on only a very small number of first-time electronic voting cases — most municipalities that introduced electronic voting did so at a municipal election; cf. table 1. The omission of the number of polling stations induces a downward bias in the effects coefficient for electronic voting, as expected. The result suggests that the significant negative effect of touch-screen voting on turnout, especially for Hispanics, reported by CM might be partly due to not controlling for touch-screen voting machine density. Thus, in addition to the possible interpretations suggested by CM (intimidation, distrust, limited English proficiency), lower turnout for Hispanics might be related to higher voting costs and a more limited access to transportation.

Voting technology might also influence the shares of the competing political parties, for example if extra voters lured to the polls by voting machines tend to vote for right-wing parties. We investigate this possibility by looking at the share of left-

wing parties; see table 4. While the coefficients suggest that the left wing share drops when electronic voting machines are used, the effects are statistically insignificant.

Residual votes are votes cast but not attributed to one of the candidates. A residual vote can be due to an error, or to an intentionally invalid or blank vote. Blank votes are sometimes used as protest against "politics" in general. When paper ballots are used, voters can fail to tick one box clearly. When electronic voting equipment is used, it is still possible to cast a blank vote, by pushing the appropriate button. However, errors on behalf of the voter leading to a residual vote are virtually impossible.

We find that electronic voting indeed lowers the proportion of residual votes; see table 5. In municipal elections the effect is particularly strong and fully related to electronic voting itself, not its introduction. The inclusion of turnout does not affect the voting equipment coefficients in a significant way.

Our data allow to test for a possible asymmetry between the effect of moving from paper ballots to electronic voting and the effect of a reverse change (as in 24 municipalities just prior to the 2006 national election). We cannot reject the hypothesis that the effects are symmetric.[6]

The analysis based on the survey among eligible voters leads to similar conclusions. In all models (linear probability models and logit models with individual specific fixed effects, for having voted and for having voted left wing) we found some significant effects for variables related to voting costs (in particular a strong positive effect of the option to vote at the polling station of own choice on the voting probability), but no significant effects for the voting technology variables.

5. Conclusion

We find that electronic voting has a small positive effect on voter turnout, in particular when used for the first time. While there is a large negative impact on the number of residual votes, we do not find an effect on the share of left wing parties,

[6] We included a dummy for the reverse change, and tested whether its coefficient is the negative of the coefficient on electronic voting. In all cases *p*-values exceeded 0.1. The power of the test is limited, given the small number of reverse changes in the data. However, while the fraction of municipalities that reverted to paper ballots is 3 percent, the change applied to 9 percent of the voters.

neither in municipal, nor in national elections. Our results therefore do not provide indications of voting irregularities related to voting equipment. Also, we do not find any evidence of an asymmetry between the effects of introducing and abandoning electronic voting. Omission of the number of polling stations (which typically decreases upon the introduction of electronic voting) biases the coefficient on electronic voting downwards. This may help to explain the discrepancy between our results and those reported by CM with regard to the effect on voter turnout.

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Table 1. Voting technology

	Municipal elections (288 municipalities)				National elections (319 municipalities)				
	1994	1998	2002	2006	1994	1998	2002	2003	2006
fraction electronic voting	0.361	0.722	0.917	0.962	0.373	0.734	0.922	0.937	0.937
fraction first time electronic voting	0.188	0.354	0.184	0.017	0	0	0	0.016	0.031
fraction reverted to paper ballot	–	–	–	–	–	–	–	–	0.034
number of polling stations per 1000 eligible voters	0.897	0.832	0.804	0.774	0.907	0.841	0.810	0.804	0.781
fraction allowing to vote at polling station of choice	–	–	–	–	–	–	–	–	0.512

Table 2. The use of voting machines [a]

	Municipal elections			National elections	
Year 1998	0.405 (2.8)	–		0.290 (3.7)	–
Year 2002	0.696 (2.8)	0.298 (1.8)		0.521 (3.4)	0.261 (2.5)
Year 2003	–	–		0.535 (3.2)	0.105 (0.9)
Year 2006	0.859 (2.3)	0.456 (1.3)		0.542 (2.8)	0.101 (0.6)
Number of inhabitants (100,000s)	−0.878 (−1.7)	0.218 (0.3)		−1.36 (−3.3)	−0.743 (−2.5)
Population density (1000s per square kilometer).	0.252 (2.4)	0.269 (2.7)		0.115 (1.3)	0.064 (0.8)
Fraction of women	19.70 (1.8)	9.56 (0.7)		7.48 (0.8)	−2.28 (−0.3)
Fraction aged 18-30	−1.20 (−0.4)	−1.59 (−0.4)		0.697 (0.2)	0.726 (0.2)
Fraction aged 65 or over	−1.40 (−0.4)	0.34 (0.1)		0.661 (0.2)	−3.33 (−0.9)
Fraction unmarried	2.02 (0.4)	5.00 (0.6)		1.87 (0.4)	2.09 (0.4)
Fraction divorced	−24.6 (−1.4)	−24.6 (−1.2)		−3.68 (−0.5)	5.13 (0.6)
Voter turnout at previous election	–	0.017 (1.5)		–	0.023 (1.5)
Share of (national) left wing parties at previous election	–	0.008 (1.7)		–	−0.002 (−0.6)
Residual vote share at previous election	–	−0.125 (−1.3)		–	−0.083 (−1.6)
Number of observations	1152	864		1582	1269

[a] Dependent variable: electronic voting (dummy variable). National elections: 319 municipalities; 1994, 1998, 2002, 2003, and 2006 elections; municipal elections: 288 municipalities; 1994, 1998, 2002, and 2006 elections. Fixed-effect panel weighted least squares estimation, using the number of eligible voters in 1998 as weights. Clustered *t*-values in parentheses. All estimations include municipality fixed effects.

Table 3. Voting technology and voter turnout [a]

	Municipal elections			National elections		
	(1)	(2)	(3)	(4)	(5)	(6)
Electronic voting	1.45 (1.7)	1.96 (2.5)	1.50 (2.1)	−0.17 (−1.0)	−0.23 (−1.3)	−0.43 (−2.2)
First time electronic voting	0.52 (1.7)	–	–	1.44 (3.6)	–	–
Number of polling stations per 1,000 eligible voters	5.23 (3.0)	5.48 (3.1)	–	2.28 (3.8)	2.29 (3.8)	–

[a] Dependent variable: voter turnout, defined as all votes cast divided by number of eligible voters. Fixed-effect panel weighted least squares estimation, using the number of eligible voters in 1998 as weights; *t*-values in parentheses, based on standard errors clustered by municipality. All estimations include municipality fixed effects, year dummies, and other controls (see text).

Table 4. Voting technology and share of (national) left wing parties [a]

	Municipal elections		National elections	
	(1)	(2)	(3)	(4)
Electronic voting	−0.52	−0.21	−1.00	−0.99
	(−0.4)	(−0.2)	(−1.6)	(−1.6)
Technology change	0.59	0.71	−0.70	−0.74
	(0.9)	(1.1)	(−0.9)	(−0.9)
Number of polling stations per 1,000 eligible voters	0.37	1.50	−0.99	−1.10
	(0.1)	(0.5)	(−0.7)	(−0.8)
Voter turnout	–	−0.22	–	0.03
		(−1.6)		(0.6)

[a] Dependent variable: share of votes cast for left wing parties (SP, GL, PvdA and D66). Fixed-effect panel weighted least squares estimation, using the number of eligible voters in 1998 as weights; *t*-values in parentheses, based on standard errors clustered by municipality. All estimations include municipality fixed effects, year dummies, and other controls (see text).

Table 5. Voting technology and proportion of residual votes[a]

	Municipal elections		National elections	
	(1)	(2)	(3)	(4)
Electronic voting	−0.45 (−4.2)	−0.53 (−3.6)	−0.13 (−6.3)	−0.13 (−6.3)
Technology change	0.03 (0.8)	0.00 (0.1)	0.04 (2.2)	0.05 (2.3)
Number of polling stations per 1,000 eligible voters	0.13 (0.7)	−0.14 (−0.5)	0.12 (2.1)	0.13 (2.3)
Voter turnout	−0.05 (−5.1)	–	0.004 (1.6)	–

[a] Dependent variable: percentage share of residual votes in total votes cast. Four municipalities with an implausibly high proportion of residual votes in 1994 were excluded. Fixed-effect panel weighted least squares estimation, using the number of eligible voters in 1998 as weights; *t*-values in parentheses, based on standard errors clustered by municipality. All estimations include municipality fixed effects, year dummies, and other controls (see text).

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