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FRAUD, CONVENIENCE, AND E-VOTING: HOW VOTING EXPERIENCE SHAPES OPINIONS ABOUT VOTING TECHNOLOGY

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Fraud, Convenience, and e-voting: How Voting Experience Shapes Opinions About Voting Technology

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Abstract

In this article we study previous experiences with voting technologies, support for e-voting, and perceptions of voter fraud, using data from the 2015 Cooperative Congressional Election Study. We find that voters prefer systems they have used in the past, and that priming voters with voting fraud considerations causes them to support lower-tech alternatives to touch-screen voting machines — particularly among voters with previous experience using e-voting technogies to cast their votes. Our results suggest that as policy makers consider the adoption of new voting systems in their states and counties, they would be well-served to pay close attention to how the case for new voting technology is framed.

1 Introduction

A recurring election-related theme in recent years concerns voters' lagging confidence in the integrity of the electoral process (Alvarez, Hall, and Llewellyn, 2008; Atkeson, Alvarez, and Hall, 2015; Caltech/MIT VTP, 2016). Despite efforts by the federal government and local election administrators to improve the accuracy and reliability of election procedures — prominent among which has been the replacement, in many states, of outdated voting equipment by e-voting technologies (Alvarez and Grofman, 2014; Stewart, 2011) — voters remain fairly skeptical that votes throughout the nation are counted as intended (Stewart, Ansolabehere, and Persily, 2016). Studies conducted in the last decade in the United States and abroad suggest that voting experiences play a key role in shaping voter confidence in the electoral process (Alvarez, Hall, and Llewellyn, 2008; Alvarez et al., 2009, 2013; Atkeson and Saunders, 2007; Herrnson et al., 2008; Claassen et al., 2013). Chief among these experiences are voters' interactions with voting systems, as well as their exposure to partisan rhetoric and media stories that paint a distorted picture of the possibility of electoral malfeasance (Bowler and Donovan, 2016; Wilson and Brewer, 2013).

One critical question that emerges from these observations is whether concerns about decreased voter confidence will lead to further adoption of electronic voting technologies, or to a push for the use of paper ballots. In this article, we investigate this question using observational and experimental data from the 2015 Cooperative Congressional Election Study (Ansolabehere and Schaffner, 2017), focusing on support for using electronic technologies to cast votes. First, we use these data to test whether voters are resistant to changes in voting technology, by examining whether there is a tendency for individuals to prefer systems they have used in the past to cast their votes. Second, we test whether exposure to arguments for reform that emphasize security concerns, as opposed to arguments that emphasize making voting easier and more convenient causes voters to prefer paper ballots. And lastly, we test whether the influence of increased concerns about voter fraud is intense enough to cause voters to prefer switching to an untried voting system.

The results of our analysis indicate that: (i) voters are highly resistant to changes in the technology used to cast their ballots; they have a strong tendency to prefer systems they have used in the past; (ii) priming voters with voting fraud considerations causes them to become more supportive of paper-based alternatives to touch-screen voting machines; and, conversely, priming them with convenience considerations causes them to display higher preference for e-voting relative to paper-based alternatives; (iii) being exposed to fraud/convenience considerations causes, meaningful deviations from voters' tendency to prefer systems they are already familiar with. Thus, our research has important implications for understanding the framing of debates about the implementation of new voting technologies in the U.S.

2 Voting Experiences and Support for e-voting

Our goal is to contribute to the emerging research on the influence of past voting experiences on voter opinions about voting technologies, with special attention to how concerns about voter fraud intervene in this relationship. Numerous aspects of the voting experience may influence voter attitudes toward the voting system, including: voting absentee by mail as opposed to in person at a polling place (Alvarez, Hall, and Llewellyn, 2008); the accessibility and openness of polling places (Stein and Vonnhame, 2012); the amount of time spent waiting in line to vote (Stewart and Ansolabehere, 2013); the quality of interactions with poll workers (Hall, Monson, and Patterson, 2009; Pomares et al., 2014a); and facing difficulties while trying to vote (Herrnson et al., 2008; Pomares et al., 2014a). Our focus here, however, is on the consequences of previous experiences with manually-marked paper ballots vs. electronic ballots marked on touch-enabled displays.

Existing evidence on the influence of e-voting experiences on trust in the electoral process is mixed. While studies conducted in the U.S. have found that e-voters were less confident that their votes were counted as intended than precinct voters who used paper/optical scan-based systems (Alvarez, Hall, and Llewellyn, 2008; Claassen et al., 2013), field studies conducted in other countries have found that e-voters declare higher confidence in electronic voting technologies relative to traditional paper-based systems (Alvarez et al., 2009; Alvarez, Katz, and Pomares, 2011; Alvarez et al., 2013), and that they evaluate the e-voting experience in decidedly positive terms (Pomares et al., 2014a,b). While several previous studies have looked at the relationship between experiences with voting technology and voter confidence in the vote count, little systematic evidence exists as to the influence of past technology use on preferences for different voting technologies. One recent study that looked at preferences for direct-recording electronic (DRE) vis-a-vis paper-based voting among Virginia voters found that those who lived in areas that used DREs made more positive evaluations of such systems (and exhibited higher preference for this technology) than those living in areas where optical scan voting had been used (Stewart, Alvarez, and Hall, 2010).[1] Analogous results were found in an e-voting pilot conducted in Argentina (Alvarez et al., 2013).

Why would past e-voting experiences influence preferences for future use of the same (or alternative) technologies? According to the Rogers (1983) model of technology adoption, prospective users are often uncertain about the advantages and disadvantages of new technologies. The experience of trying out an innovation contributes to reducing this uncertainty, as it allows users to collect evaluative information about the consequences and usefulness of the technology. If the level of uncertainty is reduced to acceptable levels and expected advantages are corroborated, then the individual may decide in favor of adoption (Rogers, 1983; Vassil et al., 2016). Thus, to the extent that past e-voters are more certain about the benefits of voting electronically (e.g. greater accessibility and ease of use), they should be more supportive of e-voting than individuals who have voted using paper ballots only.

From a cost-benefit point of view, it also makes sense that previous e-voters would be more likely to select this technology for future use than voters whose only expe-

[1]In this paper, we use the term direct-recording electronic (DRE) when we discuss previous research, as that is typically how electronic voting devices (both touchscreen and non-touchscreen) are discussed. Later in the paper, when we discuss our survey and the analysis of the survey data, we use the term touchscreen voting machine, as that is how the survey framed discussion of electronic voting technologies.

rience consists of having used paper-based systems. Maintaining a technology they have used in the past (either electronic or paper-based voting) would allow voters to avoid the economic and cognitive costs of adopting a different technology (Vassil et al., 2016). Adoption costs would include the taxpayer cost of buying new equipment and spending in poll worker training and voter education, as well as the cognitive cost to voters of learning how to operate a new voting system and of deciding on the relative advantages of the system compared to alternative options. Prospective benefits arising from security improvements, greater accessibility, and convenience gains might seem, in comparison, less tangible and more difficult to evaluate in the minds of voters.

Because of these reasons, we hypothesize that voters will exhibit strong support for systems they have used in the past (**H1**), with past users of touch-screen voting machines being more supportive of DREs than individuals reporting no previous experience with this technology. A similar result for election officials has been found in past studies. Moynihan and Lavertu (2012, p. 75) find that election officials "overvalue the technology they already possess." Along similar lines, Burden et al. (2011, p. 90-91) note that "[t]here [...] appears to be a status quo bias in which local election officials endorse existing practices but resist changes, even those the officials believe the public supports."

In addition to past voting experiences, other factors that may help to explain preferences over voting technologies are convenience and security considerations in the minds of voters. Rogers (1983) argues that perceived characteristics of innovations—including relative advantages, compatibility with societal values and norms, and complexity—influence people's adoption decisions.[2] In line with this reasoning, we expect that when considerations of convenience and efficiency gains are at the forefront,

[2] According to Rogers (1983, p. 15-16), the five characteristics of innovations relevant for explaining adoption decisions are: *relative advantages* ("the degree to which an innovation is perceived as better than an idea it supercedes"); *compatibility* ("the degree to which an innovation is being consistent with the existing values [...] of potential users [and] pervalent values and norms of a social system"); *complexity* ("the degree to which an innovation is perceived as difficult to understand and use"); *triability* ("the degree to which an innovation may be experimented on a limited basis"); and *observability* ("the degree to which the results of an innovation are visible to others").

individuals should be more supporting of e-voting. When considerations involving security are borne in mind, however, existing concerns about the reliability of electronic voting systems could turn off enthusiasm for these technologies, as they could be perceived as incompatible with the preservation of electoral integrity.

Previous studies have found that attempts at modernizing the election process following the 2000 election debacle, including the adoption of optical scan and DRE voting systems as a replacement for controversial technologies such as lever and punch-card machines, were largely effective in reducing the incidence of voting errors (Alvarez, Beckett, and Stewart, 2011; Ansolabehere and Stewart, 2005; Stewart, 2011). Studies conducted in other countries point to similar conclusions (Fujiwara, 2015). There seems to be, however, a mismatch between the actual performance of voting systems as measured by the changes in the residual vote rate (i.e. the proportion of ballots with either over- or under-votes) and voter perceptions of the accuracy of voting systems.

The limited trust in e-voting systems displayed by voters in the U.S. could be a result of numerous factors, including the inherently black box nature of electronic voting machines, academic skepticism about the security of e-voting systems, and high-profile controversies over the reliability of e-voting machines (Alvarez, Hall, and Llewellyn, 2008; Stewart, 2011). To the extent that voters in other countries have displayed more positive views toward similar technologies (Alvarez et al., 2009; Alvarez, Katz, and Pomares, 2011; Alvarez et al., 2013; Pomares et al., 2014a,b), it would seem that the political environment and media coverage of elections could be playing an important role in shaping attitudes toward e-voting among U.S. voters.

Much of the recent debate over the reliability of e-voting machines has focused on discrepancies between election results and media exit polls (Stewart, 2011), despite the fact that exit polls are an imperfect instrument which, taken in isolation, tells us little about the integrity of the electoral process (Alvarez, Atkeson, and Hall, 2013). In the context of these claims, and regardless of their basis in reality, we hypothesize that exposing voters to arguments for election reform that emphasize security considerations will raise concerns about touch-screen voting technologies and lead to increased preferences for paper/optical-scan voting (**H2**).

One last question that we explore in this article is: when voters are exposed to arguments for election reform that emphasize considerations about voter fraud, as opposed to convenience considerations, is the influence of fraud/convenience cues intense enough to beat voters' resistance to technological change? In a context where surveys show that many Americans believe that voter fraud exists in U.S. elections, priming considerations of electoral malfeasance could have wide impact on attitudes toward e-voting, even among voters who have tried these systems in the past and have found them to their liking (Ansolabehere and Persily, 2008; Stewart, Ansolabehere, and Persily, 2016). We hypothesize that voters who previously used electronic voting machines to cast their votes will exhibit status quo bias upon exposure to convenience cues, but will be driven away from this technology upon exposure to fraud cues (**H3a**). On the other hand, voters whose previous experiences include only paper/optical-scan voting not support touch-screen voting machines upon exposure to fraud cues, but will be more supportive of this technology upon exposure to convenience cues (**H3b**).

The likelihood that different individuals have tried different voting technologies depends to some extent on their past decisions about whether to vote by mail or in person. These choices, in turn, are limited by the availability of convenience voting opportunities in the state (e.g. being able to register as an absentee voter without presenting an excuse) and are partly driven by individual attributes such as age and disability (Alvarez, Levin, and Sinclair, 2012). The bulk of the evidence gathered so far suggests that absentee voters are more likely to over- or under-vote compared to precinct voters (Alvarez, Beckett, and Stewart, 2011), and that they are less confident that their ballots were counted as intended (Alvarez, Hall, and Llewellyn, 2008). In assessing the influence of voting experiences on preferences over voting technology, we will acount for people's opportunities to vote by mail instead of in person at a precinct, as voting mode may influence both the likelihood of having used electronic-based systems and opinions about voting technology.

3 Data

The analysis reported in this article is based on survey data from the University of Georgia team module of the 2015 Cooperative Congressional Election Study (CCES). This data set encompasses a nationally-representative sample of 1,000 respondents to the 2015 CCES. Interviews were conducted over the Internet soon after the off-year 2015 general election. The survey instrument was made up of questions from the 2015 CCES Common Content (Ansolabehere and Schaffner, 2017), as well as team content from the UGA module of the 2015 CCES (Poole, 2016), including a survey experiment on attitudes toward voting technologies. We provide the materials necessary to replicate the analyses reported here in the journal's Dataverse (Alvarez, Levin, and Li, 2018). Next, we describe the wording of the explanatory variables of interest and outcome variables used in this study.

First, information about past experiences with voting technology was obtained through a question that asked about previous use of different voting systems, which included a brief description of each system:

> *Have you ever cast a ballot in an election where the following voting technologies were used? Check all that apply.*
>
> - ***Hand-counted paper ballots***. *Under this system, voters mark their choices on a paper ballot and place the ballot in a ballot box. After the polls close, precinct election officials open the ballot box and count the paper ballots by hand.*
> - ***Optical scan paper ballot counting***. *Under this system, voters mark their choices on a paper ballot and feed the marked ballot into an optical scanner. After the polls close, the optical scanner automatically tabulates all recorded votes.*
> - ***Touchscreen voting machines***. *Under this system, voters select their preference on an electronic ballot displayed on a touch screen*

voting machine. After the polls close, the voting machine automatically tabulates all recorded votes.

In answering this question, respondents could also select *some other method* or *don't know*. The order of the three response options was randomized. The distribution of responses to this question shows that 48.6% of respondents reported having used hand-counted paper ballots, 39.1% reported having used optical scan paper ballot counting, and 41.5% reported having used touchscreen voting machines. Numerous voters reported mixed experiences, with 25.1% selecting both paper/optical-scan technologies and touchscreen voting machines. A substantial proportion of respondents (17.5%) did not select any of the listed technologies. The proportion of respondents reporting having used hand-counted paper ballots is larger than might be expected, as today most counties that use paper ballots do not count them by hand but by feeding ballots through optical scanners. A likely culprit driving this potential over-reporting of use of hand-counted paper ballots is that, since voters do not directly observe what happens after votes are cast, many may be uncertain about the tabulation method. Some voters may wrongly guess that ballots were counted by hand, or may express their uncertainty by selecting both tabulation methods (by hand *and* optical scan). Indeed, no more than 17% of respondents indicate having voted using hand-counted paper ballots only (much lower than the approximately 47% that indicate having used hand-counted paper ballots among other methods). Our analysis focuses on the method used to *mark* the ballot: paper ballot or touch-screen interface. Therefore, confusion as to how votes were counted (by hand or by optical scan) should not affect our results.

Also, we used the specific term touchscreen voting machine in the survey, as we wanted respondents focused on that specific type of voting technology — voting machines that look like and operate like automated teller machines (ATMs). The term direct recording electronic, while used by academics and stakeholders when they discuss voting technologies, is vague (as it includes both ATM-style voting machines, as well as other electronic voting machines where voters do not indicate their voting preferences by touching a screen [for example, the Hart Intercivic eSlate machine]). To avoid confusing study respondents, we used the term touchscreen voting machine, and to maintain that clarity in our analyses in this paper, we use that term and its abbreviation (TVM).

Next, to learn about the influence of exposing respondents to arguments for reform that emphasized security concerns, as opposed to arguments that emphasized convenience, we used a split-sample design whereby respondents were randomly assigned to two alternative wordings of a similar question. Half of the sample was asked a question that stressed security concerns:

> *Do you agree or disagree that the primary consideration in selecting a voting system should be* ***ensuring that votes are not tampered with in any way?***

The other half of the sample was asked a question that emphasized convenience considerations:

> *Do you agree or disagree that the primary consideration in selecting a voting system should be* ***making voting easier and more convenient?***

In either case, respondents were provided responses that included the options, agree, disagree, and don't know. Based on information about respondents' assignment to the two alternate question wordings — and without regard to the level of agreement with the reform criterion — we created a *Fraud Cues* indicator taking the value 1 if the question emphasized fraud concerns and the value 0 if the question emphasized convenience considerations.[3]

[3] The "primary consideration" question had a single purpose: to prime respondents about security- and convenience-related aspects of technology adoption. Since only the question wording (but not responses) was randomly assigned, responses to this question were recorded but not used to code treatment indicators. Among respondents in the fraud frame, 90.5% agreed that "ensuring that votes are not tampered with in any way" should be the primary consideration in selecting a voting system. Among those in the convenience frame, a similar percentage (75.1%) agreed that "making voting easier and more convenient" should be the primary consideration.

In this situation, given the relatively small sample size, a no-cues control condition was not included. Splitting the sample three ways, given the potential for survey non-response (both in these questions and in the others that would be used in the analysis), risked a significant reduction in potential statistical power. While the absence of a control condition means that we cannot easily assess the independent effect of either frame we can still assess the differences in outcome between the two conditions (fraud or convenience), which is the goal for our empirical analysis of the data below.[4]

Lastly, we gathered information used to code our outcome variable (i.e. preferences over voting technologies) through a question that asked:

> *If you could choose a voting technology to be used in future elections, what would it be?*

In answering this question, respondents could choose from five mutually-exclusive alternatives: *hand-counted paper ballots*; *optical scan paper ballot counting*; *touch-screen voting machines*; *I'm indifferent*; and *don't know*. The order in which the first three options were presented to respondents was randomized. In total, 70% of respondents specified a preferred technology. The most popular alternative was touchscreen voting machines (42.4%), followed by optical scan paper ballot (16.9%) and by hand-counted paper ballots (10.6%).

Before presenting the results, it's worthwhile to look at the covariates included in the analysis.[5] As shown in Table A.1 in the Online Appendix, the respondents

[4]Our research design allows us to establish whether statistically significant differences in support for touch-screen voting machines (TVMs) exist between groups of respondents exposed to fraud and convenience cues. Because of the omission of a control group, however, we are unable to establish which one of the treatment conditions — or if both — would lead to changes in support for TVMs relative to a group of respondents exposed to neither cue (Gaines, Kuklinski, and Quirk, 2007). Differences in support for TVMs between respondents exposed to fraud and convenience cues could be either smaller or larger in magnitude than differences between either treatment group and a no-cues control group. Had we included a control condition, then, we would have been able to conduct a more nuanced analysis. Nonetheless, the inclusion of a control condition would have compromised our ability to detect the effect of interest, as partitioning the sample three ways would have necessarily lead to smaller numbers of respondents assigned to each condition.

[5]Eighteen of 1,000 observations contain missing values in at least one of the covariates and hence are dropped for subsequent analysis. In particular, there is 1 missing value for disabled, 10 for length of residency, 3 for homeowner, 3 for didn't vote in 2012, 3 for voted for Obama in 2012, 1 for party

in the sample are 47.7 years old on average; 38.3% have an education level of high school or less; 33.6% have some college education; and the rest have a college degree or more. Voters in the sample on average have lived in the same city for 15.3 years, with slightly more than half owning their home. Among respondents in the sample, 51.9% are female; a quarter of them are non-white; and 5.9% have disability.

In the 2012 election, 23.6% of the respondents did not vote, and 39.4% voted for Obama. Moreover, 55.9% of them are from counties where Obama won. The respondents have an average score of 3.7 on a 1-7 party identification scale ranging from "Strong Democrat" to "Strong Republican."[6] A large proportion (36.4%) of the respondents live in the South, while the rest are roughly evenly split between the Northeast, Midwest and West. As for election laws, a small percentage (3.9%) of all voters in the sample live in a state where elections are held entirely by mail. Absentee voting by mail is allowed with no excuse in about half of the voters' states. 17.8% of the voters live in a state where permanent absentee voting is permitted. Finally, early voting is allowed in 63.2% of the cases.

4 Results

4.1 Effect of previous voting experiences

We first consider the relationship between voters' past experiences and technology preferences. We expect voters to exhibit inertia towards voting technology, as hypothesized in Section 2 (**H1**). A naïve analysis, presented in Table 1, shows that voters having previously used different technologies have dissimilar technology preferences. Few voters (6.5%) with touchscreen voting machine (TVM) experience choose paper ballots as their preferred voting technology for future elections, with most (83.6%)

identification (1-7 scale), 2 for choosing touchscreen voting machines for future elections, and 2 for choosing hand-counted/optical-scan paper ballots for future elections. Survey weights, trimmed at 0.3 from below and 3 from above, are always employed before summary statistics are calculated and analysis is conducted.

[6]The 1-7 party identification scale is labeled as follows: (1) Strong Democrat, (2) Not very strong Democrat, (3) Lean Democrat, (4) Independent/Other/Not sure, (5) Lean Republican, (6) Not very strong Republican, and (7) Strong Republican.

Table 1: Voting experiences and technology preferences

Voting Experience	N	Technology Preference Paper Ballot(%)	TVM(%)	Indifferent/Don't Know(%)
Paper Ballot Only	402	44.6	28.7	26.7
TVM Only	161	6.5	83.6	9.9
Mixed Experiences	249	28.6	50.7	20.8
No Experience	170	7.2	36.6	56.2

Note: The table provides sample sizes (first columns) and row percentages (second to fourth column). Rows correspond to self-reported past voting experiences: paper/optical-scan (Paper Ballot Only), touch-screen voting (TVM Only), both paper-based and touch-screen voting (Mixed Experiences), and neither technology (No Experience). The first column shows the number of respondents in each category. Other columns correspond to preferences over technologies to be used in future elections: paper/optical-scan (Paper Ballot), touch-screen voting (TVM), and indifferent/don't know. Percentages are calculated using sampling weights.

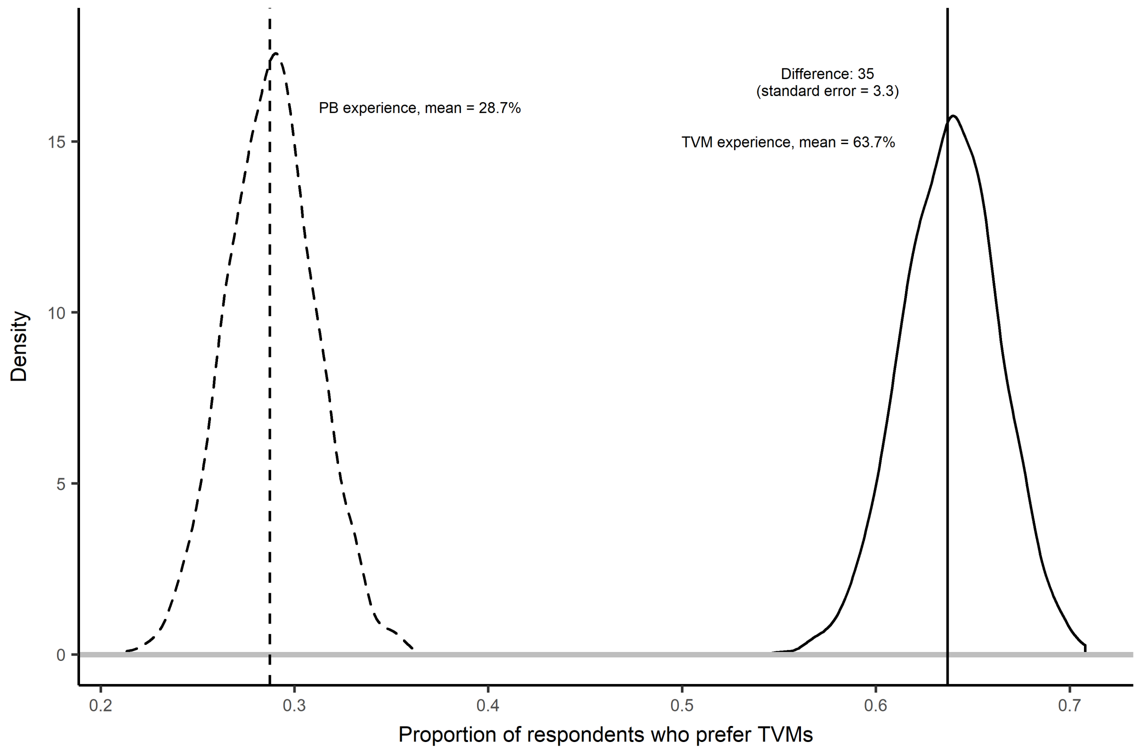
sticking to electronic voting methods. On the other hand, among voters who have previously only used paper ballots, most of them prefer paper ballots to touchscreen voting machines (44.6% vs. 28.7%) for the future. Voters with mixed experiences lie in between, with more of them preferring TVMs instead of paper ballots as their desired voting technology (50.7% vs. 28.6%). Based only on these data, it is clear that we need to take into account the previous experiences that voters have had with balloting technology, when we study their preferences for new balloting technologies. To focus on the effect of TVM experience, we remove respondents reporting previous experience with neither voting technology and compare individuals with and without TVM experience hereafter.[7][8]

Figure 1 displays graphically the proportion of respondents who prefer TVMs, with paper ballot experience and TVM experience (TVM experience or mixed experience) respectively. Bootstrapped densities are plotted to reflect estimation uncertainty.

[7]Respondents reporting previous experience with neither voting technology are relatively young and most report not having voted in the 2012 presidential election (see Table A.2 in the Online Appendix).

[8]In other words, we group respondents into two categories: (1) respondents with paper ballot experience only and (2) respondents with TVM experience only or with mixed experiences.

Figure 1: Voting experiences and technology preferences



Note: The figure shows the densities of the proportion of respondents who prefer TVMs in 1,000 bootstrap samples, with paper ballot (PB) experience and touchscreen voting machine (TVM) experience respectively. Sample weights are used in the bootstrap procedure. The density for TVM experience is drawn with a solid line and the density for PB experience is drawn with a dashed line.

Less than a third of respondents with only paper ballot experience select TVMs to be their desired voting technology, whereas 63.7% of the respondents with TVM experience prefer TVMs. The difference is large and significant (35.0 percentage points, s.e. = 3.3). In fact, the bootstrapped densities from 1,000 bootstrap samples for the two groups do not overlap at all. Again, past experiences with voting technology are important to be taken into consideration when trying to understand preferences about possible new voting technologies.

This simple observational analysis provides support for our hypothesis, but does not establish the effect of past experiences on technology preferences. The reason is that individuals who have tried different technologies differ in terms of their individual attributes and by various contextual factors. Any effect of voting experiences could be confounded by these factors. In particular, as is clear from Table A.2 in the Online Appendix, 31.7% of TVM voters are non-white, whereas only 20.4% of paper ballot voters are non-white. The turnout rate in the 2012 election is much lower for TVM voters than paper ballot voters. As for the discrepancy by region, the proportion of Southern and Northeastern voters are higher for voters with TVM experience than paper ballot experience. Imbalances are also present in terms of election laws. These differences are consistent with the geographical pattern of adoption of this technology.

Given that a respondent's past experience is not randomly assigned, controlling for imbalances in covariates is critical. To learn about the effect of previous experience, we use linear regression and three different matching procedures (subclassification, nearest neighbor, and coarsened exact matching).[9][10][11] In the linear regression, we include all the covariates mentioned before (summarized in Table A.1 in the Online Appendix). In subclassification and nearest neighbor matching, we first estimate a propensity score, using all the covariates as well as survey weights. Then we either group observations into subclasses (subclassfication) or select the best control match for each individual in the treatment group (nearest neighbor matching) based on the propensity score. In coarsened exact matching, we create strata based on covariate values, calculate the treatment effect within each strata, and then aggregate across the matched sample.

[9]In subclassfication matching, we first form 9 subclasses based on the propensity score estimated using a logistic regression, where each subclass have approximately the same total number of units (treated and control). We calculate the treatment effect as the weighted difference in the outcome variable, using both subclass weights and original survey weights.

[10]In nearest neighbor matching (without replacement), we first estimate the propensity score as in subclassication matching. Then matches are chosen for each treated unit one at a time. At each matching step we choose the control unit that is not yet matched and is the closest to the treated unit according to the propensity score. The treatment effect is calculated as a weighted average of the difference in TVM choice between each pair, using the original survey weight for the treated unit in each pair.

[11]In coarsened exact matching, we create bins for each covariate (we drop region and three election law covariates so as to have enough matched units) and then form strata. We calculate the treatment effect within each stratus as the weighted difference in the outcome variable, using original survey weights. Finally we aggregate the effects across matched samples using stratus weights.

Table 2: Effect of previous voting experiences

	Effect (TVM vs. Paper Ballot experiences)		
	Estimate	Standard Error	N
Naïve	35.0	3.3	812
Regression (OLS)	32.3	4.0	812
Matching (subclass)	36.3	3.8	812
Matching (nearest)	36.3	4.2	596
Matching (CEM)	29.6	10.3	177

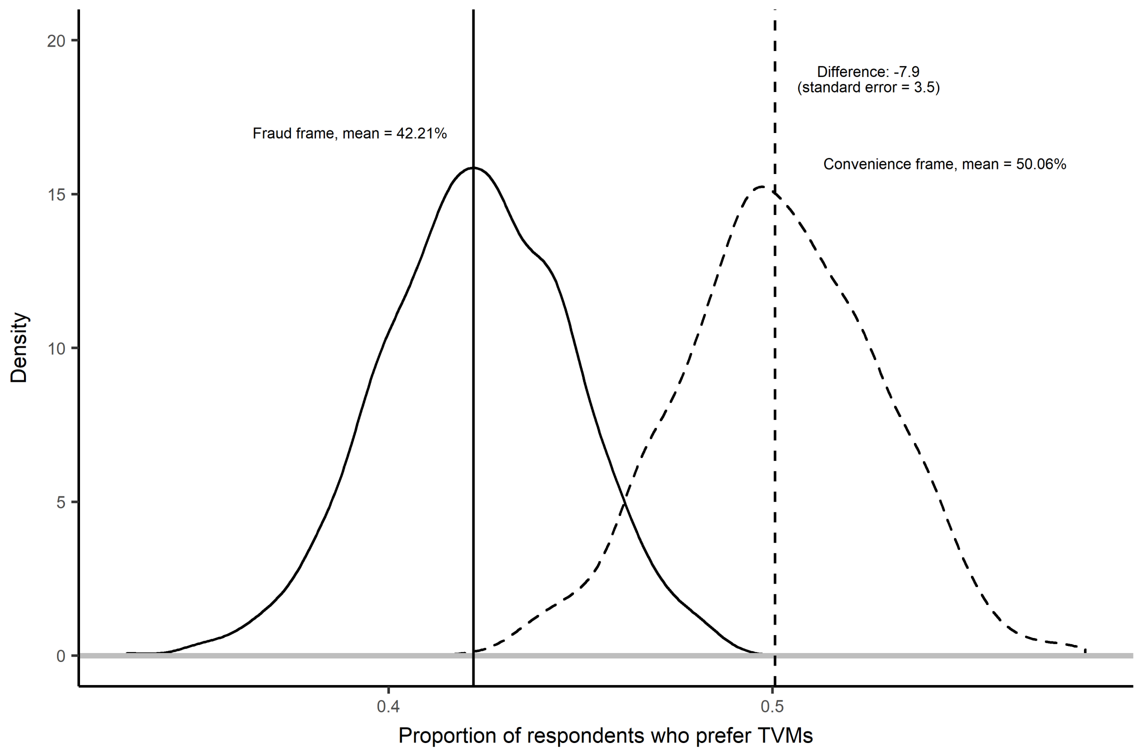
Note: Effects are calculated as the difference in percentages of respondents who prefer TVMs, between those who have used TVMs in the past and those that have only used paper/optical-scan ballots. The naïve estimate is the difference in proportions in the original sample (i.e., without matching). The regression (ordinary least square, or OLS) estimate refers to the coefficient of the TVM indicator in a linear regression of preferring touchscreen voting machines for future elections on TVM experience indicator, fraud cue indicator and covariates (full regression results in Table A.4). The matching estimates from subclassification (subclass), nearest neighbor matching (nearest), and coarsened exact matching (CEM) are calculated as the difference in proportions in the matching sample from corresponding methods. In all cases (except for OLS), standard errors are calculated via bootstrapping. All the analysis is conducted using sampling weights.

Table 2 confirms our previous result. In a linear regression specification, voters with TVM experience are 32.3 percentage points less likely to choose touchscreen voting machines as a technology to be used in future elections, relative to voters without such experience. The effect is slightly larger in subclassification and nearest neighbor matching. We drop many observations in coarsened exact matching, as many strata do not contain at least one treated and one control observation. But the results are similar to those using other matching techniques, as we find that voters who have used touchscreen voting machines before are 29.6 percentage points more likely to favor this technology in the future.

4.2 Effect of fraud and convenience cues

Our next set of results relates to how fraud concerns in the minds of voters, in contrast to convenience considerations, affect the technology preferences of voters. Since the assignment of survey respondents to the fraud or convenience conditions was randomized, we expect covariates to be well balanced across frames. An examination of the characteristics of respondents assigned each condition suggests that both groups are, indeed, comparable in terms of a number of individual attributes (see Table A.3 in the Online Appendix). Among a large number of covariates, the noticeable exceptions are education (high school or less, some college), the indicator for all vote by mail, and to a lesser extent, age (by two years).

Figure 2: Effect of fraud/convenience cues



Note: The figure shows the densities of the proportion of respondents who prefer TVMs in 1,000 bootstrap samples, under fraud frame and convenience frame respectively. Sample weights are used in the bootstrap procedure. The density under fraud frame is drawn with a solid line and the density under convenience frame is drawn with a dashed line.

We hypothesized (**H2**) that fraud concerns discourage voters from choosing TVMs, and encourage voters to favor paper ballots. Figure 2 shows the proportion of respondents who prefer TVMs under the two different frames, as well as the densities of these percentages in 1,000 bootstrap samples to reflect estimation uncertainty. As shown in the figure, 42.2% of the respondents select TVMs to be their desired voting technology under the fraud frame, whereas 50.1% of the respondents prefer TVMs under the convenience frame. Consistent with our expectations, voters who are reminded of fraud considerations are 7.9 percentage points (s.e. = 3.5) less likely to choose TVMs as a voting technology they wish to use in future elections. The bootstrapped density plot shows that the likelihood of the difference being driven by estimation uncertainty is modest.[12]

Differences in support for TVMs between individuals primed with fraud considerations and those primed with convenience considerations persist when regression analysis is used to adjust for minor observed imbalances between both groups. According to the regression results shown in Table A.5 in the Online Appendix, exposure to fraud cues reduces the likelihood of TVM preference by approximately 7 percentage points, an effect size very similar to the one found by comparing the proportions of respondents primed with each cue that indicated TVM preference.

4.3 Fraud cues, voting experiences, and support for TVM

In the last stage of our analysis, we estimate parametric models incorporating both past experiences, fraud cues and their interaction, to evaluate the effects of fraud cues in the presence and absence of previous experience with touch-screen voting technologies. We estimate both a linear regression and a logistic regression on the matched data from the subclassification procedure employed before (see Table 2), to control for imbalances in covariates for respondents with different voting experiences.[13] The results of this new regression analysis confirm our previous results: voters with touchscreen voting machines experience are more likely to choose touchscreen voting machines as a technology to be used in future elections, relative to voters without such experience.

[12]The effect of exposure to the fraud cue is smaller in magnitude (about -6.0 percentage points, with s.e. = 3.2) when respondents that report no previous experience with voting technologies are included in the sample. Results including these respondents are show in Figure A.1 in the Online Appendix.

[13]The complete set of regression coefficients is given in Table A.6 in the Online Appendix.

To evaluate whether the effect of exposure to fraud cues varies depending on previous voting experiences, we use estimates from the logistic regression to simulate the level of support for TVM under fraud and convenience frames (first and second rows of Table 3, respectively) for typical voters in our sample with and without past TVM experience (first and second columns of Table 3, respectively).[14] Among past TVM users, fraud concerns moderate the likelihood of support for touchscreen voting machines. The broad majority of TVM users report preference for maintaining technology under the convenience frame (approximately 87%), but support for TVM drops sharply, by about 9.8 percentage points (s.e. = 4.1), under the fraud frame. These results are largely consistent with hypothesis **H3a**. Among past voters without TVM experience, support for TVM is markedly lower than among past TVM users (close to 50%) under either frame. PB users are 4.4 percentage points (s.e. = 7.6) less likely to prefer TVM for future elections when exposed to fraud cues instead of convenience cues, but this difference is not statistically significant. This last piece of evidence is weakly consistent with hypothesis **H3b**. Altogether, our results suggest that previous voting experiences act as a mediator of the influence of fraud/convenience cues.

Table 3: Simulated probabilities of selecting TVMs as technology for future elections

	Technology Experience		
Frame	TVM	Paper ballot	Difference
Fraud cue	76.7	48.6	28.1
	(6.8)	(10.3)	(6.6)
Convenience cue	86.5	53.0	33.5
	(4.4)	(10.0)	(7.3)
Difference	-9.8	-4.4	-5.4
	(4.1)	(7.6)	(8.6)

Note: The table provides simulated predicted probabilities (in percentages) based on coefficient estimates from the logistic regression, evaluated at weighted modal values for categorical covariates and weighted mean values for other covariates. All the analysis is conducted using matched data from subclassification and using sampling weights. In the parentheses are bootstrapped standard errors.

[14] We define a typical voter as one who has (weighted) modal values for categorical characteristics and (weighted) mean values for other characteristics.

We also examined whether the effect of exposure to fraud cues instead of convenience cues varies significantly as a function of past experience with touch-screen voting technologies (bottom-right cell of Table 3). While, as explained in the previous paragraph, the decline in support for TVM under the fraud frame (relative to the convenience frame) is considerably larger among past TVM users, the difference in effects is only 5.4 percentage points, is noisy (s.e. = 8.6), and is not statistically significant.

5 Conclusion

American voters were buffeted in the 2016 election with assertions that the electoral system was rigged, that voters were being disenfranchised, and that the election administration infrastructure of the nation was possibly at risk. Also, questions arose regarding potential problems with voting machines in a number of battleground states, and about the aging election infrastructure in the U.S.[15] Whether these concerns will further diminish the confidence that American voters have in their electoral process remains to be seen, as surveys and opinion polls conducted in 2016 become available to researchers we will be able to study voter confidence in more detail.

Our work shows that the framing of discussions about voting technology has an important effect on voter preferences for the use of electronic-based versus paper-based systems. As policy makers consider the acquisition and implementation of new voting systems in their states and counties, they would be well-served to pay close attention to how the justification for new voting technology is articulated. Using a frame that focuses on election fraud leads voters to be more favorable towards paper ballots than electronic voting. But using a frame that focuses on convenience leads voters to be more inclined to support electronic voting. We confirmed these results using a wide variety of methodologies, so we are confident that we have isolated these key results in our experimental survey data.

Yet past experience with voting technology is an important factor, when voters are

[15] See, for example, (Norden and Famighetti, 2015; Caltech/MIT VTP, 2016).

asked to consider changing the means by which they cast their ballots. Voters become comfortable with the system they have used in the past to cast their ballots, and their comfort with the system they are familiar with makes them strongly predisposed to be disinclined to change their voting system. Importantly, the framing of preferences about the future use of a particular voting system is mediated by past use of voting technologies: when we looked at the interaction between past experience and the framing of preference about future voting systems, the voting fraud frame lessens voters' preferences for touch-screen voting technologies, particularly so among past users of this type of equipment.

Another way to view the results reported in this paper is that perhaps election officials should consider acquiring and using voting technologies that offer voters both security and convenience. For example, there are voting technologies that are convenient, in that they allow a voter to use an electronic touchscreen to make their choices, but which also offer security, in that the voter's choices are marked by the voting system on paper which the voter can verify, and which can be independently audited. While our research does not speak directly about the perceptions that voters have about these types of voting technologies, future research could examine whether opinions about convenience and election fraud are mitigated if voters use ballot marking technologies like these.

In the U.S., there are continued calls for states and counties to consider changing the voting systems and technologies used by their voters. Some states and counties (like Oregon, Washington, and Colorado) have turned to voting by mail, using paper ballots. Other jurisdictions have moved to use electronic voting systems, or to voting systems that use electronic technologies to print and scan paper ballots. And as many counties and states in the U.S. will be seeking to replace their aging voting machines, our research has important implications for how election officials should consider proceeding with the process of technology replacement. In particular, our work shows that voters should not be considered passive participants in the process of selecting and implementing new voting systems; their preferences for new voting systems are influenced by past experience and how the case for new voting approaches is framed. More research like this is necessary, so that students of election administration and voting technology — and election officials — can be informed about how to best select and implement new voting systems.

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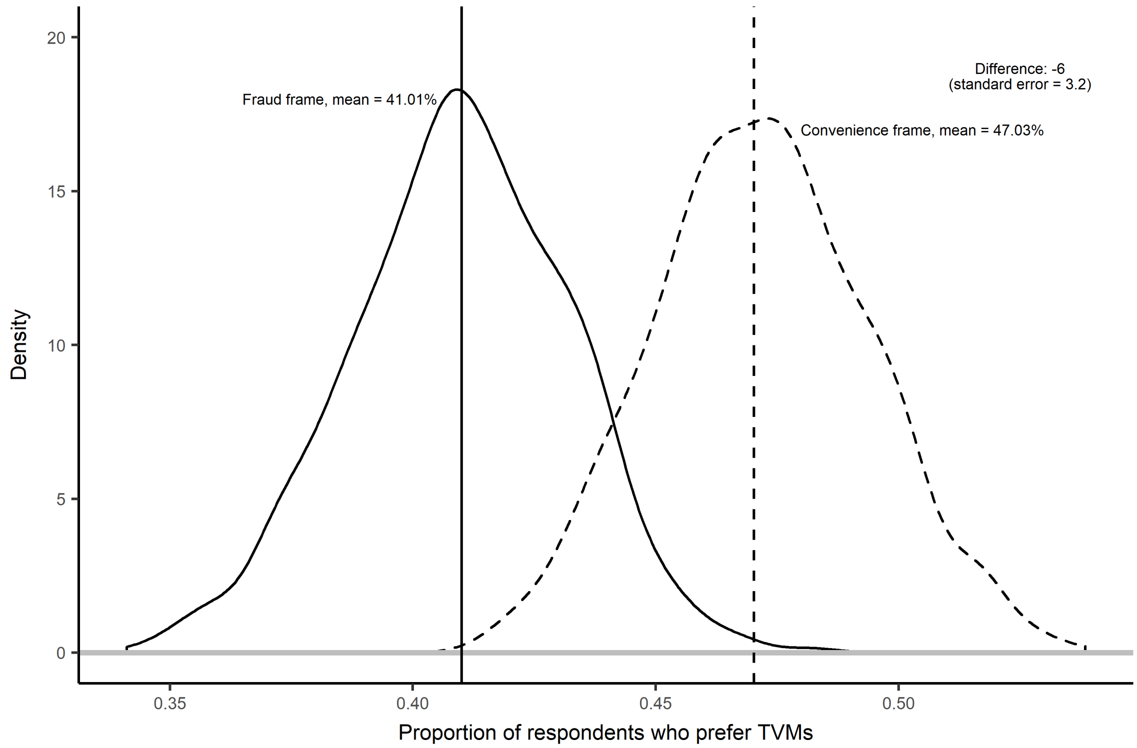
Online Appendix

A Supplementary Tables and Figures

Figure A.1: Effect of fraud/convenience cues (including inexperienced respondents)



Note: The figure shows the densities of the proportion of respondents who prefer TVMs in 1,000 bootstrap samples, under fraud frame and convenience frame respectively. Sample weights are used in the bootstrap procedure. The density under fraud frame is drawn with a solid line and the density under convenience frame is drawn with a dashed line. This figure differs from Figure 2 in that respondents who reported no experience with any listed voting technology are included.

Table A.1: Summary statistics: individual attributes and contextual factors

Age (years)	47.7
	(17.3)
Education	
High school or less (%)	38.3
Some college (%)	33.6
College or more (%)	28.1
Homeowner (%)	56.9
Length of residency (years)	15.3
	(14.8)
Female (%)	51.9
Non-White (%)	25.0
Disabled (%)	5.9
Party identification (1-7 scale)	3.7
	(2.1)
2012 election	
didn't vote (%)	23.6
voted for Obama (%)	39.4
Obama won in county (%)	55.9
Region	
Northeast (%)	19.7
Midwest (%)	22.2
South (%)	36.4
West (%)	21.7
Election laws	
All vote by mail (%)	3.9
No-excuse absentee voting (%)	51.7
Permanent absentee voting (%)	17.8
Early voting (%)	63.2

Note: The table presents summary statistics for the entire sample without missing value (N = 982). Mean and standard deviation (in parentheses) are shown for age, length of residency and party identification. Percentages are shown for other variables. Calculations are made using survey weights.

Table A.2: Balance statistics: previous voting experiences

	PB Only	TVM Only	Mixed	None
Age (in years)	50.4	46.3	52.2	38.3
Education				
High school or less (%)	36.6	41.0	24.8	54.9
Some college (%)	34.8	30.8	33.4	33.4
College or more (%)	28.6	28.2	41.9	11.6
Homeowner (%)	59.1	64.1	63.9	39.3
Length of residency (years)	15.4	15.0	15.9	14.3
Female (%)	49.4	53.9	46.2	61.7
Non-White (%)	20.4	31.7	20.5	34.0
Disabled (%)	7.2	6.8	2.5	6.3
Party identification (1-7 scale)	3.7	3.7	4.1	3.5
2012 election				
didn't vote (%)	13.6	20.4	6.0	65.1
voted for Obama (%)	46.1	45.4	43.2	18.3
Obama won in county (%)	60.6	52.7	45.6	61.2
Region				
Northeast (%)	17.7	22.7	13.9	28.0
Midwest (%)	27.1	10.5	24.0	19.3
South (%)	26.0	55.4	41.5	36.4
West (%)	29.2	11.4	20.6	16.3
Election laws				
All vote by mail (%)	7.1	2.1	1.5	2.0
No-excuse absentee voting (%)	53.9	48.3	56.7	44.5
Permanent absentee voting (%)	20.2	15.0	16.3	16.9
Early voting (%)	60.4	62.8	71.3	59.3

Note: The table presents summary statistics for four groups by past voting experiences. Columns correspond to self-reported past voting experiences: paper/optical-scan (Paper Ballot Only), touch-screen voting (TVM Only), both paper-based and touch-screen voting (Mixed Experiences), and neither of both technologies (No Experience). Calculations are made using survey weights.

Table A.3: Balance statistics: convenience vs. fraud treatment conditions

	Convenience	Fraud	t satistic	p-value
Age (in years)	49.09	51.26	1.85	0.07
Education				
High school or less (%)	37.59	30.28	-2.20	0.03
Some college (%)	29.58	37.56	2.41	0.02
College or more (%)	32.83	32.15	-0.21	0.84
Homeowner (%)	59.93	62.99	0.89	0.37
Length of residency (years)	15.73	15.22	-0.50	0.62
Female (%)	50.54	48.03	-0.72	0.47
Non-White (%)	22.72	22.58	-0.05	0.96
Disabled (%)	6.70	4.77	-1.18	0.24
Party identification (1-7 scale)	3.79	3.84	0.32	0.75
2012 election				
didn't vote (%)	14.61	10.71	-1.67	0.10
voted for Obama (%)	42.44	47.58	1.47	0.14
Obama won in county (%)	56.14	52.88	-0.93	0.35
Region				
Northeast (%)	17.17	17.88	0.27	0.79
Midwest (%)	22.80	23.04	-0.52	0.60
South (%)	37.35	35.57	0.08	0.94
West (%)	22.69	23.51	0.28	0.78
Election laws				
All vote by mail (%)	5.81	3.02	-1.93	0.05
No-excuse absentee voting (%)	52.66	54.73	0.59	0.55
Permanent absentee voting (%)	17.78	18.26	0.18	0.86
Early voting (%)	63.99	64.48	0.15	0.88

Note: The table presents summary statistics for two groups by the treatment conditions. T statistics and p-values are shown for the differences. Calculations are made using survey weights.

Table A.4: Balance statistics: convenience vs. fraud treatment conditions (including inexperienced respondents)

	Convenience	Fraud	t satistic	p-value
Age (in years)	46.58	48.89	2.09	0.04
Education				
High school or less (%)	40.87	35.60	-1.70	0.09
Some college (%)	31.45	35.80	1.44	0.15
College or more (%)	27.68	28.60	0.32	0.75
Homeowner (%)	54.68	59.18	1.42	0.15
Length of residency (years)	15.69	14.79	-0.96	0.34
Female (%)	53.44	50.31	-0.98	0.33
Non-White (%)	24.69	25.36	0.24	0.81
Disabled (%)	7.10	4.53	-1.72	0.09
Party identification (1-7 scale)	3.71	3.78	0.52	0.60
2012 election				
didn't vote (%)	26.74	20.34	-2.36	0.02
voted for Obama (%)	35.93	43.20	2.33	0.02
Obama won in county (%)	57.32	54.40	-0.92	0.36
Region				
Northeast (%)	18.62	20.95	0.92	0.36
Midwest (%)	22.17	22.16	-1.53	0.13
South (%)	38.70	33.99	-0.00	1.00
West (%)	20.51	22.90	0.91	0.36
Election laws				
All vote by mail (%)	4.57	3.20	-1.11	0.27
No-excuse absentee voting (%)	50.52	52.97	0.77	0.44
Permanent absentee voting (%)	17.68	17.88	0.08	0.93
Early voting (%)	63.10	63.24	0.05	0.96

Note: The table presents summary statistics for two groups by the treatment conditions. T statistics and p-values are shown for the differences. Calculations are made using survey weights. This table differs from Table A.3 in that respondents who reported no experience with any listed voting technology are included.

Table A.5: Regression analysis in the original sample (without matching)

	OLS		Logit	
	Estimate	Std. Error	Estimate	Std. Error
Intercept	0.514	0.118	0.129	0.565
TVM experience	0.323	0.040	1.440	0.191
Fraud cue	-0.069	0.038	-0.331	0.188
Control variables:				
Age	-0.002	0.001	-0.008	0.006
Education: Some college	-0.051	0.049	-0.252	0.239
Education: College or more	-0.096	0.048	-0.465	0.230
Homeowner	-0.007	0.045	-0.035	0.221
Length of residency (years)	-0.001	0.001	-0.006	0.006
Female	0.072	0.038	0.348	0.185
Non-White	0.060	0.051	0.287	0.250
Disabled	-0.065	0.087	-0.309	0.424
Voted for Obama	-0.096	0.056	-0.459	0.277
Obama won in county	-0.011	0.043	-0.059	0.208
party identification (1-7 scale)	-0.020	0.013	-0.094	0.063
Region: Midwest	0.023	0.069	0.117	0.338
Region: South	0.117	0.073	0.548	0.353
Region: West	-0.014	0.110	-0.056	0.530
All vote by mail	-0.104	0.128	-0.667	0.712
No-excuse absentee voting	-0.021	0.056	-0.106	0.271
Permanent absentee voting	0.056	0.099	0.265	0.480
Early voting	0.034	0.068	0.157	0.327
N	812		812	
AIC	1221		984.1	

Note: The table presents coefficient estimates and standard errors for (weighted) linear regression implemented in Table 2, Section 4.1. The coefficient estimates and standard errors for a (weighted) logistic regression are also reported. The dependent variable is an indicator variable for selecting touchscreen voting machines as the desirable technology for future elections.

Table A.6: Regression analysis in the matched sample (including interaction between TVM experience and fraud cue)

	OLS		Logit	
	Estimate	Std. Error	Estimate	Std. Error
Intercept	0.480	0.116	-0.049	0.555
TVM experience	0.386	0.057	1.739	0.280
Fraud cue	-0.037	0.058	-0.177	0.295
TVM experience × Fraud cue	-0.108	0.078	-0.492	0.385
Control variables:				
Age	-0.002	0.001	-0.010	0.007
Education: Some college	-0.058	0.051	-0.279	0.249
Education: College or more	-0.123	0.049	-0.591	0.239
Homeowner	0.014	0.046	0.072	0.222
Length of residency (years)	-0.001	0.001	-0.005	0.007
Female	0.056	0.039	0.271	0.189
Non-White	0.047	0.052	0.226	0.254
Disabled	-0.083	0.091	-0.388	0.451
Voted for Obama	-0.079	0.053	-0.382	0.263
Obama won in county	0.006	0.044	0.027	0.214
party identification (1-7 scale)	-0.020	0.012	-0.094	0.059
Region: Midwest	0.073	0.068	0.369	0.336
Region: South	0.167	0.071	0.815	0.352
Region: West	0.008	0.110	0.077	0.533
All vote by mail	-0.100	0.136	-0.592	0.716
No-excuse absentee voting	-0.013	0.060	-0.073	0.284
Permanent absentee voting	0.105	0.100	0.494	0.485
Early voting	-0.012	0.071	-0.067	0.344
N	812		812	
AIC	1255		990.9	

Note: The table presents coefficient estimates and standard errors for (weighted) linear and logistic regressions implemented in Table 3 in section 4.3. The dependent variable is an indicator variable for selecting touchscreen voting machines as the desirable technology for future elections.