The Electoral Effects of Voting Technology: Evidence from Bulgaria *

Milena Djourelova[†] Teodora Tsankova[‡]

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Abstract

Can voting technology improve the integrity of elections in developing democracies? We study this question in the context of Bulgaria's transition from paper ballots to voting via direct-recording electronic machines – a measure introduced with the goals of improving the accuracy of elections, enhancing ballot secrecy and reducing opportunities for human interference in the voting process. Our empirical strategy leverages a sharp discontinuity in the rule for the allocation of voting machines across polling stations, and variation in the implementation of machine voting over nine consecutive general elections. We document two main results. First, machine voting significantly increases the share of valid votes, effectively increasing the likelihood that votes – especially those cast by less educated, elderly, or ethnic minority voters – are counted toward the electoral outcome. Second, machine voting causes a large and significant reduction in turnout, particularly in poor and rural areas. Decomposing this decline, we find that it is driven by a reduction in votes for parties that were locally dominant at baseline, while we find no change in votes for other parties. We conduct representative surveys to investigate further mechanisms related to the reduction in bought or fictitious votes, as well as alternative mechanisms related to voters' aversion to new technologies.

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†Cornell University and CESifo. Email: mnd43@cornell.edu.

‡Tilburg University and IZA. Email: T.N.Tsankova@tilburguniversity.edu.

1 Introduction

The legitimacy and accountability of elected governments hinge on the implementation of fair and inclusive elections (Norris 2014). Yet, many democracies grapple with concerns over the integrity of their electoral processes. Between 2020 and 2024, one in five elections worldwide faced legal challenges over voting or vote counting procedures, and one-third of voters today live in countries with deteriorating electoral integrity (International IDEA 2024). Understanding whether, and which, electoral reforms can address these problems is therefore an important policy question.

In this paper, we ask whether voting technology can be instrumental in improving the integrity of elections in developing democracies. Specifically, we study the effects of voting using direct-recording electronic (DRE) voting machines – a technology currently employed in about 20 countries, including Brazil, India, and the Philippines. These machines are designed to minimize ambiguities in how voter intent is captured and interpreted, and can thereby reduce invalid votes (i.e., votes that are not counted toward the election results). They are also hypothesized to enhance ballot secrecy by limiting opportunities for tracking votes – such as through the use of pre-filled ballots – and to constrain interference by polling station officials, as the machines keep record of votes in real time.

We study the effects of this technology in the context of Bulgaria – a democracy with independent electoral institutions and strong electoral competition, where concerns over electoral integrity have nonetheless been pervasive for the past 30+ years. Specifically, numerous accounts suggest widespread vote-buying and coercion—that is, the use of monetary incentives or threats to induce voters to turn out and support a given party, or to pressure polling station officials to interfere with the voting process.[1] According to a representative survey conducted by Gallup, over 50% of respondents know of instances of vote-buying or coercion in their locality. Only 10% of Bulgarians report confidence in the honesty of elections – the

[1] Throughout the paper, we use the term vote-buying/coercion to refer both to payments or threats directed at voters in exchange for their votes, and to payments or threats directed at polling station officials to tamper with the vote (e.g., through ballot stuffing). The corresponding term in Bulgarian is also usually understood to encompass both practices. Our findings are consistent that machine voting limits opportunities for both forms of interference, though we cannot disentangle their separate effects.

lowest level globally and six times below the EU median (Gallup 2024).

In an attempt to reduce the share of invalid votes and the incidence of vote-buying, Bulgaria introduced machine voting in 2021. From an empirical perspective, the setting has several useful features that allow us to credibly evaluate the causal effects of the voting technology. First, Bulgaria had 7 general elections since 2021 with different versions of machine voting – either mandating it (a regime we refer to as "machine elections"), or giving voters the choice between machine and paper ballot (a regime we refer to as "mixed elections").[2] Second, in all of these elections, machine voting was only implemented in polling stations with 300 or more ex-ante registered voters, while polling stations below this cutoff continued to vote with paper ballots throughout. Under the assumptions of no manipulation of the running variable and continuity of potential outcomes around the threshold, this discontinuous rule allows us to estimate the causal effects of machine versus paper-ballot voting on polling-station level electoral outcomes in a regression-discontinuity framework. We provide evidence in support of these assumptions – the distribution of the number of ex-ante registered voters is smooth around the threshold, and we find that both baseline electoral outcomes (prior to the introduction of machine voting), and the socio-economic characteristics of polling station localities are largely balanced around the threshold.

Our first result is that machine voting increases the share of valid votes by about four percentage points. This is driven by the (almost full) elimination of null votes – i.e., votes that cannot be unambiguously assigned to a party or are filled out improperly, and thus are not counted in the election results.[3] While this effect is ubiquitous, its magnitude varies depending on the socio-economic characteristics of polling station localities. It is significantly larger in localities with low education, a high share of ethnic minorities, or a high share of elderly population. We also document positive effects of the option of machine voting in mixed elections, with a magnitude roughly proportional to machine take-up.

[2] These frequent elections are a result of ongoing political instability and a failure to form a stable coalition government.

[3] We find that machine voting also leads to a significant but quantitatively small reduction in the share of blank votes – that is, votes explicitly indicating support for no one (an option available on both the paper and machine ballots).

Our second result is that, despite improving accuracy, machine voting causes a sizable reduction in turnout. Pooling the three machine elections, we estimate a negative effect on turnout of about five percentage points. This is a sizable magnitude given the low turnout rate in Bulgaria in this period (about 43%). The effect is driven entirely by rural areas, by localities with low education, and ones with high unemployment.[4] Looking at mixed elections, we find no significant impact of the machine option on turnout.

Together, these results present a puzzle from a Downsian calculus-of-voting perspective. Despite increasing the probability of being pivotal – which should, if anything, increase voters' incentives to turn out – we find that machine voting has a strong negative impact on turnout. In fact, the second effect dominates the first in terms of magnitude, which results in a 10% reduction in the number of valid votes at the machine assignment threshold.

This pattern may be consistent with the stated motivation behind the introduction of machine voting: to reduce the volume of bought and fictitious votes. Specifically, by preventing practices such as the distribution of pre-filled ballots and by reducing opportunities for tempering by polling station officials (such as stuffing the ballot), the machine technology may directly hinder these practices or reduce parties' willingness to pay for votes in machine polling stations.

We take two approaches to investigate this mechanism. First, we consider the implications of a reduction in vote-buying for the distribution of votes across parties. We conjecture, given Bulgaria's proportional representation system in which strategic incentives play a limited role, that the main determinant of the distribution of vote-buying activity is parties' ability to control brokers and/ or polling station committees. This leads to the prediction that a reduction in these practices should disproportionately weaken parties that were dominant in a given locality under the paper ballot regime. We test this prediction by dis-aggregating the total valid votes received in each polling station into votes for parties that were most voted in that polling station at baseline (i.e., dominant parties), versus votes for other parties. We find that the reduction in total votes is driven entirely by votes for dominant parties

[4] On the other hand, we find no significant heterogeneity in the turnout effect by the share of elderly or by the share of ethnic minorities.

(which decline at the threshold by about 20%), while we find no effect for other parties. We further show that this heterogeneity is not explained by a general reduction in turnout among supporters of established versus new parties, and that it is robust to alternative definitions of party dominance (e.g., a measure based on the party of the incumbent municipal mayor).

Second, we partnered with Gallup International to implement a nationally representative, door-to-door survey that elicited retrospective reports of vote-buying and coercion in the period following the introduction of machine voting. We examine the relationship between these reports and respondents' self-reported polling station assignment—machine versus paper—controlling for individual and locality-level characteristics. Over half of respondents report having heard of vote-buying attempts in their locality between 2021 and 2024. However, consistent with the hypothesis that machine voting reduces this practice, the prevalence of such reports is lower among respondents assigned to machine polling stations. The difference is particularly pronounced in rural areas, where respondents assigned to machine stations are 23 percentage points less likely to report instances of vote-buying than those assigned to paper-based stations.

Finally, we consider an alternative mechanism: that turnout may be depressed by technology-related obstacles at the polling station or by voters' ex ante aversion to the technology. We view polling-station obstacles as an unlikely explanation for our results: we find no evidence of increased wait times or widespread technical malfunctions associated with machine voting. Other sources of aversion—such as security concerns—could, in principle, reduce participation if they affect the turnout decision ex ante and vary discontinuously at the assignment threshold; that is, if they are triggered by an individual's own assignment to a machine polling station rather than by broader electoral context. However, this explanation is difficult to reconcile with our findings from the initial machine elections, when information about polling-station-level technology assignment was limited.

To assess this explanation more directly, our survey with Gallup included a question on self-reported discouragement from voting due to the use of machine technology. We find that, while 8% of respondents report being discouraged by the technology, this rate is statistically indistinguishable between individuals assigned to machine-voting and paper-ballot polling stations. In other words, although some voters express aversion to machine voting, this aversion does not vary with individual assignment—a necessary condition for it to generate a discontinuity in turnout at the assignment threshold.

This paper contributes to several strands of literature. The study closest to ours is Fujiwara (2015), which analyzes Brazil's transition from paper ballots to machine voting, with a focus on the de-facto enfranchisement of illiterate voters. More recently, Aragón et al. (2025) analyze the introduction of machine voting in the case of Peru. In line with these studies, we find that machine voting helps voters of lower socio-economic status cast valid votes, if they turn out. However, in contrast to these studies, we document a sizable negative effect on turnout, concentrated among voters of locally dominant parties – consistent with the interpretation that voting technology reduces clientelistic mobilization.[5] In a similar vein, Debnath et al. (2017) find that the adoption of machine voting in Indian state assembly elections is associated with lower turnout, consistent with decreased fraud. Our setting is uniquely well suited to study this question causally as we can identify the effects of voting technology within the same election and electoral district, holding candidate and constituent characteristics, as well as any trends in political preferences, constant. Additionally, we can compare the effects of mandatory machine voting adoption to those of partial adoption in mixed elections. We thus contribute new causal evidence to the debate about the role of technology in enhancing electoral integrity.[6]

Our study also contributes to a theoretical and empirical literature on vote-buying and coercion. Prior work has examined the effects of anti–vote-buying campaigns aimed at educating voters and reducing compliance with clientelistic practices (Vicente 2014; Schechter and Vasudevan 2023; Blattman et al. 2024). We instead study an institutional reform that changes the mechanics of how elections are conducted. This speaks to a central question

[5] One possible reason why Fujiwara (2015) and Aragón et al. (2025) find no economically significant effects on turnout is that voting is compulsory in both Brazil and Peru, and participation rates are about twice as high as in Bulgaria.

[6] Card and Moretti (2007) study the effects of touch-screen voting in the 2004 US presidential election, testing the hypothesis that the new technology is *more* vulnerable to deliberate manipulation in favor of the incumbent Republican party. They find no such evidence.

in the literature: how vote-buying can persist under the secret ballot (Stokes 2005; Nichter 2008). Whereas existing explanations emphasize social networks and norms of reciprocity between brokers and voters (Finan and Schechter 2012; Duarte et al. 2023),[7] we highlight how procedural flaws—such as compromised secrecy—can sustain clientelism. In doing so, we relate to historical studies of the adoption of the secret ballot in the United States and Western Europe (Heckelman 1995; Ferlenga and Knight 2025; Aidt and Jensen 2016).

In addition to enhancing secrecy, the voting technology reduces opportunities for polling station officials to temper with votes. Our findings therefore relate to studies showing that increased monitoring of polling stations can reduce electoral fraud in high-risk environments (Enikolopov et al. 2013; Callen and Long 2015; Gonzalez 2021).

More broadly, a growing literature in development economics studies the potential for information technology to reduce corruption and improve state capacity in areas such as welfare distribution, public procurement and tax collection (Lewis-Faupel et al. 2016; Banerjee et al. 2020; Okunogbe and Pouliquen 2022, e.g.,). We contribute to this literature by studying the impact of technology in the electoral process, which is arguably foundational to the functioning of other institutions.

Finally, this paper relates to a literature on the impact of electoral rules on voter turnout in developed democracies – recently reviewed by Cantoni et al. (2024). Previous studies have examined the turnout effects of various electoral procedures, including voter registration (Braconnier et al. 2017; Nickerson 2015), early or mail-in voting (Kaplan and Yuan 2020; Thompson et al. 2020) and voter ID laws (Cantoni and Pons 2021).[8] While the focus in this literature is on how electoral rules affect the cost side of voters' turnout decision, we investigate an additional channel that may operate in less established democracies – the effect of voting procedures (in this case – voting technology) on the mechanics of election fraud.

The rest of this paper is organized as follows. Section 2 introduces the setting and the outline of Bulgaria's transition to machine voting. Section 3 introduces the data used in

[7]Related work examines how political parties monitor and incentivize brokers to enforce vote-buying agreements (Larreguy et al. 2016; Bowles et al. 2020).

[8]Other related studies consider the role of distance to the polls or voting wait times (Cantoni 2020; Chen et al. 2022).

our analysis. Section 4 presents our empirical strategy. Section 5 presents the main results. Section 6 presents evidence on the mechanism, and Section 7 concludes.

2 Background

Electoral system. Bulgaria has an open-list proportional representation system with 31 multi-member constituencies. Each constituency elects several representatives to the National Assembly, with the number of seats allocated based on population size. The overall distribution of seats is determined by the proportion of votes each party receives at the national level, with a minimum threshold of 4% vote share. The open-list element allows voters optionally to express preferences for candidates within the party list, which can lead to a re-ranking if one or more lower-ranked candidates surpass a threshold in preference votes (typically 7% of their party's total district votes). However, in practice, such re-ranking is a rare occurrence.

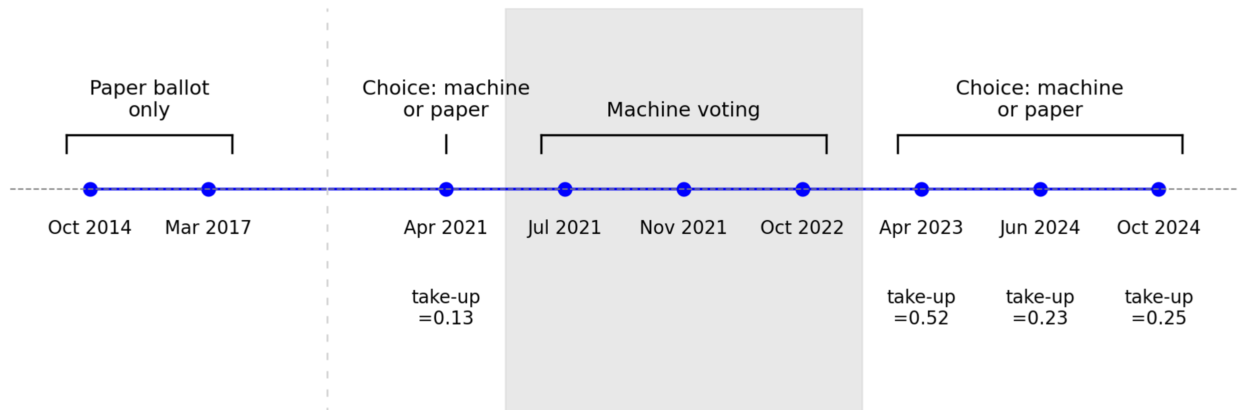
Timeline of the introduction of machine voting. During the period of our study, the Bulgarian political landscape is highly fragmented. Between 2021 and 2025, a stable coalition government failed to emerge due to disagreements between parties on major issues such as judicial reforms and Bulgaria's involvement in the war in Ukraine. This led to a period of political deadlock and a series of snap elections. In addition, several new parties entered in this period (such as PP and ITN), and some established parties split up (DPS split into DPS - New Beginning and Alliance for Rights and Freedoms).[9] As a result, party loyalty in our setting is quite low. Exit poll data from Gallup suggests that in our sample period 35% of voters switch the party they vote for between consecutive elections.

The focus of this study are the nine parliamentary elections that took place during the period 2014-2024. Machine voting was first introduced in April 2021 on a voluntary basis – voters in polling stations with a machine had the choice between paper ballot and machine

[9] The general election of October 2024 included 19 parties and 9 coalitions, with 8 making it to the National Assembly.

voting. After an amendment in the electoral law, machine voting became mandatory in polling stations with a machine. This was the case in the following three elections – July 2021, November 2021, and October 2022. Since April 2023, elections have reverted back to the earlier rules offering a choice to voters. Figure 1 illustrates this timeline.

Figure 1: Timeline of elections



Notes: This figure reports the timeline of the nine general elections in our sample. These elections fall into three voting technology regimes: (1) Voting with paper ballot only; (2) Machine voting (in polling stations with ≥ 300 registered voters); (3) Mixed elections with choice between machine or paper (in polling stations with ≥ 300 registered voters). Polling stations below the 300 threshold continued to vote with paper ballot in all elections. For mixed elections, we report machine take-up (i.e., the share of machine votes) in polling stations close to the threshold, i.e., in the range of 300 to 400 registered voters.

Voting process. Figure A1 illustrates the voting process, comparing machine voting to voting with a paper ballot. All eligible voters in Bulgaria are automatically registered to vote and assigned to a unique polling station based on their permanent address. In the polling station, the voter first presents their ID to a polling station official who verifies whether that voter is in the list of registered voters. Polling station officials are nominated by the political parties running in the election; each party has the right to appoint representatives to every polling station.

In the case of paper-ballot voting, voters receive the ballot and mark their choice in a designated private area – typically behind a curtain or a paravent. In the machine voting case, the voter receives an electronic card that activates the machine, which is positioned such that the voter is visible to others but the machine screen is not.[10] Bulgaria uses Direct

[10] This layout further enhances ballot secrecy by increasing the visibility of any attempt to photograph the

Recording Electronic (DRE) machines with a Voter-Verified Paper Audit Trail (VVPAT). This means that machine votes are recorded both electronically and physically: when a vote is successfully cast, the machine produces a printout that the voter checks and casts into a ballot box. Since 2023, official machine vote results are based on a manual tallying of these printouts.

The machine interface has an identical format to the paper ballot, with parties listed on the left-hand side and candidates from the party lists listed on the right-hand side. For a vote to be valid, it must include a party choice, while choosing a candidate is optional.

The arguments for machine voting. The motivation for the introduction of machine voting in Bulgaria was two-fold. The first explicit goal was to reduce the consistently high number of invalid votes (i.e. blank or null votes). In the 2017 parliamentary election, invalid ballots accounted for about 7% of all votes cast. Machine voting alleviates this issue as the machine interface makes it impossible to cast an ambiguous choice (though one can still cast a blank ballot by choosing the explicit "support no one" option).

The second explicit goal was to combat Bulgaria's persistent problem with vote-buying and voter coercion. The magnitude of this problem is difficult to quantify, but survey evidence from Gallup suggests that 11% of voters would be willing to sell their vote or would give in to coercion (an additional 8% state that they are unsure).[11] These rates are higher among the poor, the less educated and among ethnic minorities – consistent with evidence that the susceptibility to clientelistic practices is linked to economic vulnerability (Bobonis et al. 2022; Fajury 2023).[12]

An example of a vote-buying scheme that machine voting was expected to impede is the so-called 'Indian string' scheme – an iterative process involving pre-filled ballots. The scheme begins with a broker handing a pre-filled ballot to a voter willing to sell their vote. The voter casts this ballot at the polling station and returns with the blank ballot as proof, allowing

ballot—another common tactic used by vote brokers to verify bought votes.

[11] A method based on detecting statistical anomalies in electoral returns suggests that between 2013 and 2017, 5 to 18% of all votes were cast in polling stations suspected of widespread fraud (Kraynova and Rusinov 2021).

[12] https://www.gallup-international.bg/42259/corrupted-vote-in-bulgaria/

the cycle to continue. Machine voting disrupts this process, as the only 'ballot' cast is the real-time printout generated by the machine, which cannot be pre-filled.

Machine voting was also expected to limit opportunities for manipulation of the results by polling station officials. Unlike paper ballots, which can be added or altered during the counting process, machine printouts are generated in real time.[13] Moreover, the dual recording of votes—both electronically and physically—may deter tampering by increasing the likelihood of detection.

On the other hand, there are other clientelistic practices that should not be affected by the technology. For example, while machine voting increases the secrecy of the vote, it does not necessarily affect the observability of turnout. Hence, we do not expect that pure turnout-buying strategies – i.e. the targeting of latent supporters conditional only on turning out and not on observing their votes (Nichter 2008) – will be impacted by the technology. In other words, using the terminology of Gans-Morse et al. (2014), enhanced vote secrecy should hinder pure vote-buying and double-persuasion, but not necessarily other strategies.

The arguments against machine voting. A number of concerns have been raised by opponents of machine voting, ultimately leading to the reintroduction of the mixed system in April 2023. The first argument was that the new technology may present an obstacle or inconvenience to some voters (e.g., to the elderly). In practice, the voting machine has an interface identical to the paper ballot and is no more difficult to operate than an ATM.

The second argument is about possible technical issues with the machines on election day. As insurance against such events, printed ballots are always supplied to all polling stations, to be used in case of a machine malfunction. Additionally, voters are allowed to annul their machine vote if it is unsuccessful and can cast a paper ballot instead.

The third argument revolves around the security of the electronic system. In practice, machine votes in Bulgaria have been counted based on physical printouts since 2023 (elec-

[13] Several cases of polling station workers filling out empty paper ballots or over-writing filled ballots during the counting process have been documented via video-monitoring. See, e.g. `https://btvnovinite.bg/bulgaria/narushenie-ili-zritelna-izmama-samnenie-za-dopisvane-na-bjuletini-v-izbornata-nosht-1.html`.

tronically recorded votes are only used to verify this manual count). The security argument has nonetheless gained traction, culminating in the lead-up of the local elections of October 2023, when machine voting was banned 36 hours before election day because of a complaint about the documentation of the machines' certification. The Supreme Court later declared this ban unlawful.

Party stances on machine voting. Parties' positions on machine voting changed over time, but can be broadly categorized as follows. All three established parties — the center-right Citizens for European Development of Bulgaria (GERB, the main incumbent party until 2021), the ethnic-based Movement for Rights and Freedoms (DPS), and the Bulgarian Socialist Party (BSP) — expressed reservations about machine voting and voted in favor of reintroducing a mixed voting system in 2022. Indeed, critics dubbed these parties "the paper coalition". The main proponents of full-scale machine voting were new parties established or gaining influence after 2017 – the reformist We Continue the Change (PP) and Democratic Bulgaria (DB), as well as the far-right Revival – which all voted against reinstating a mixed voting system.[14]

Voter preferences appear to align with these patterns, as reflected in machine take-up during mixed elections (Appendix Figure A2): supporters of established parties more often cast paper ballots, whereas supporters of new parties more often opt for machine voting.

Case study. The hypothesized electoral effects of machine voting can be illustrated by the case of Bukovlak, a village in Northwest Bulgaria (the poorest region in the EU) with a documented history of electoral fraud over the years.[15] This case attracted media attention due to stark changes in electoral outcomes following the introduction of machine-only voting.

Appendix Figure A3 presents the evolution of electoral outcomes in Bukovlak. The three polling stations in the village exceed the 300-voter threshold and were thus all assigned at

[14]The party There is Such a People (ITN), established in 2020, initially supported machine voting but raised concerns ahead of the 2023 local election. The party was not represented in the National Assembly at the time of the vote on reinstating the mixed system.

[15]`https://novini.bg/bylgariya/izbori/565227`

least one voting machine. The most notable pattern is that turnout collapsed from about 80% prior to the introduction of machine-only voting to about 20% after, picking up only when the mixed system was reintroduced. The decline was concentrated in votes for DPS and GERB – the two most voted parties in the 2014 and 2017 elections. Accounts from Bukovlak voters, cited in the media, suggest that this effect is due to a reduction in clientelistic mobilization efforts by vote brokers.[16]

Election recount. A partial recount of the October 2024 mixed election sheds light on the relative reliability of machine versus paper voting. The recount was mandated by the Constitutional Court in response to allegations of widespread electoral fraud. It covered 1,777 polling stations, in which machine take-up was 38%.

Appendix Figure A4 shows that nearly all revisions involved downward adjustments to the number of votes cast with paper ballots, typically due to missing ballots or other missing documentation. The largest adjustments affected two established parties – DPS–New Beginning and GERB–SDS. While payments to or coercion of voters may not be directly detectable through a recount, the pattern suggests that paper ballot votes are systematically more susceptible to tampering and inflation than machine-recorded votes.

3 Data

Electoral returns. We collect electoral returns by polling station from the Central Electoral Commission of Bulgaria for all general elections taking place between 2014 and 2024. For each of about 12,000 polling stations in the country, these data report whether the station had a voting machine or not, the number of registered voters (as of the election day), the number of total votes cast, the number of valid votes cast, as well as their breakdown by party. Following Fujiwara (2015), we define a vote as valid if it counts towards the vote share of a party or a candidate. This definition excludes blank votes (which indicate support

[16] `https://bntnews.bg/news/zhitelka-na-bukovlak-drug-pat-ni-davat-pari-da-glasuvame-sega-nishto-ne-zna html`

for "No one"), as well as null votes (which do not comply with the rules of the electoral commission or cannot be uniquely assigned to a party/candidate). Turnout is defined as the total votes cast in a polling station (including blank and null votes), divided by the respective number of registered voters as of the election day.

For our running variable, we use information on the number of *ex-ante* registered voters (recorded several months before each election), which determines the allocation of machines to polling stations. Voting registration is automatic in Bulgaria and the assignment to polling stations is based on the address register, with each polling station having a geographically defined catchment area. This variable, and consequently the allocation of voting machines, varies over time as address registrations change between elections. However, because the elections in our sample are quite frequent, we find that these changes tend to be small, with only 2.2% of polling stations switching sides of the threshold between 2021 and 2024.

Table 1 reports summary statistics for the main outcomes of interest separately for paper, machine, and mixed elections. In paper elections the average turnout is 50% and the average share of valid votes is 93%. Comparing this baseline to the period after the introduction of machine voting, it is evident that the share of valid votes increases by around 2 percentage points in mixed elections and 5 percentage points in machine elections (driven by a decline in null votes). At the same time, turnout declined substantially after the machines were introduced by 12 to 13 percentage points. Yet, some of these changes over time may be attributable to reasons other than the voting technology – e.g., the very frequently held elections starting in 2021 likely led to significant voter fatigue. Thus, our empirical strategy will need to account for such time effects.

Local socioeconomic characteristics. We add to the above polling-station dataset locality-level characteristics from the 2011 census (there are about 5,600 localities in Bulgaria). This includes the share of the population that is 65 years of age or older, the share without secondary education, the share of ethnic minorities (Turkish or Roma), the unemployment rate, and the type of locality (village versus town/city).

Table 1: Summary statistics

	N	Mean	Sd
Paper elections			
Turnout / num. reg. voters	23819	0.502	0.108
Valid votes / turnout	23818	0.932	0.044
Blank votes / turnout	23818	0.012	0.016
Null votes / turnout	23818	0.057	0.045
Machine elections			
Turnout / num. reg. voters	36887	0.373	0.129
Valid votes / turnout	36882	0.978	0.020
Blank votes / turnout	36887	0.020	0.017
Null votes / turnout	36887	0.002	0.011
Mixed elections			
Turnout / num. reg. voters	49054	0.384	0.134
Valid votes / turnout	49053	0.947	0.030
Blank votes / turnout	49057	0.029	0.020
Null votes / turnout	49057	0.024	0.028
Share machine votes	49057	0.396	0.245

Notes: Polling station-level summary statistics, weighted by number of registered voters, for the main outcomes of interest. *Paper elections* include elections in October 2014 and March 2017, *Machine elections* include elections in July 2021, November 2021 and October 2022, and *Mixed elections* include elections in April 2021, April 2023, June 2024 and October 2024.

Survey data. In order to understand the mechanisms behind our observational results better, we partnered with Gallup International to embed questions on attitudes toward machine voting and experiences with vote-buying in electoral surveys taking place before and after the election of June 2024. The survey was constructed by Gallup to be nationally representative and was administered to 1,811 respondents.

Our block of questions asked respondents to recall the general elections of the past three years (2021-2024), i.e. in the period since the introduction of machine voting. Respondents were asked whether they had voted in this period, and conditional on having voted at least once, whether their polling station had a voting machine or not. We further asked the following "Yes" or "No" questions: *"In this period (2021-2024), were you ever discouraged from voting due to the voting technology used?"* and *"In this period (2021-2024), have you* *ever heard about vote-buying attempts in your locality?"*. For the survey wave taking place before the June 2024 election, we also included a question on knowledge about the voting technology in the respondent's polling station in the upcoming election.

Finally, we have access to data from the Gallup Exit Poll Survey conducted for all elections between March 2017 and June 2024. Specifically, we use responses to questions related to machine voting, as well as information on the party for which the respondent voted in this and the previous election.

4 Empirical Strategy

4.1 Polling station-level RDD

The discontinuity in the allocation of voting machines. Our preferred empirical strategy exploits the rule set by the electoral commission for the allocation of machines across polling stations. In all elections since 2021, voting machines were distributed only to polling stations with 300 or more ex-ante registered voters, while smaller polling stations continued to vote with paper ballots throughout.[17] The motivation for this allocation rule was the limited number of machines available and economies of scale in their distribution to larger polling stations. About 22% of polling stations fall below the threshold of 300 ex-ante registered voters. To the best of our knowledge, no other electoral procedure varies at this threshold.

Figure B1 shows that compliance with the machine allocation rule is virtually perfect – the share of stations with a voting machine in any machine election is exactly zero for polling stations with fewer than 300 ex-ante registered voters, and exactly one for polling stations with 300 or more ex-ante registered voters (with only one deviation in April 2021).[18]

[17]As ex-ante registration is not required abroad, rules regarding machine allocation differ. Specifically, stations with either 300 or more ex-ante registered voters or actual voters in the previous election are allocated a machine. Hence, our sample excludes stations abroad, which account for less than 5% of all polling stations.

[18]Mobile polling stations, stations based in medical facilities, homes for the elderly and other specialized institutions for the provision of social services do not receive a machine regardless of their number of registered voters. In practice, stations that fall under these exceptions have few registered voters and therefore almost always fall below the threshold.

Estimation. To estimate the causal effects of machine voting, we use the polling-station-level cutoff and employ a sharp regression discontinuity design. We estimate specifications of the following form:

$$y_p = \alpha + \beta_1 1\{v_p \geq 300\} + \beta_2 v_p + \beta_3 v_p 1\{v_p \geq 300\} + \epsilon_p, \tag{1}$$

The dependent variable y_p indicates an electoral outcome in polling station p. The running variable v_p is defined as the number of ex-ante registered voters in polling station p. The treatment variable is $1\{v_p \geq 300\}$, i.e., a function that takes the value 1 if this number exceeds 300, with β_1 denoting the respective treatment effect. Our preferred specification pools all three machine and all four mixed elections together, controlling for province $\times$ election fixed effects to account for secular province-level trends. We cluster standard errors by polling station.

The estimation samples are restricted to polling stations close to the cutoff, i.e., to stations with $v_p \in (300 - h; 300 + h)$. We consider two approaches when choosing the bandwidth h – using either the data-driven optimal bandwidth determined by the procedure of Calonico et al. (2015) or setting $h = 100$ (which happens to be close to the average optimal bandwidth). We present robust estimates following Calonico et al. (2014a) throughout, applying local linear estimation with a triangular kernel.[19]

Identifying assumption. This empirical strategy identifies the causal effects of voting technology under the assumption that the running variable (i.e., the number of ex-ante registered voters) is not manipulated. We believe that this assumption is plausible in our setting because this number is based on individual address registrations several months prior to the respective election.

To assess further the validity of the assumption, we examine the smoothness of the number of ex-ante registered voters around the threshold, implementing a formal sorting test for

[19] Our main results are very similar if we apply the conventional or the bias-corrected estimator instead. They are also robust to different functional forms for the running variation, such as a quadratic instead of linear polynomial.

manipulation of the running variable following McCrary (2008). Figure B2 presents this test, pooling the three machine elections in panel (a), and the four mixed elections in panel (b). In both cases, we fail to reject the null hypothesis that the density of the number of ex-ante registered voters is continuous at the threshold of 300 (with a McCrary test p-val = 0.553 in panel (a), and 0.114 in panel (b)).

Additionally, we implement a placebo test for any baseline differences between polling stations below and above the threshold of 300 ex-ante registered voters. For this test we consider the 2014 and 2017 elections that took place *before* the introduction of machine voting. Table B1 shows that our main outcomes of interest – valid votes and turnout – are smooth around the threshold in this baseline period. We also find no discontinuities at the threshold in electoral outcomes of the 2023 local election (Table B3), in which machine voting was suspended days before the first round election. Finally, in Table B2 we test whether polling stations on either side of the threshold differ with respect to the socio-economic characteristics of the towns or villages they are located in, as measured by the 2011 census. With the exception of a negative and marginally significant coefficient for log population, we fail to detect any discontinuity in socio-economic characteristics at the threshold.

4.2 Municipality-level difference-in-differences

The regression discontinuity strategy in Equation 1 allows us to estimate a local average treatment effect for polling stations close to the cutoff. One may wonder whether the average effect differs. Furthermore, a limitation of the RDD analysis is that it does not allow us to distinguish between absolute changes in electoral outcomes and a reallocation of electoral activity from machine to paper-ballot polling stations (or vice versa). This question is particularly relevant for the turnout analysis, as vote-buying activity may shift from machine polling stations to paper polling stations. To understand whether such spillovers are at play and to test the robustness of the RD results, we leverage the panel dimension of our data and adopt a difference-in-differences strategy at the municipality $\times$ election level.[20]

[20] Bulgaria consists of 265 municipalities where a municipality has on average around 25,000 registered voters. The median number of polling stations per municipality is 23.

Specifically, we estimate event study regressions of the following form:

$$y_{me} = \sum_{e \neq Mar2017} [\theta_e ShareVoters^{\geq 300}_{mMar2017} \times 1\{Election = e\}] + \delta_m + \delta_{pe} + \epsilon_{me}, \qquad (2)$$

where y_{me} denotes an electoral outcome in municipality m and election e, $ShareVoters^{\geq 300}_{mMar2017}$ is the share of ex-ante registered voters in municipality m assigned to stations with 300 or more registered voters in the March 2017 election, $1\{Election = e\}$ are a set of election indicators (with March 2017 as the omitted category), and δ_m and δ_{pe} are municipality and province $\times$ election fixed effects, respectively.[21]

The coefficients of interest θ_e estimate the election-specific effects of the voting technology, under the assumption that, in its absence, municipalities with different levels of exposure would have followed similar outcome trends. Alternatively, we report difference-in-differences results pooling elections with the same technology regime. In our preferred specification, we further control for the second-order polynomial of the number of ex-ante registered voters at baseline interacted with election dummies, in order to account for the fact that larger and more urban municipalities tend to have larger polling stations. Standard errors are clustered at the municipality level.

5 Results

5.1 Share of valid votes

RDD results. We start by examining the effects of voting technology on the share of valid votes. Figure 2 compares polling stations below and above the threshold of 300 registered voters, pooling the three machine elections in panel (a), and the four mixed elections in panel (b). Figure 3 presents separate RDD coefficients for each of the nine elections we consider, estimated either using the optimal bandwidth suggested by the procedure of Calonico et al.

[21] We obtain similar results if, instead of using 2017 share of ex-ante registered voters assigned to stations with 300 or more voters, we use the contemporaneous election-specific share.

(2015), or with a bandwidth uniformly set to 100.

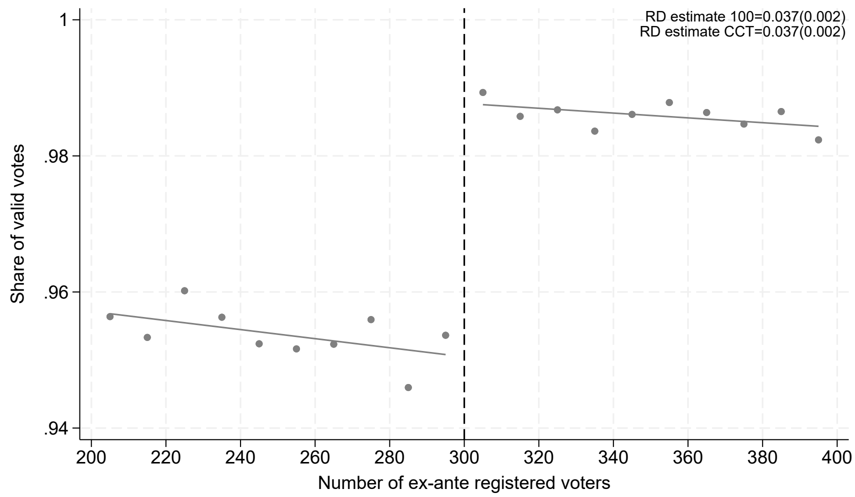
In machine elections, the share of valid votes fluctuates around 95% in polling stations just below the machine-voting threshold, but jumps to 99% in stations just above. This discontinuity is statistically significant, with a similar magnitude in all three machine elections. For mixed elections, on the other hand, we find a smaller, but still statistically significant discontinuity of about 0.8 percentage points. Since machine take-up in mixed elections is around 40% on average, this implies a treatment effect that is roughly proportional to the one estimated for machine elections. Indeed, Table C1 in the Appendix shows that the pooled effect for mixed elections is driven mostly by the two elections with the highest machine take-up (April 2023 and October 2024).

We can further decompose these effects into a reduction in null votes and a reduction in blank votes (Appendix Tables C2 and C3). We find that the increased share of valid votes in both machine and mixed elections is almost fully accounted for by a reduction in null votes, whereas we find a significant, but quantitatively small, reduction in blank votes. We interpret this evidence as consistent with a mechanical prevention of null votes enabled by the machine technology – an effect that is ubiquitous under full machine voting, but also detectable in mixed elections, provided that machine take-up is sufficiently high.

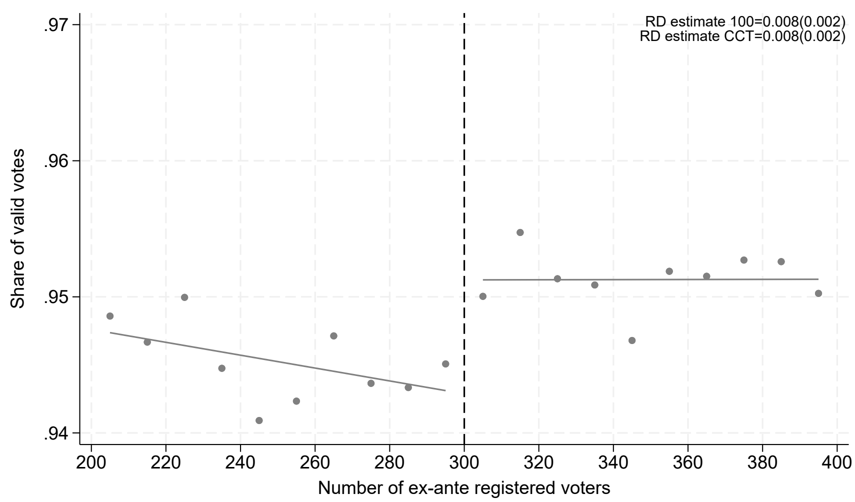
Heterogeneity. This mechanical effect can have a different bite for different types of voters, depending on their propensity to cast a null vote. We examine this heterogeneity in Appendix D.1, by estimating separate RDD regressions for polling stations in localities with different socio-economic characteristics. Specifically, we consider rural versus urban localities, and ones with below- versus above-median share of population without secondary education, share of ethnic minorities, share of individuals older than 65, and unemployment rate. The increase in the share of valid votes under machine voting is significant in all localities. However, it is significantly larger in magnitude in locations with lower educational attainment (p-val = 0.05), a higher share of ethnic minorities (p-val = 0.02), and a higher share of elderly population (p-val = 0.01). We find the same patterns for mixed elections, with the difference

Figure 2: Share valid votes: RDD estimates

(a): Machine elections (pooled)



(b): Mixed elections (pooled)

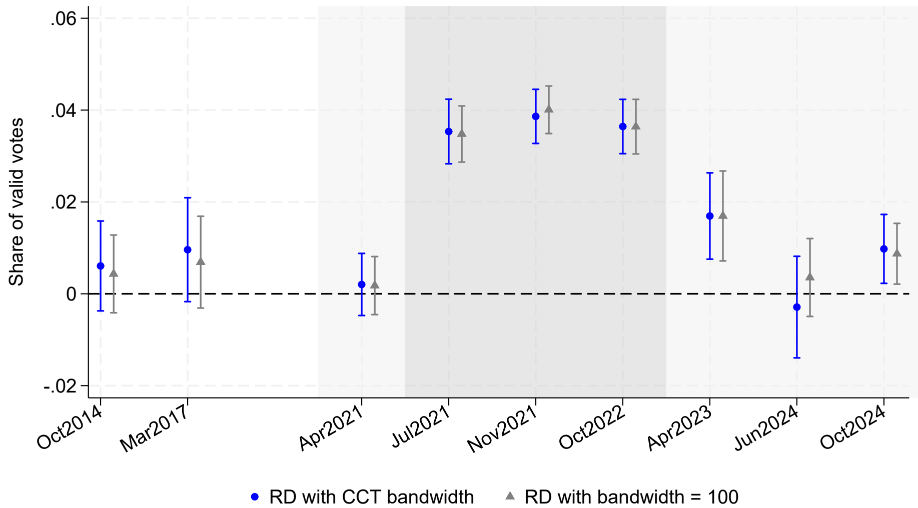


Notes: Binned scatter plot: Share of valid votes over turnout by bin of the number of ex-ante registered voters. The vertical line indicates the threshold that determines the allocation of voting machines across polling stations. The sample in panel (a) consists of the three elections with machine voting in polling stations above the threshold. The sample in panel (b) consists of the four elections with a choice of machine or paper voting in polling stations above the threshold.

that in this case localities with lower socio-economic status on these dimensions *fully* account for the increase in the share of valid votes. This is despite the fact that machine take-up is much lower in localities with these characteristics (see Appendix Figure D1).

Overall, these results show that machine voting is most effective in preventing null votes among vulnerable groups and, thus, increases the likelihood that their preferences are re-

Figure 3: Share valid votes: RDD estimates by election



Notes: The plot shows RDD estimates of the effect of voting technology on the share of valid votes, estimated separately for each election. Estimates in the dark gray area show effects in machine elections and estimates in the light gray area show effects in mixed elections.

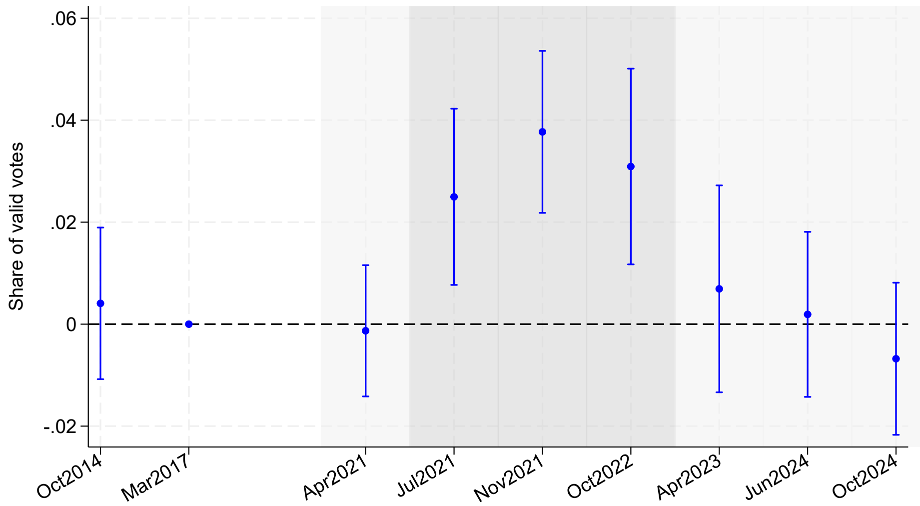
flected in the election results.

Municipality-level DiD results. We further probe the robustness of the above results to the alternative empirical strategy, which exploits variation across municipalities in exposure to machine voting and variation over time in its implementation. Figure 4 presents election-specific estimates from Equation 2, and Appendix Table C4 reports estimates pooled by election type. Note that our preferred specification controls flexibly for the number of registered voters in a municipality. The results mimic closely those from the RDD analysis – they suggest a 3 percentage point increase in the share of valid votes in machine elections (compared to a 3.7 percentage points increase estimated in the RDD analysis), though in this case we do not detect a significant municipality-level effect for mixed elections.

5.2 Turnout.

RDD results. Next, we turn to the effects of voting technology on turnout, defined as the total votes cast (valid or invalid) as a share of the number of registered voters. Figure 5 presents scatter plots of turnout around the machine-voting threshold, pooling machine

Figure 4: Share valid votes: Municipality-level event study estimates (DiD)



Notes: The plot shows event-study estimates of the effect of voting technology on the share of valid votes. Estimates in the dark gray area show effects in machine elections and estimates in the light gray area show effects in mixed elections.

elections in panel (a), and mixed elections in panel (b). Figure 6 presents separate RDD estimates for each election.

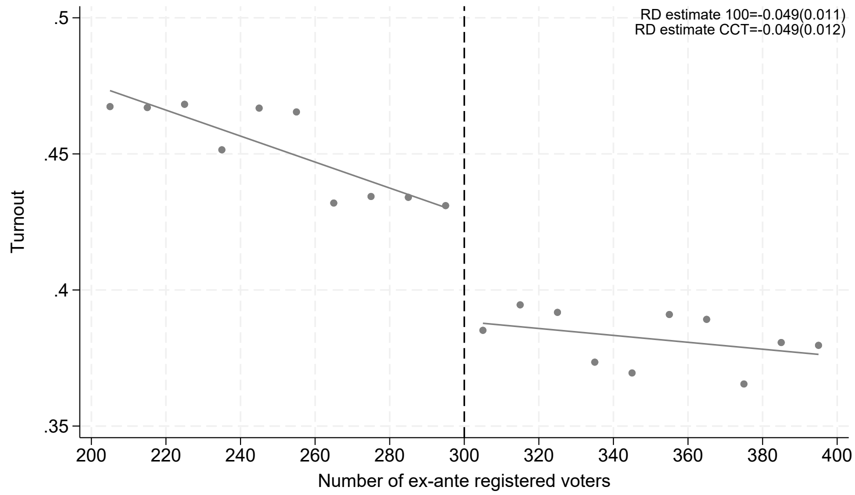
The results show a significant negative impact of machine voting on turnout – pooling the three machine elections, we find that turnout is, on average, 4.9 percentage points lower in polling stations just above the machine voting threshold compared to those just below. This corresponds to a 12% decline relative to the mean. The negative effect holds for each of the three machine elections, but is largest and most precisely estimated for the general elections of July 2021 and November 2021. Indeed, we find similar effects in both rounds of the presidential election held in November 2021 with the same voting technology (Appendix Figure C2).[22]

Yet, giving voters the choice between machine and paper has no effect on turnout – the estimates for the four mixed elections are noisy and switch signs but are always insignificant, and the pooled sample estimate rules out a negative reduced form effect larger than 1.6 percentage points (Appendix Table C5).

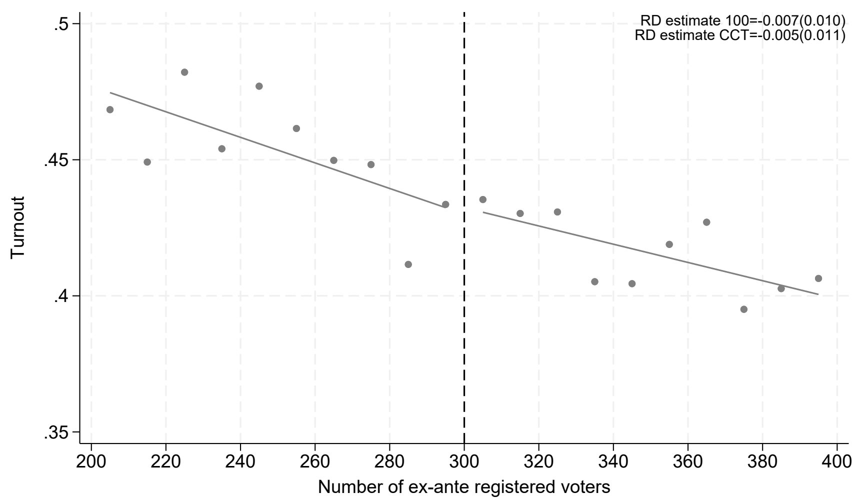
[22]The first round of the presidential election was held concurrently with the general election; the run-off was held one week later.

Figure 5: Turnout: RDD estimates

(a): Machine elections (pooled)



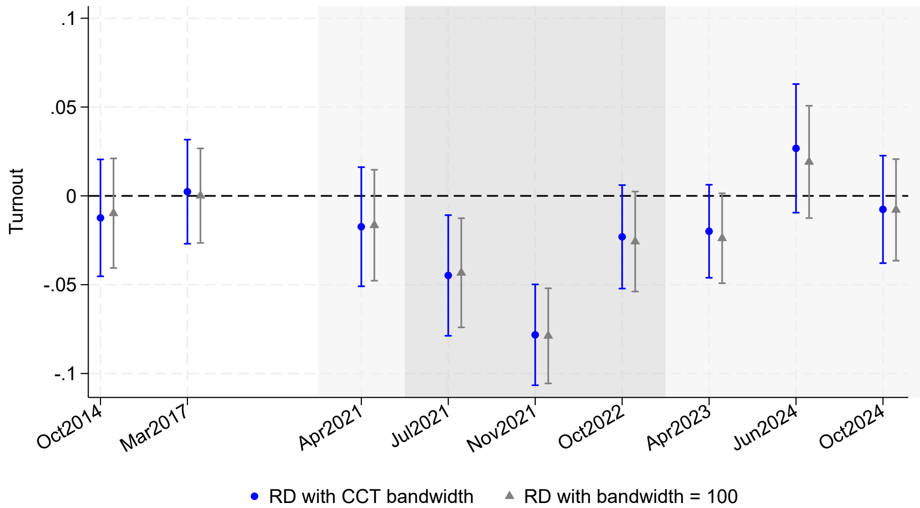
(b): Mixed elections (pooled)



Notes: Binned scatter plot: Share of turnout over registered voters by bin of the number of ex-ante registered voters. The vertical line indicates the threshold that determines the allocation of voting machines across polling stations. The sample in panel (a) consists of the three elections with machine voting in polling stations above the threshold. The sample in panel (b) consists of the four elections with a choice between machine or paper voting in polling stations above the threshold.

Heterogeneity. Appendix section D.2 presents a heterogeneity analysis of these effects, splitting the sample based on the socio-economic characteristics of polling station localities. For machine elections, these results consistently show that the decline in turnout is driven by polling stations located in disadvantaged areas – it is more pronounced in villages compared to towns or cities (p-val = 0.14), in localities with higher unemployment rates (p-val = 0.27),

Figure 6: Turnout: RDD estimates by election



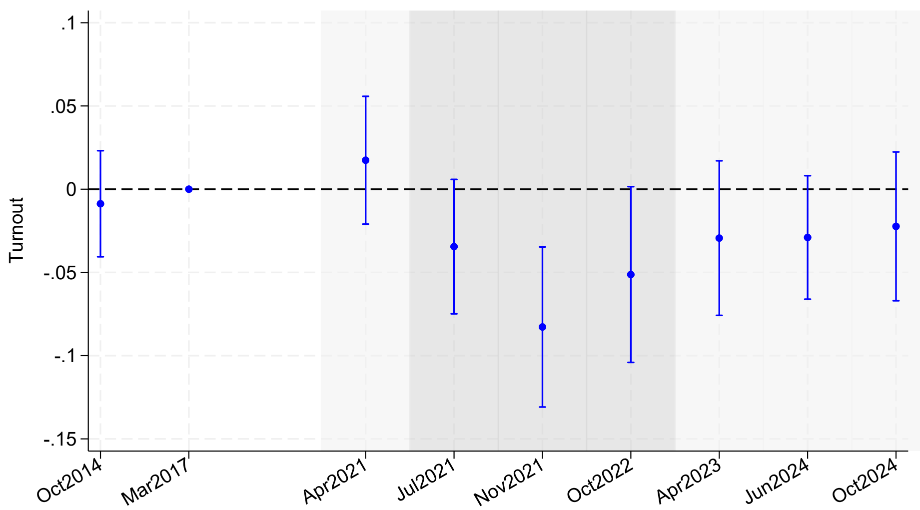
and ones with lower educational attainment (p-val = 0.07).

For mixed elections, the heterogeneity analysis supports the conclusion that giving voters a choice between machine and paper does not affect turnout – we find no significant effect in any of the sub-samples we examine.

Municipality-level DiD results. As mentioned above, one limitation of the RDD analysis is that the estimated decline may reflect a reallocation of vote-buying from polling stations above the machine threshold towards the ones below. To make this distinction, we turn to the municipality-level analysis. If there are negative spillovers from one side of the threshold to the other, and if they operate locally – i.e. within a municipality – we would expect that aggregating the analysis up to this level should lead to an attenuation of the estimated effects.

Figure 7 and Appendix Table C6 report the results of specification 2. The estimated effects are remarkably similar to the RDD ones, suggesting a decline in turnout in machine elections by about 5 percentage points. Again, we find no impact on turnout in mixed elections. This indicates that the RDD results documented in the previous section are unlikely to be due to a reallocation of voting or vote-buying activity from one side of the threshold to the other.

Figure 7: Turnout: Municipality-level event study estimates (DiD)



Notes: The plot shows event-study estimates of the effect of voting technology on turnout. Estimates in the dark gray area show effects in machine elections, and estimates in the light gray area show effects in mixed elections.

6 Mechanism

Our results thus far are surprising from a Downsian calculus-of-voting perspective: They suggest that, despite increasing the likelihood of votes cast being counted towards the election results and thus increasing the probability of being pivotal (conditional on turning out), machine voting leads to a significant reduction in turnout. In this section, we investigate two potential interpretations of this result.

6.1 Reduction in bought and fictitious votes

First, in line with the motivations behind the introduction of machine voting described in Section 2, the decline in turnout may reflect a reduction in bought or fictitious votes. In the absence of direct measures of electoral fraud, we take an indirect approach to test the implications of this mechanism for (1) the distribution of votes across parties, and (2) for voters' reports of instances of vote-buying and coercion.

Votes for locally dominant parties versus other parties. Bulgaria has a proportional representation system, which means that where within the 31 constituencies in the country parties get their votes has relatively little bearing on their overall seat share. Therefore, we conjecture that the main determinant of where and to what extent parties engage in vote-buying is the strength of their established local networks – i.e., their ability to control vote brokers and/or exert influence over electoral commissions. This leads to the prediction that, if machine voting reduces vote-buying (whether directed at voters or at polling station officials), we should see a reduction in votes particularly for parties that were traditionally dominant in the respective locality.

We take this prediction to the data by decomposing the total number of valid votes cast on either side of the machine voting threshold into votes for parties that were locally dominant in the respective polling station under the paper ballot regime, versus votes for other parties. We do this classification using the two elections taking place prior to the introduction of machine voting (in 2014 and 2017), and consider as "dominant" the parties that were most voted in the polling station in either of these two elections. For placebo checks looking at 2014 and 2017 election results, we consider the party that was most voted in the same election. Note that this classification is not party-specific – the same party can be a "dominant" party in one polling station, but fall into the "other" category in another station.

Table 2 presents these results for the pooled sample of the three machine elections in panel (a), and for the pooled sample of the four mixed elections in panel (b). Column (1) reports the effects of machine voting on the total number of valid votes, and columns (2) and (3) break down this number into votes for traditionally dominant parties versus other parties. Figure 8 presents scatter plots corresponding to these outcomes pooling the elections in each technology regime, and Figure 9 presents the estimated effects for each separate election.

The results show that, in machine elections, about 10% fewer valid votes are cast in polling stations above the machine voting threshold compared to the ones below, indicating that the negative turnout effect dominates the increase in the share of valid votes. This decline is not uniform across parties – it is driven entirely by a decline in votes for parties

Table 2: Votes for locally dominant parties versus other parties: RDD estimates

(a): Machine elections

	(1) IHS(Total valid votes)	(2) IHS(Votes for dominant parties)	(3) IHS(Votes for other parties)
Machine voting	-0.0984***	-0.241***	-0.0308
	(0.0380)	(0.0900)	(0.0672)
Province × election FEs	Yes	Yes	Yes
Mean dep var (levels)	125.07	55.70	69.46
Effective observations left	1,296	1,702	1,168
Effective observations right	1,507	2,028	1,352
Bandwidth	85	112	80
p-value (2) = (3)			0.06

(b): Mixed elections

	(1) IHS(Total valid votes)	(2) IHS(Votes for dominant parties)	(3) IHS(Votes for other parties)
Choice machine or paper	-0.0275	-0.0952	-0.0143
	(0.0319)	(0.0889)	(0.0615)
Province × election FEs	Yes	Yes	Yes
Mean dep var (levels)	128.04	57.54	70.27
Effective observations left	1,673	2,413	1,735
Effective observations right	1,857	2,898	1,943
Bandwidth	80	119	87
p-value (2) = (3)			0.45

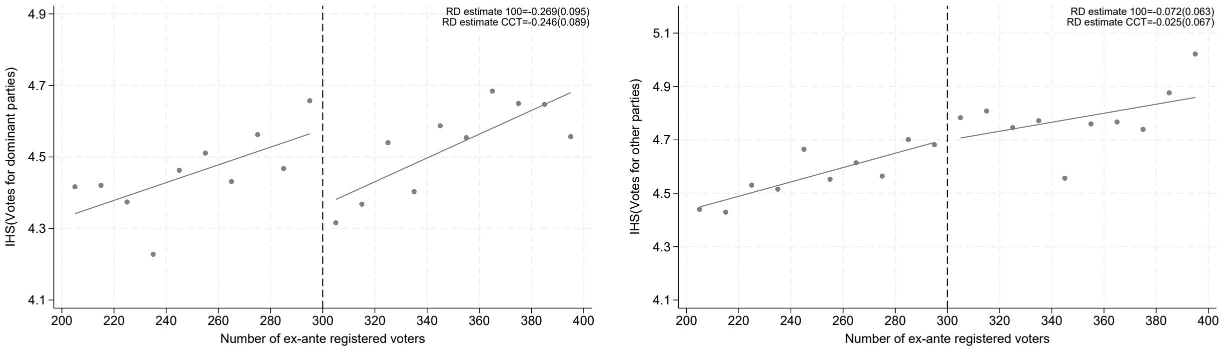
Notes: RDD estimates of the effects of voting technology on the number of votes for parties that are locally dominant at baseline, versus other parties. The table presents β coefficients estimated from equation 1. The sample in panel (a) consists of the three elections with machine voting in polling stations above the threshold. The sample in panel (b) consists of the four elections with a choice of machine or paper voting in polling stations above the threshold. The bandwidth in each regression is chosen using the MSE optimal procedure suggested by Calonico et al. (2014b). Standard errors clustered by polling station. Significance levels: * p < 0.1, ** p < 0.05, *** p < 0.01.

that were dominant in the respective polling station at baseline (a decline of 24%), while votes for other parties are unaffected.[23] We reject the null hypothesis of equality of the coefficients estimated for these two outcomes at the 6% level. We find no significant effects

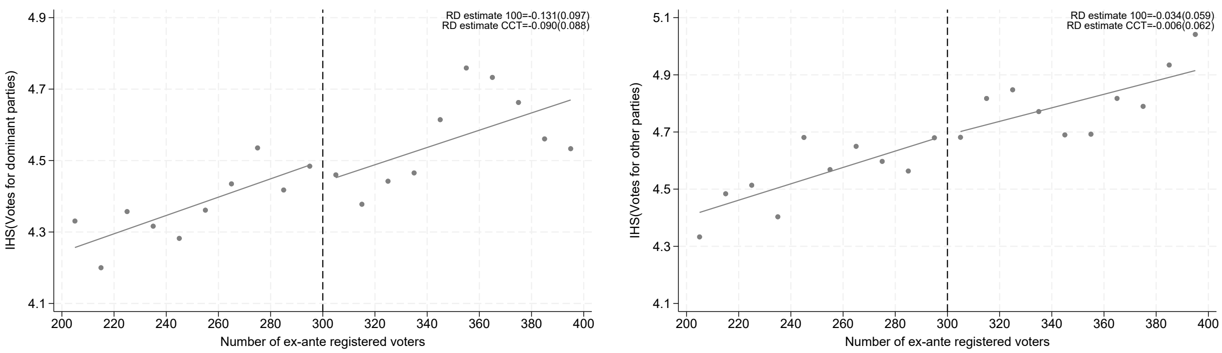
[23]We define the dependent variables as the inverse hyperbolic sine (IHS) of the number of votes of each type, as the disaggregation creates some zeros in these vote counts. Unlike the logarithmic transformation, the IHS is well-defined in such cases. That said, results are similar when using a log(1+x) transformation or when normalizing the number of votes by the number of registered voters.

Figure 8: Votes for locally dominant parties versus other parties: RDD estimates

(a): Machine elections (pooled)



(b): Mixed elections (pooled)

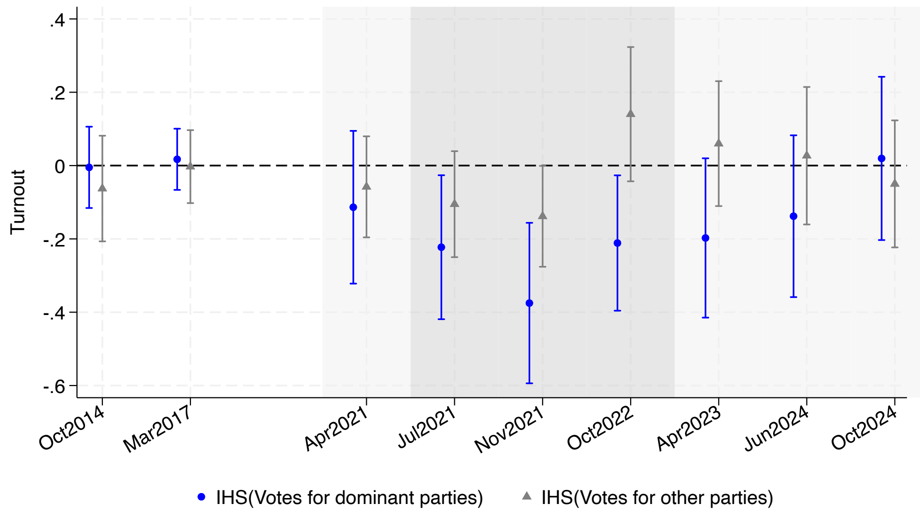


Notes: Binned scatter plot: The vertical line indicates the threshold that determines the allocation of voting machines across polling stations. The sample in panel (a) consists of the three elections with machine voting in polling stations above the threshold. The sample in panel (b) consists of the four elections with a choice of machine or paper voting in polling stations above the threshold.

looking at the pooled sample of mixed elections – neither on total valid votes cast, nor on votes for locally dominant or other parties, although we estimate a negative and marginally significant coefficient for votes for dominant parties in April 2023.

Importantly, this heterogeneity is not driven by generally lower turnout among supporters of established versus new parties, which may be correlated with skepticism toward the new technology. Rather, established parties lose votes only in areas where they were initially dominant, but not elsewhere. We show this in Appendix Table C7 by disaggregating votes for non-dominant parties into those for established parties that were not dominant in the respective polling station at baseline, and those for new parties – i.e., parties that were either created or began receiving significant vote shares only after 2017. We find no significant effect of the voting technology on votes for either group.

Figure 9: Votes for locally dominant parties versus other parties: RDD estimates by election



Notes: The plot shows RDD estimates of the effect of voting technology on the number of votes for parties that are locally dominant at baseline, versus other parties, estimated separately for each election. Estimates in the dark gray area show effects in machine elections and estimates in the light gray area show effects in mixed elections.

As a robustness check, we also consider alternative definitions of party dominance. First, in Appendix Table C8 we define as locally "dominant" only parties that were *consistently* most voted in the respective polling station in both baseline elections. Second, in Appendix Table C9, we use the party affiliation of the incumbent municipal mayor. The latter measure has the advantage that it looks at the local government currently in power rather than at past election results.[24] We find similar results using both definitions – parties that were locally dominant in past general elections, as well as those currently holding the mayoral office, tend to lose votes under the new voting technology.

Survey evidence: Reports of vote-buying and coercion. Next, we turn to the survey data we collected in collaboration with Gallup, in which we elicit reports of vote-buying attempts. The goal of this analysis is to test whether such reports differ between respondents assigned to machine versus paper-ballot polling stations. To do so, we use an indicator for self-reported polling station assignment, equal to one if the respondent reports was assigned

[24]Note that local elections in the period of interest took place only with paper ballots, with the exception of runoffs in 2023).

to a polling station with a machine at least once since the introduction of machine voting, and equal to zero otherwise. This variable is available for respondents who have voted at least once since the introduction of machine voting (which is the case for 70% of all respondents). We assume that this assignment does not change over time, as the period of interest is relatively short (about 3 years) and switches of polling stations' status are rare in the electoral data.

While the survey data does not allow us to implement an RDD strategy, we can estimate linear probability models of the dependent variables of interest on an indicator for self-reported machine versus paper polling station assignment, conditional on respondent and locality characteristics. Specifically, we control for respondents' age, age squared, and indicators for gender, high school education, ethnic minority status, and employment (full or part-time). Locality-level controls include log population, share without secondary education, share of ethnic minorities, share of elderly population, and unemployment rate. In the full sample regressions, we also include indicators for whether the locality is a village, a small town, a large town, or the capital.

Table 3 reports the results. Conditional on answering the question about knowledge of vote-buying or coercion (and conditional on non-missing polling station assignment), 55% of respondents report such instances. The full sample estimates suggest that, other things equal, respondents assigned to machine polling stations are about 10 percentage points less likely to report vote-buying or coercion compared to those assigned to paper polling stations, though this correlation is imprecisely estimated (p-value = 0.131 in our preferred specification). The difference is more strongly pronounced in the subsample of rural areas, where respondents assigned to machine stations are 23 percentage points (about 46%) less likely to report vote-buying activity compared to respondents assigned to paper polling stations (p-value = 0.036). We find no such correlation in towns and cities – consistent with the fact that the turnout effect documented earlier is driven entirely by rural areas.

Table 3: Survey evidence: Reports of vote-buying or voter coercion

	Full sample		Villages		Towns/ Cities	
	(1)	(2)	(3)	(4)	(5)	(6)
	Heard of vote-buying					
Machine present in polling station	-0.095	-0.103	-0.261**	-0.230**	0.014	-0.007
	(0.067)	(0.069)	(0.105)	(0.108)	(0.080)	(0.086)
Respondent characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Locality characteristics	No	Yes	No	Yes	No	Yes
Locality type FEs	Yes	Yes	No	No	No	No
Observations	1,056	1,041	209	205	847	836
R^2	0.03	0.05	0.04	0.11	0.00	0.03
Mean dep var	0.55	0.56	0.50	0.49	0.57	0.57

Notes: This table presents respondent-level regressions of an indicator for self-reported knowledge of local vote-buying on an indicator for machine presence in the respondent's polling station. Respondent characteristics include gender, age, age squared, and indicators for high school, ethnic minority status, and being employed. Locality characteristics include log population, share without secondary education, share of ethnic minorities, share of elderly population, and unemployment rate. Locality type refers to village, small town, large town or the capital. Columns (1) and (2) report estimates for the full sample of survey respondents; Columns (3) and (4) report estimates for the sub-sample of rural areas; Columns (5) and (6) report estimates for the sub-sample of towns and cities. Robust standard errors in parenthesis. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

6.2 Alternative mechanism: Discouragement

An alternative explanation for the negative effect of machine voting on turnout is that the technology makes it more difficult for some vote voters to cast a vote, or that it discourages some voters from turning out because of distrust in the technology.

Capacity constraints and technical difficulties. Although longer wait times or technical malfunctions associated with the new technology could, in principle, reduce turnout, such concerns are unlikely to be vital in small polling stations near the machine assignment threshold. Polling stations at the threshold record an average turnout of approximately 130 votes, while experimental evidence from the Central Election Commission indicates that a single voting machine can process up to 75 votes per hour.[25] Given the 13-hour duration of the election day, this suggests that these stations operate well below capacity.

Nonetheless, as a test for the role of capacity constraints, we exploit a discontinuity in

[25] https://www.actualno.com/topnews/cik-po-75-izbirateli-na-chas-glasuvat-s-mashina-news_1599101.html#google_vignette

machine allocation between polling stations equipped with one versus two voting machines. The assignment of a second machine was based on a turnout threshold from the previous general election.[26] Figure C4 confirms that the thresholds – set at 425 voters in July 2021 and 350 voters in October 2022 – were binding: polling stations just above the cutoff received two machines, while those just below received only one. Despite the sharp increase in machine allocation at the threshold, we find no corresponding change in turnout. Thus, there is no evidence that capacity constraints induced by the technology played a meaningful role in driving the observed decline in voter participation.

We also find little evidence of widespread technical malfunctions. In exit poll surveys conducted by Gallup during the July 2021 and October 2022 elections, only 3.9% of voters assigned to machine stations report any problems with the machines. As mentioned in section 2, in the rare cases when a machine did malfunction, voters were permitted to switch to paper voting.

Information on voting technology available to voters. Even in the absence of deterrence from wait times or technical malfunctions at the polling station, turnout may be negatively affected if voters factor the voting technology into their turnout decision ex ante. To generate the observed discontinuity in turnout at the machine assignment threshold, this mechanism would require that voters were informed in advance about the technology assigned to their polling station. However, such information was scarce during the initial phases of machine voting implementation.

Prior to the full-scale rollout of machine voting, the Central Election Commission launched an information campaign that included television advertisements and an online voting simulator disseminated to familiarize voters with the new technology. Notably, the campaign omitted any reference to the fact that small polling stations—constituting only a minor share of the electorate—would continue to use paper ballots. This implies that any potential disincentive effects on turnout would not systematically vary by station type.

[26] In the November 2021 election, polling stations with more than 320 voters in both the April and July 2021 elections received a second machine. Due to this double discontinuity, we do not report RDD estimates for this election.

To the best of our knowledge, the only polling-station specific information released by the Electoral Commission is a spreadsheet posted on its website in the weeks before each election, which lists the polling stations equipped with machines. Yet, given the lack of active dissemination, it is unlikely that voters—particularly those with limited digital literacy—accessed this data at a significant rate.[27] Consistent with this, in our June 2024 survey, conducted after five consecutive machine-based elections and just one week before the upcoming election, over 50 percent of respondents report that they do not know what voting technology would be used in their polling station.

Self-reported discouragement. To more directly assess whether voter discouragement contributes to the negative effect of machine voting on turnout, we examine responses to a survey question on self-reported deterrence. Among respondents who answered this question, approximately 8%—and 10% within the estimation sample—report having been discouraged from voting at least once due to the use of voting machines. The two most commonly cited reasons are mistrust in the reliability of machine voting and the perception that the technology is difficult to use.

However, the regression results in Table 4 indicate no significant difference in reported discouragement between individuals assigned to machine versus paper polling stations, conditional on covariates. This null result holds across both urban and rural areas, with statistically insignificant estimates in both subsamples and, if anything, negative point estimates in the rural sample.

These findings suggest that while aversion to the new technology is not negligible and may contribute to lower turnout in machine elections overall, it is unlikely to generate the sharp discontinuity observed at the polling station assignment threshold.

[27] In contrast, voters can query the address of their assigned polling station based on their national ID number through a user-friendly online platform or through a free messaging service. Neither service included information on whether the station is equipped with a voting machine.

Table 4: Survey evidence: Self-reported discouragement

	Full sample		Villages		Towns/ Cities	
	(1)	(2)	(3)	(4)	(5)	(6)
	Discouraged from voting					
Machine present in polling station	0.006	-0.001	-0.006	-0.076	0.001	-0.002
	(0.047)	(0.049)	(0.097)	(0.096)	(0.053)	(0.056)
Respondent characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Locality characteristics	No	Yes	No	Yes	No	Yes
Locality type FEs	Yes	Yes	No	No	No	No
Observations	1,050	1,035	204	200	846	835
R^2	0.03	0.03	0.03	0.09	0.02	0.03
Mean dep var	0.10	0.10	0.13	0.14	0.09	0.09

Notes: This table presents respondent-level regressions of an indicator for self-reported discouragement from voting due to the machine technology, on an indicator for machine presence in the respondent's polling station. Respondent characteristics include gender, age, age squared, and indicators for high school, ethnic minority status, and being employed. Locality characteristics include log population, share without secondary education, share of ethnic minorities, share of elderly population, and unemployment rate. Locality type refers to village, small town, large town or the capital. Columns (1) and (2) report estimates for the full sample of survey respondents; Columns (3) and (4) report estimates for the sub-sample of rural areas; Columns (5) and (6) report estimates for the sub-sample of towns and cities. Robust standard errors in parenthesis. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

7 Conclusion

In this paper, we examine the potential of voting technology to enhance electoral integrity in developing democracies. Using administrative data from Bulgaria and a regression discontinuity design, we show that the introduction of machine voting increases the share of valid ballots but also leads to a sizable decline in voter turnout. The decline in turnout is concentrated in poor and rural areas and arises only when machine voting is mandatory rather than optional. This effect is driven by a reduction in votes for parties that were locally dominant prior to the reform. Evidence from a nationally representative survey points to a decline in bought or fictitious votes as a plausible mechanism.

Our findings suggest several avenues for future research. First, our results speak to the effects of machine voting in a relatively short timespan. Whether and how clientelistic parties adjust their strategies in the longer run is an open question.[28]

[28] For example, the framework by (Gans-Morse et al. 2014) suggests that increased ballot secrecy reduces pure vote-buying (which is conditioned on verifying vote choice) but may lead to an increase in turnout-

Second, although we conclude that voters' doubts over the accessibility and security of machine voting are unlikely to fully account for our results, we document that such concerns are non-negligible. Understanding the origins of these perceptions remains an important area for future work, particularly given their prominence in other countries adopting similar technologies.

Third, we note that our analysis applies to a setting characterized by independent electoral institutions and strong electoral competition. Whether and how voting technology can be (mis)-used in more authoritarian settings remains an open question.

buying – i.e., the practice of offering incentives to latent supporters conditional on turnout but irrespective of vote choice.

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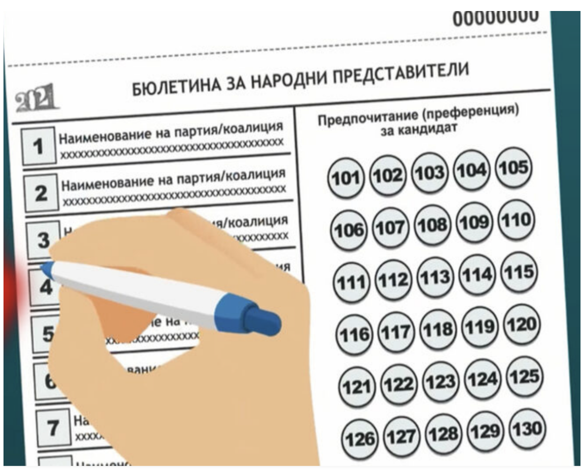
A Background

Figure A1: Logistics of paper-ballot versus machine voting

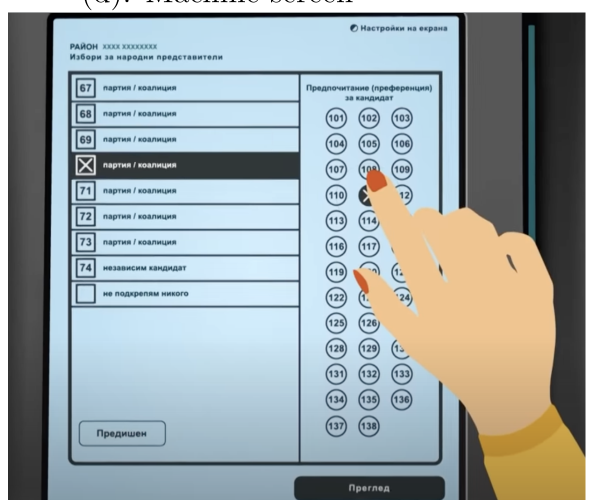
(a): Voting with paper ballot

(b): Voting with machine

(c): Paper ballot

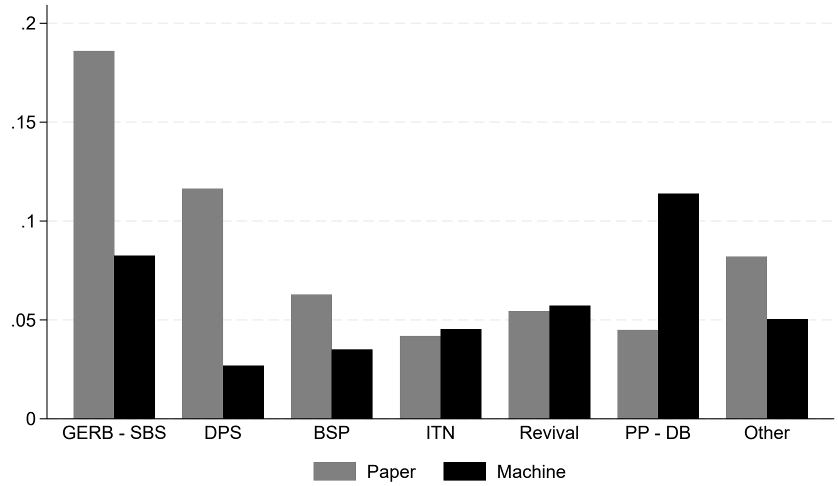


(d): Machine screen



Notes: The figure illustrates the logistics of paper-ballot and machine voting in Bulgarian general elections. Panels (a) and (b) depict the polling station setup for each type of voting technology, while panels (c) and (d) show the respective ballot formats.

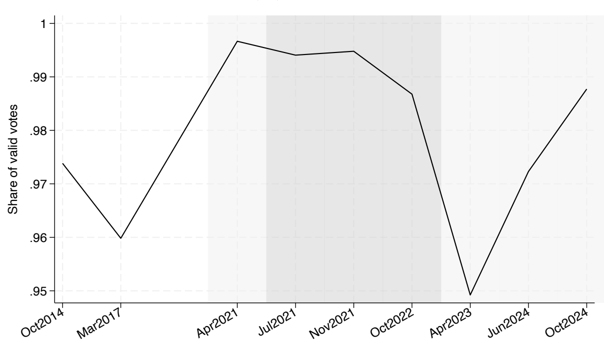
Figure A2: Machine take-up in mixed elections by party



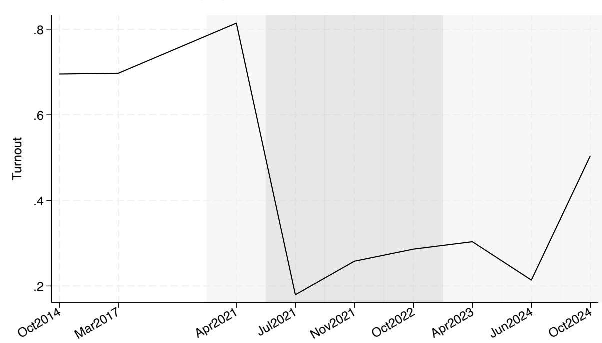
Notes: The figure plots party vote shares in mixed elections separately for votes cast with paper ballots (in gray) and machine votes (in black) in polling stations above the 300 ex-ante registered voters threshold.

Figure A3: Case study: Bukovlak

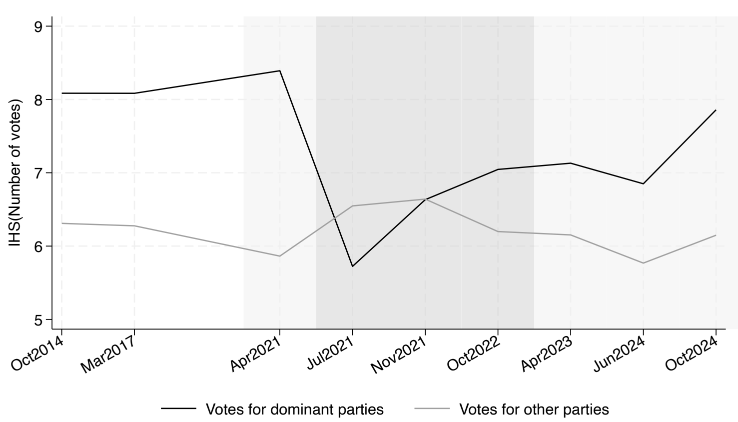
(a) Share of valid votes



(b) Turnout

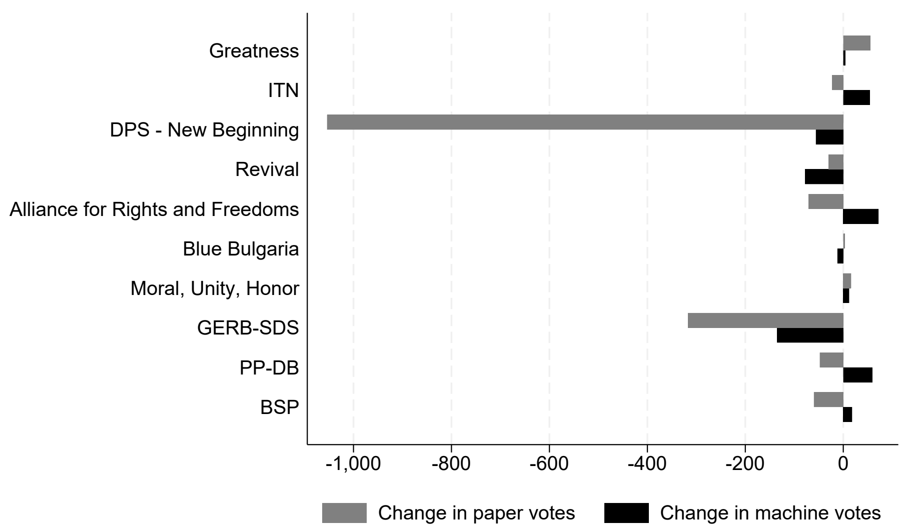


(c) Votes for locally dominant parties versus other parties



Notes: Evolution of electoral outcomes in the village of Bukovlak.

Figure A4: Changes in the number of party votes in the October 2024 election recount

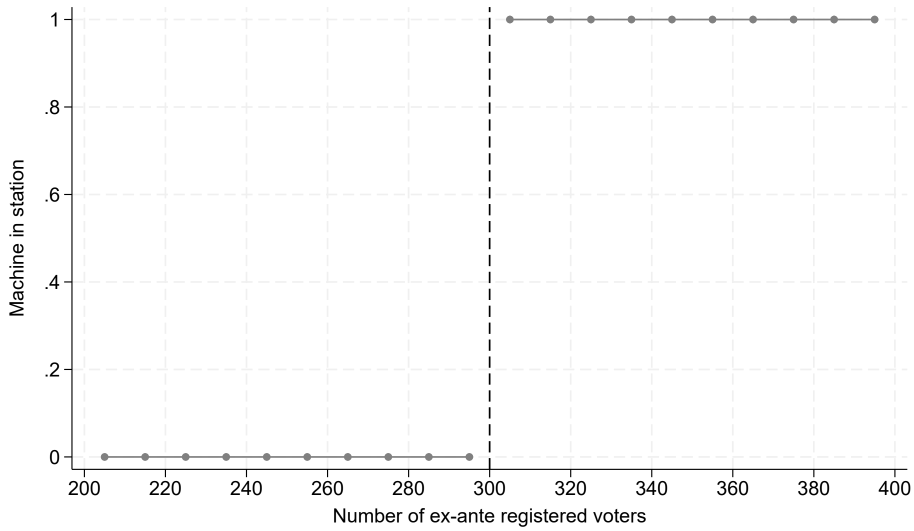


Notes: The figure plots the change in the number of party votes between the originally announced results after the October 2024 election and the recount per party by paper and machine. The figure includes the ten parties that received the highest overall number of votes according to the final election results.

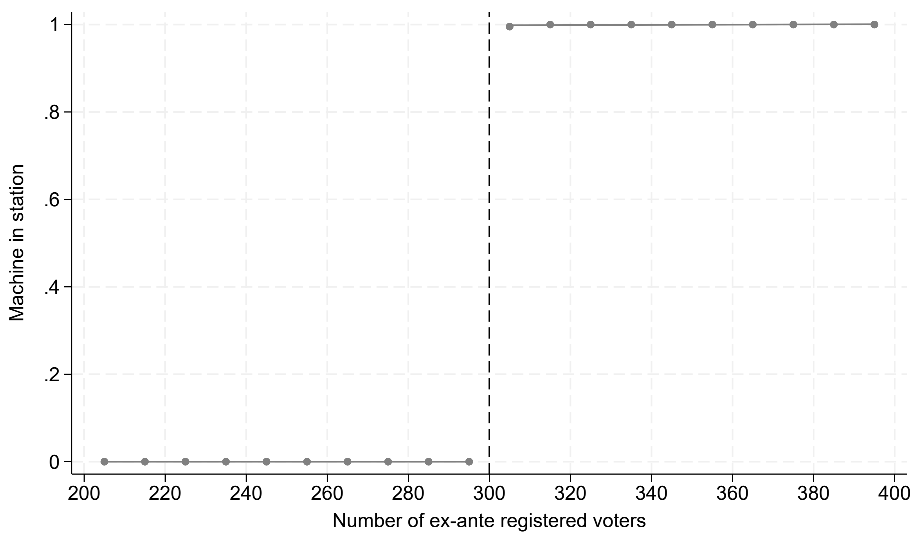
B RDD manipulation and placebo checks

Figure B1: Allocation of voting machines

(a): Machine elections



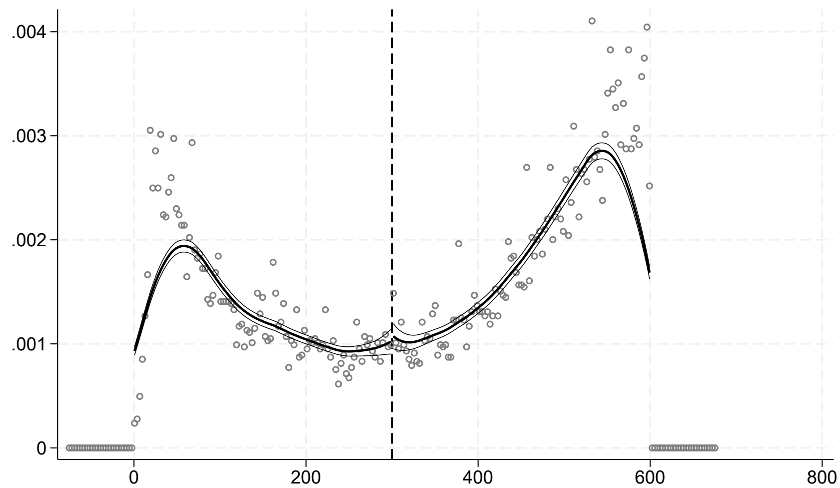
(b): Mixed elections



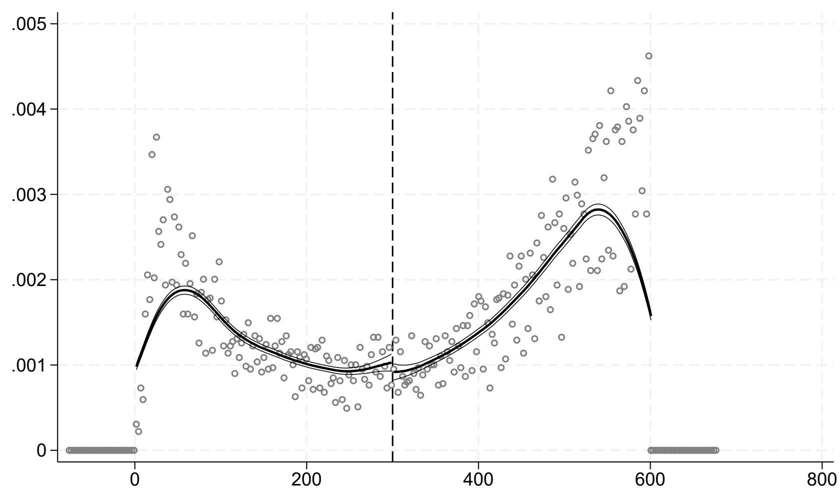
Notes: Binned scatter plot: Share of polling stations with (one or more) machine by bin of the number of ex-ante registered voters. The vertical line indicates the threshold that determines the allocation of voting machines across polling stations. The sample in panel (a) consists of the three elections with machine voting in polling stations above the threshold. The sample in panel (b) consists of the four elections with a choice of machine or paper voting in polling stations above the threshold.

Figure B2: McCrary test for manipulation of the running variable

(a): Machine-only elections



(b): Mixed elections



Notes: McCrary test for discontinuity in the density of the running variable – number of ex-ante registered voters. The vertical line indicates the threshold that determines the allocation of voting machines across polling stations. The sample in panel (a) consists of the three elections with machine-only voting in polling stations above the threshold. The sample in panel (b) consists of the four elections with a choice of machine or paper voting in polling stations above the threshold.

Table B1: Placebo: Baseline outcomes prior to the introduction of machine voting

	Valid votes / turnout	
	(1) Oct2014	(2) Mar2017
$\geq$ 300 ex-ante registered voters	0.00604	0.00956*
	(0.00499)	(0.00576)
Province × election FEs	Yes	Yes
Mean dep var	0.92	0.92
Effective observations left	372	410
Effective observations right	384	406
Bandwidth	70	76

	Turnout / registered voters	
	(1) Oct2014	(2) Mar2017
$\geq$ 300 ex-ante registered voters	-0.0124	0.00236
	(0.0168)	(0.0149)
Province × election FEs	Yes	Yes
Mean dep var	0.54	0.56
Effective observations left	486	432
Effective observations right	491	432
Bandwidth	88	79

	(1) Oct2014	(2) Mar2017
$\geq$ 300 ex-ante registered voters	-0.00735	0.0191
	(0.0572)	(0.0416)
Province × election FEs	Yes	Yes
Mean dep var	4.96	5.05
Effective observations left	411	504
Effective observations right	428	538
Bandwidth	76	94

Notes: Placebo test for pre-treatment discontinuity in outcomes of interest. The table presents β coefficients estimated from Equation 1 for the baseline period prior to the introduction of machine voting. The dependent variables are the number of valid votes over turnout in the upper panel, turnout over the number of registered voters in the middle panel, and the IHS-transformed number of votes for the dominant party (i.e., the party obtaining most votes in the respective polling station) in the lower panel. The bandwidth in each regression is chosen using the MSE optimal procedure suggested by Calonico et al. (2014b). Significance levels: * p < 0.1, ** p < 0.05, *** p < 0.01.

Table B2: Placebo: Socio-economic characteristics of polling station localities

(a): Machine elections

	(1) Log population	(2) Unemployment rate	(3) Share without secondary education	(4) Share minority population	(5) Share elderly population
$\geq$ 300 ex-ante registered voters	-0.223*	-0.0139	0.00655	0.0179	0.00120
	(0.119)	(0.0187)	(0.00990)	(0.0239)	(0.0103)
Province $\times$ election FEs	Yes	Yes	Yes	Yes	Yes
Mean dep var	6.66	0.22	0.21	0.29	0.27
Effective observations left	1,845	1,559	2,088	2,187	1,923
Effective observations right	2,192	1,839	2,499	2,624	2,308
Bandwidth	116	101	129	135	121

(b): Mixed elections

	(1) Log population	(2) Unemployment rate	(3) Share without secondary education	(4) Share minority population	(5) Share elderly population
$\geq$ 300 ex-ante registered voters	-0.188*	-0.0118	0.00983	0.0167	-0.00389
	(0.109)	(0.0176)	(0.00939)	(0.0227)	(0.00932)
Province $\times$ election FEs	Yes	Yes	Yes	Yes	Yes
Mean dep var	6.70	0.22	0.21	0.28	0.27
Effective observations left	2,422	2,186	2,753	3,031	2,532
Effective observations right	2,869	2,568	3,312	3,671	3,017
Bandwidth	114	104	128	137	118

Notes: Placebo test for discontinuity in the socio-economic characteristics of polling station localities. The table presents β coefficients estimated from Equation 1. The dependent variables are from the 2011 census and are measured at the locality level. The sample in panel (a) consists of the three elections with machine voting in polling stations above the threshold. The sample in panel (b) consists of the four elections with a choice of machine or paper voting in polling stations above the threshold. The bandwidth in each regression is chosen using the MSE optimal procedure suggested by Calonico et al. (2014b). Standard errors are clustered by locality. Significance levels: * p < 0.1, ** p < 0.05, *** p < 0.01.

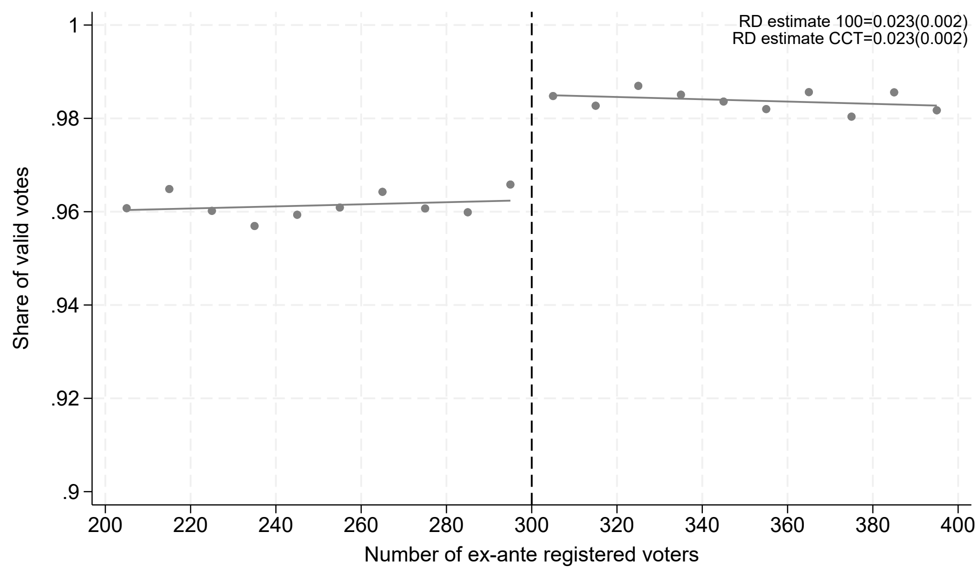
Table B3: Placebo: Local elections 2023, Round 1

	(1) Valid votes / turnout	(2) Turnout / registered voters
Machine voting	0.000532	0.0136
	(0.00571)	(0.0295)
Province FEs	Yes	Yes
Mean dep var	0.93	0.48
Effective observations left	414	144
Effective observations right	488	211
Bandwidth	73	73

Notes: Placebo test for discontinuity in outcomes of interest during the first round of local elections conducted in October 2023. The table presents β coefficients estimated from Equation 1. The dependent variables are shown in the column titles. The bandwidth in each regression is chosen using the MSE optimal procedure suggested by Calonico et al. (2014b). Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

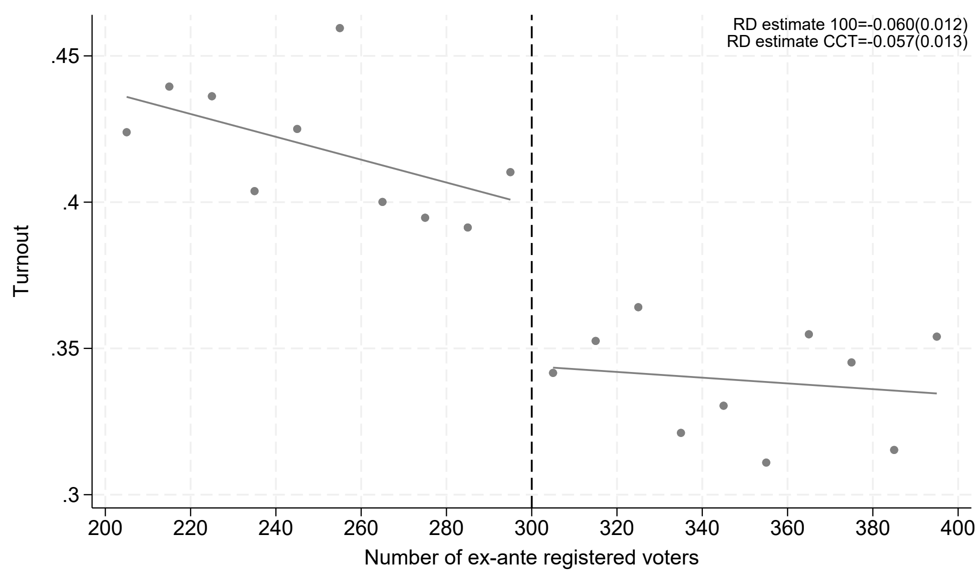
C Additional results

Figure C1: Share valid votes: Presidential election



Notes: Binned scatter plot: Share of valid votes over turnout by bin of the number of ex-ante registered voters. The vertical line indicates the threshold that determines the allocation of voting machines across polling stations. Sample: first and second round of the presidential election of November 2021.

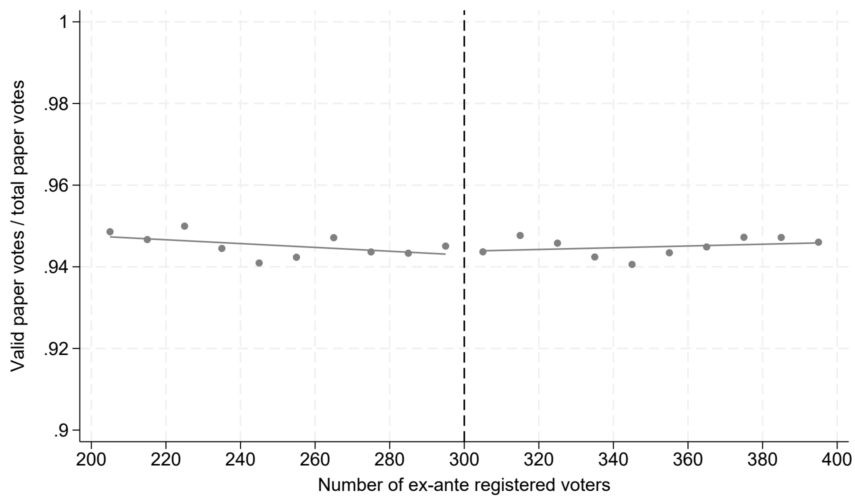
Figure C2: Turnout: Presidential election



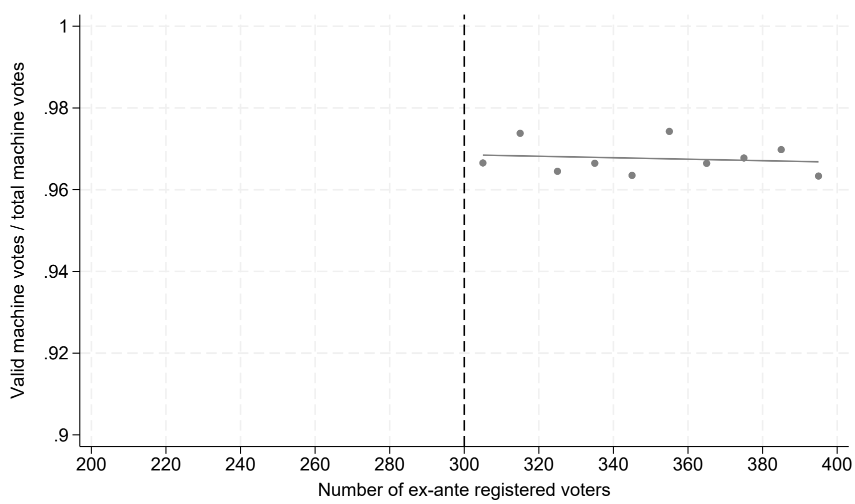
Notes: Binned scatter plot: Share of turnout over registered voters by bin of the number of ex-ante registered voters. The vertical line indicates the threshold that determines the allocation of voting machines across polling stations. Sample: first and second round of the presidential election of November 2021.

Figure C3: Breakdown of valid votes in mixed elections

(a): Valid paper votes/ total paper votes



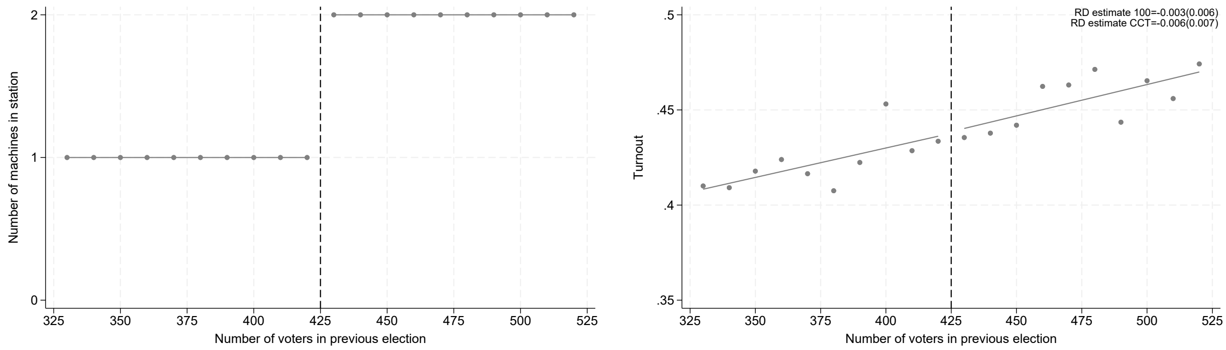
(b): Valid machine votes/ total machine votes



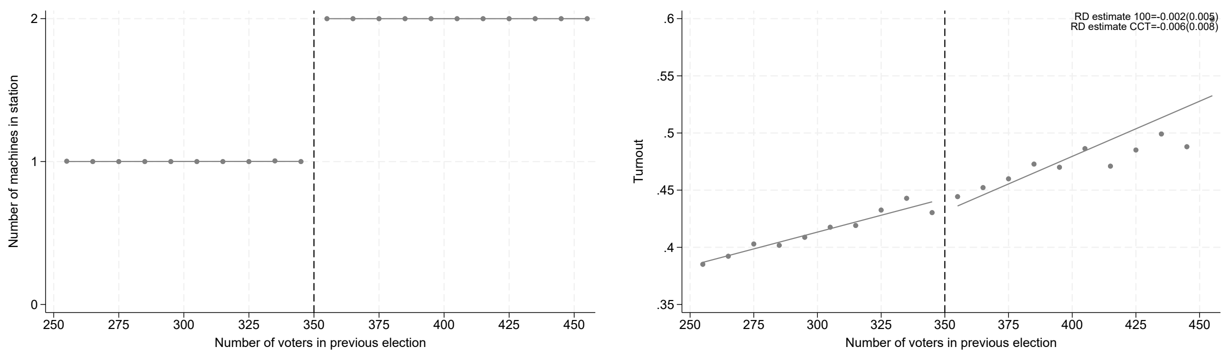
Notes: Binned scatter plot: Decomposition of the share of valid votes, by bin of the number of ex-ante registered voters. The vertical line indicates the threshold that determines the allocation of voting machines across polling stations. The sample consists of the four elections with a choice of machine or paper voting in polling stations above the threshold.

Figure C4: Number of machines in station and turnout: RDD estimates

(a): July 2021 election



(b): October 2022 election



Notes: Binned scatter plot: Number of machines in station and turnout by number of voters in the previous election. The vertical line indicates the threshold that determines the allocation of a second voting machine across polling stations. The sample is polling stations with at least one voting machine.

Table C1: Share of valid votes: RDD estimates

(a): Machine elections

	Valid votes / turnout			
	(1) Jul2021	(2) Nov2021	(3) Oct2022	(4) Pooled
Machine voting	0.0353***	0.0386***	0.0364***	0.0371***
	(0.00359)	(0.00300)	(0.00303)	(0.00202)
Province $\times$ election FEs	Yes	Yes	Yes	Yes
Mean dep var	0.98	0.97	0.96	0.97
Effective observations left	399	369	530	1,643
Effective observations right	472	416	610	1,935
Bandwidth	80	74	100	105

(b): Mixed elections

	Valid votes / turnout				
	(1) Apr2021	(2) Apr2023	(3) Jun2024	(4) Oct2024	(5) Pooled
Choice machine or paper	0.00203	0.0169***	-0.00288	0.00980**	0.00783***
	(0.00345)	(0.00480)	(0.00564)	(0.00384)	(0.00231)
Province $\times$ election FEs	Yes	Yes	Yes	Yes	Yes
Mean dep var	0.96	0.95	0.94	0.95	0.95
Mean take-up	0.13	0.51	0.20	0.22	0.28
Effective observations left	435	561	321	415	2,532
Effective observations right	503	660	314	446	3,017
Bandwidth	84	106	60	78	118

Notes: RDD estimates for the effects of voting technology on the share of valid votes. The table presents β coefficients estimated from Equation 1. The sample in panel (a) consists of the three elections with machine voting in polling stations above the threshold. The sample in panel (b) consists of the four elections with a choice of machine or paper voting in polling stations above the threshold. The bandwidth in each regression is chosen using the MSE optimal procedure suggested by Calonico et al. (2014b). Standard errors in pooled specifications are clustered by polling station. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table C2: Null votes: RDD estimates

(a): Machine elections

	Null votes / turnout			
	(1) Jul2021	(2) Nov2021	(3) Oct2022	(4) Pooled
Machine voting	-0.0310***	-0.0328***	-0.0329***	-0.0332***
	(0.00307)	(0.00273)	(0.00218)	(0.00166)
Province × election FEs	Yes	Yes	Yes	Yes
Mean dep var	0.01	0.02	0.02	0.01
Effective observations left	425	315	456	1,625
Effective observations right	498	356	502	1,911
Bandwidth	84	62	86	103

(b): Mixed elections

	Null votes / turnout				
	(1) Apr2021	(2) Apr2023	(3) Jun2024	(4) Oct2024	(5) Pooled
Choice machine or paper	-0.000262	-0.0145***	0.00392	-0.0107***	-0.00696***
	(0.00316)	(0.00349)	(0.00537)	(0.00310)	(0.00201)
Province × election FEs	Yes	Yes	Yes	Yes	Yes
Mean dep var	0.04	0.02	0.04	0.03	0.03
Mean take-up	0.13	0.51	0.20	0.22	0.28
Effective observations left	446	566	338	391	2,374
Effective observations right	516	671	336	420	2,820
Bandwidth	87	107	63	75	112

Notes: RDD estimates for the effects of voting technology on the share of null votes. The table presents β coefficients estimated from Equation 1. The sample in panel (a) consists of the three elections with machine voting in polling stations above the threshold. The sample in panel (b) consists of the four elections with a choice of machine or paper voting in polling stations above the threshold. The bandwidth in each regression is chosen using the MSE optimal procedure suggested by Calonico et al. (2014b). Standard errors in pooled specifications are clustered by polling station. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table C3: Blank votes: RDD estimates

(a): Machine elections

	Blank votes / turnout			
	(1) Jul2021	(2) Nov2021	(3) Oct2022	(4) Pooled
Machine voting	-0.00371***	-0.00509***	-0.00253	-0.00391***
	(0.00125)	(0.00128)	(0.00211)	(0.00111)
Province × election FEs	Yes	Yes	Yes	Yes
Mean dep var	0.01	0.01	0.02	0.01
Effective observations left	554	627	707	1,820
Effective observations right	679	745	841	2,147
Bandwidth	108	118	130	115

(b): Mixed elections

	Blank votes / turnout				
	(1) Apr2021	(2) Apr2023	(3) Jun2024	(4) Oct2024	(5) Pooled
Choice machine or paper	-0.00125	-0.00235	-0.00142	0.00141	-0.000778
	(0.00113)	(0.00254)	(0.00224)	(0.00203)	(0.00126)
Province × election FEs	Yes	Yes	Yes	Yes	Yes
Mean dep var	0.01	0.03	0.02	0.02	0.02
Mean take-up	0.14	0.51	0.22	0.25	0.29
Effective observations left	555	639	494	626	2,586
Effective observations right	655	758	556	742	3,083
Bandwidth	106	120	93	117	120

Notes: RDD estimates of the effects of voting technology on the share of blank votes. The table presents β coefficients estimated from Equation 1. The sample in panel (a) consists of the three elections with machine voting in polling stations above the threshold. The sample in panel (b) consists of the four elections with a choice of machine or paper voting in polling stations above the threshold. The bandwidth in each regression is chosen using the MSE optimal procedure suggested by Calonico et al. (2014b). Standard errors in pooled specifications are clustered by polling station. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table C4: Share of valid votes: Municipality-level DiD

	(1)	(2)
Share voters in ≥ 300 stations $\times$ Machine election	0.0133*	0.0292***
	(0.00740)	(0.00749)
Share voters in ≥ 300 stations $\times$ Mixed election	-0.0125**	-0.00185
	(0.00565)	(0.00574)
Municipality FEs	Yes	Yes
Province $\times$ election FEs	Yes	Yes
Num. registered voters (2017) controls	No	Yes
Mean dep var	0.95	0.95
N	2376	2376

Notes: Panel-analysis estimates from Equation 2. The level of observation is municipality $\times$ election and the sample consists of all elections since 2014. Robust standard clustered by municipality.

Table C5: Turnout: RDD estimates

(a): Machine elections

	Turnout / registered voters			
	(1) Jul2021	(2) Nov2021	(3) Oct2022	(4) Pooled
Machine voting	-0.0448***	-0.0782***	-0.0230	-0.0488***
	(0.0173)	(0.0145)	(0.0149)	(0.0115)
Province × election FEs	Yes	Yes	Yes	Yes
Mean dep var	0.44	0.40	0.40	0.41
Effective observations left	425	427	470	1,538
Effective observations right	498	507	518	1,801
Bandwidth	83	84	90	99

(b): Mixed elections

	Turnout / registered voters				
	(1) Apr2021	(2) Apr2023	(3) Jun2024	(4) Oct2024	(5) Pooled
Choice machine or paper	-0.0174	-0.0199	0.0268	-0.00760	-0.00550
	(0.0171)	(0.0134)	(0.0185)	(0.0154)	(0.0109)
Province × election FEs	Yes	Yes	Yes	Yes	Yes
Mean dep var	0.52	0.41	0.39	0.41	0.43
Mean take-up	0.13	0.50	0.21	0.23	0.27
Effective observations left	435	476	394	489	1,882
Effective observations right	503	536	439	535	2,109
Bandwidth	85	90	77	91	90

Notes: RDD estimates of the effects of voting technology on turnout. The table presents β coefficients estimated from Equation 1. The sample in panel (a) consists of the three elections with machine voting in polling stations above the threshold. The sample in panel (b) consists of the four elections with a choice of machine or paper voting in polling stations above the threshold. The bandwidth in each regression is chosen using the MSE optimal procedure suggested by Calonico et al. (2014b). Standard errors in pooled specifications are clustered by polling station. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table C6: Turnout: Municipality-level DiD

	(1)	(2)
Share voters in $\geq$ 300 stations $\times$ Machine election	-0.0343*	-0.0518**
	(0.0207)	(0.0216)
Share voters in $\geq$ 300 stations $\times$ Mixed election	-0.0173	-0.0114
	(0.0108)	(0.0126)
Municipality FEs	Yes	Yes
Province $\times$ election FEs	Yes	Yes
Num. registered voters (2017) controls	No	Yes
Mean dep var	0.43	0.43
N	2376	2376

Notes: Panel-analysis estimates from Equation 2. The level of observation is municipality $\times$ election and the sample consists of all elections since 2014. Robust standard clustered by municipality in parenthesis.

Table C7: Votes for non-dominant parties: Established versus new parties

(a): Machine elections

	(1) IHS(Votes for non-dominant established parties)	(2) IHS(Votes for non-dominant new parties)
Machine voting	-0.0566	-0.0684
	(0.130)	(0.0774)
Province × election FEs	Yes	Yes
Mean dep var (levels)	23.12	45.71
Effective observations left	1,747	1,288
Effective observations right	2,088	1,489
Bandwidth	116	86

(b): Mixed elections

	(1) IHS(Votes for non-dominant established parties)	(2) IHS(Votes for non-dominant new parties)
Choice machine or paper	0.0174	-0.107
	(0.111)	(0.0706)
Province × election FEs	Yes	Yes
Mean dep var (levels)	23.22	46.47
Effective observations left	2,244	1,998
Effective observations right	2,680	2,306
Bandwidth	111	99

Notes: RDD estimates of the effects of voting technology on the number of votes for non-dominant parties: other established parties versus new parties. The table presents β coefficients estimated from Equation 1. The sample in panel (a) consists of the three elections with machine voting in polling stations above the threshold. The sample in panel (b) consists of the four elections with a choice of machine or paper voting in polling stations above the threshold. The bandwidth in each regression is chosen using the MSE optimal procedure suggested by Calonico et al. (2014b). Standard errors clustered by polling station. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table C8: Votes for dominant parties versus other parties: Consistent dominance definition

(a): Machine elections

	(1) IHS(Votes for dominant parties)	(2) IHS(Votes for other parties)
Machine voting	-0.186**	-0.0660
	(0.0932)	(0.0865)
Province × election FEs	Yes	Yes
Mean dep var (levels)	56.05	71.27
Effective observations left	1,061	904
Effective observations right	1,281	1,068
Bandwidth	112	96
p-value (1) = (2)		0.35

(b): Mixed elections

	(1) IHS(Votes for dominant parties)	(2) IHS(Votes for other parties)
Choice machine or paper	-0.0644	0.00699
	(0.0823)	(0.0779)
Province × election FEs	Yes	Yes
Mean dep var (levels)	57.38	71.20
Effective observations left	1,448	1,205
Effective observations right	1,712	1,352
Bandwidth	112	94
p-value (1) = (2)		0.53

Notes: RDD estimates of the effects of voting technology on the number of votes for parties that were *consistently* locally dominant in both baseline elections, versus votes for other parties. The sample includes polling stations where the same party received the highest number of votes in both baseline elections. The table presents β coefficients estimated from Equation 1. The sample in panel (a) consists of the three elections with machine voting in polling stations above the threshold. The sample in panel (b) consists of the four elections with a choice of machine or paper voting in polling stations above the threshold. The bandwidth in each regression is chosen using the MSE optimal procedure suggested by Calonico et al. (2014b). Standard errors clustered by polling station. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table C9: Votes for dominant parties versus other parties: Definition based on local incumbency

(a): Machine elections

	(1) IHS(Votes for parties affiliated with incumbent mayor)	(2) IHS(Votes for other parties)
Machine voting	-0.190**	-0.0862
	(0.0820)	(0.0697)
Province × election FEs	Yes	Yes
Mean dep var (levels)	59.72	141.33
Effective observations left	1,574	1,094
Effective observations right	1,850	1,249
Bandwidth	116	83
p-value (1) = (2)		0.34

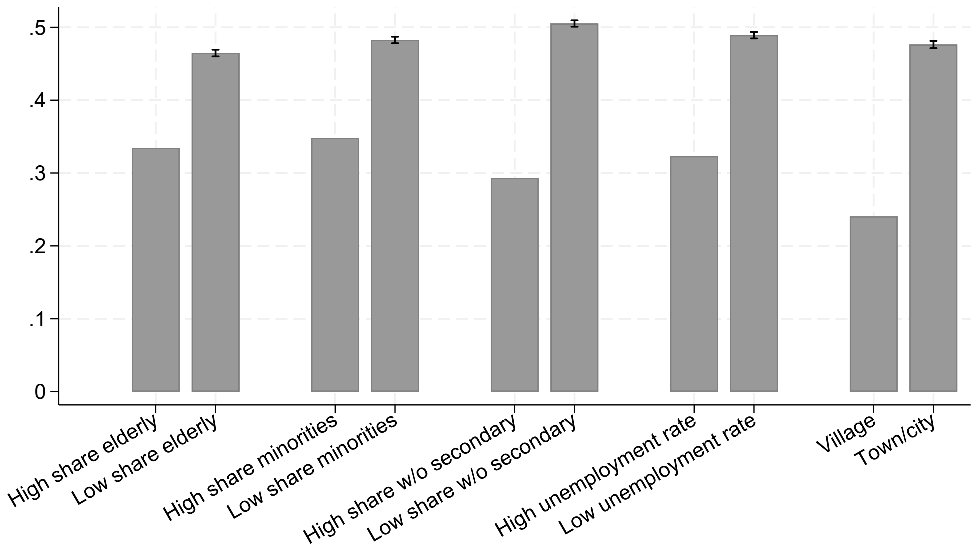
(b): Mixed elections

	(1) IHS(Votes for parties affiliated with incumbent mayor)	(2) IHS(Votes for other parties)
Choice machine or paper	-0.149*	0.0174
	(0.0829)	(0.0669)
Province × election FEs	Yes	Yes
Mean dep var (levels)	65.33	131.54
Effective observations left	1,605	1,188
Effective observations right	1,763	1,262
Bandwidth	92	70
p-value (1) = (2)		0.12

Notes: RDD estimates of the effects of voting technology on the number of votes for parties aligned by the incumbent municipality mayor, versus other parties. The table presents β coefficients estimated from Equation 1. The sample in panel (a) consists of the three elections with machine voting in polling stations above the threshold. The sample in panel (b) consists of the four elections with a choice of machine or paper voting in polling stations above the threshold. The bandwidth in each regression is chosen using the MSE optimal procedure suggested by Calonico et al. (2014b). Standard errors clustered by polling station. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

D Heterogeneity analysis

Figure D1: Machine take-up by locality characteristics



Notes: Bar chart: Machine take-up by locality-level demographic and socio-economic characteristics. “Low” refers to below median and “High” refers to above median. Share elderly is the share of the population that is 65 years of age or older; Share minority is the share of the population that is Roma or Turkish; Share without secondary is the share of the population that has primary education or less. The figure reports the 95 percent confidence intervals from a polling station-level regression of machine take-up on a dummy for “Low share elderly”, “Low share minorities”, “Low share primary”, “Low unemployment rate” and “Town/city”, respectively. Standard errors are heteroskedasticity-robust. Sample: Machine polling stations and the four elections with a choice of machine or paper voting in polling stations above the threshold.

D.1 Heterogeneity: Share of valid votes

Table D1: Effects on share of valid votes: By town/ village

	Valid votes / turnout	
	(1) Village	(2) Town/ City
Machine-only voting	0.0381***	0.0304***
	(0.00212)	(0.00875)
Province × election FEs	Yes	Yes
Mean dep var	0.97	0.97
Effective observations left	1,311	71
Effective observations right	1,318	265
Bandwidth	89	88
p-value (1) = (2)		0.39

	Valid votes / turnout	
	(1) Village	(2) Town/ City
Choice machine or paper	0.00888***	-0.0116**
	(0.00271)	(0.00569)
Province × election FEs	Yes	Yes
Mean dep var	0.95	0.94
Effective observations left	1,897	83
Effective observations right	1,796	204
Bandwidth	94	62
p-value (1) = (2)		0.00

Notes: Heterogeneity in the effects of voting technology on the share of valid votes by urbanity. The table presents β coefficients estimated from Equation 1 for polling stations with different characteristics – stations in villages in Column (1) and in towns or cities in Column (2). The sample consists of the three elections with machine voting in polling stations above the cutoff. The dependent variable is the share of valid votes over turnout. The bandwidth is chosen using the MSE optimal procedure suggested by Calonico et al. (2014b). Robust standard clustered by polling station.

Table D2: Share of valid votes: Heterogeneity by unemployment rate

	Valid votes / turnout	
	(1) Below-median unemployment rate	(2) Above-median unemployment rate
Machine-only voting	0.0347***	0.0373***
	(0.00382)	(0.00224)
Province × election FEs	Yes	Yes
Mean dep var	0.97	0.97
Effective observations left	591	1,136
Effective observations right	674	1,384
Bandwidth	106	112
p-value (1) = (2)		0.57

	Valid votes / turnout	
	(1) Below-median unemployment rate	(2) Above-median unemployment rate
Choice machine or paper	0.00620*	0.00983***
	(0.00375)	(0.00329)
Province × election FEs	Yes	Yes
Mean dep var	0.95	0.95
Effective observations left	871	1,213
Effective observations right	990	1,380
Bandwidth	116	90
p-value (1) = (2)		0.47

Notes: β coefficients estimated from Equation 1 for polling stations with different characteristics – stations in municipalities with below-median unemployment rate in Column (1) and above-median unemployment rate in Column (2). The sample consists of the three elections with machine voting in polling stations above the cutoff. The dependent variable is the share of valid votes over turnout. The bandwidth is chosen using the MSE optimal procedure suggested by Calonico et al. (2014b). Robust standard clustered by polling station.

Table D3: Share of valid votes: Heterogeneity by share without secondary education

	Valid votes / turnout	
	(1) Below-median share without secondary ed.	(2) Above-median share without secondary ed.
Machine-only voting	0.0260***	0.0366***
	(0.00474)	(0.00245)
Province × election FEs	Yes	Yes
Mean dep var	0.97	0.97
Effective observations left	185	962
Effective observations right	284	1,036
Bandwidth	82	75
p-value (1) = (2)		0.05
	Valid votes / turnout	
	(1) Below-median share without secondary ed.	(2) Above-median share without secondary ed.
Choice machine or paper	0.000737	0.00922***
	(0.00434)	(0.00292)
Province × election FEs	Yes	Yes
Mean dep var	0.95	0.95
Effective observations left	276	1,648
Effective observations right	425	1,717
Bandwidth	86	93
p-value (1) = (2)		0.10

Notes: β coefficients estimated from Equation 1 for polling stations with different characteristics – stations in municipalities with below-median share without secondary education in Column (1) and above-median share without secondary education in Column (2). The sample consists of the three elections with machine voting in polling stations above the cutoff. The dependent variable is the share of valid votes over turnout. The bandwidth is chosen using the MSE optimal procedure suggested by Calonico et al. (2014b). Robust standard clustered by polling station.

Table D4: Share of valid votes: Heterogeneity by share of ethnic minorities

	Valid votes / turnout	
	(1) Below-median minority share	(2) Above-median minority share
Machine-only voting	0.0306***	0.0397***
	(0.00248)	(0.00303)
Province × election FEs	Yes	Yes
Mean dep var	0.97	0.97
Effective observations left	726	816
Effective observations right	760	1,014
Bandwidth	104	94
p-value (1) = (2)		0.02

	Valid votes / turnout	
	(1) Below-median minority share	(2) Above-median minority share
Choice machine or paper	0.00203	0.0113***
	(0.00270)	(0.00386)
Province × election FEs	Yes	Yes
Mean dep var	0.95	0.95
Effective observations left	938	1,066
Effective observations right	954	1,304
Bandwidth	101	91
p-value (1) = (2)		0.05

Notes: β coefficients estimated from Equation 1 for polling stations with different characteristics – stations in municipalities with below-median minority share in Column (1) and above-median minority share in Column (2). The sample consists of the three elections with machine voting in polling stations above the cutoff. The dependent variable is the share of valid votes over turnout. The bandwidth is chosen using the MSE optimal procedure suggested by Calonico et al. (2014b). Robust standard clustered by polling station.

Table D5: Share of valid votes: Heterogeneity by share of individuals 65 and above

	Valid votes / turnout	
	(1) Below-median share elderly	(2) Above-median share elderly
Machine-only voting	0.0246***	0.0382***
	(0.00495)	(0.00231)
Province × election FEs	Yes	Yes
Mean dep var	0.98	0.97
Effective observations left	132	1,272
Effective observations right	268	1,242
Bandwidth	67	94
p-value (1) = (2)		0.01

	Valid votes / turnout	
	(1) Below-median share elderly	(2) Above-median share elderly
Choice machine or paper	-0.00583	0.00914***
	(0.00491)	(0.00276)
Province × election FEs	Yes	Yes
Mean dep var	0.95	0.95
Effective observations left	169	1,777
Effective observations right	336	1,662
Bandwidth	65	97
p-value (1) = (2)		0.01

Notes: β coefficients estimated from Equation 1 for polling stations with different characteristics – stations in municipalities with below-median share of individuals 65 years of age and above in Column (1) and above-median minority share in Column (2). The sample consists of the three elections with machine voting in polling stations above the cutoff. The dependent variable is the share of valid votes over turnout. The bandwidth is chosen using the MSE optimal procedure suggested by Calonico et al. (2014b). Robust standard clustered by polling station.

D.2 Heterogeneity: Turnout

Table D6: Turnout: Heterogeneity by town/ village

	Turnout / registered voters	
	(1) Village	(2) Town/ City
Machine-only voting	-0.0481***	0.0302
	(0.0121)	(0.0518)
Province × election FEs	Yes	Yes
Mean dep var	0.41	0.43
Effective observations left	1,225	71
Effective observations right	1,250	257
Bandwidth	84	85
p-value (1) = (2)		0.14

	Turnout / registered voters	
	(1) Village	(2) Town/ City
Choice machine or paper	-0.00464	0.0262
	(0.0113)	(0.0362)
Province × election FEs	Yes	Yes
Mean dep var	0.43	0.42
Effective observations left	1,655	99
Effective observations right	1,577	458
Bandwidth	84	94
p-value (1) = (2)		0.42

Notes: β coefficients estimated from Equation 1 for polling stations with different characteristics – stations in villages in Column (1) and in towns or cities in Column (2). The sample consists of the three elections with machine voting in polling stations above the cutoff. The dependent variable is turnout over the number of registered voters. The bandwidth is chosen using the MSE optimal procedure suggested by Calonico et al. (2014b). Robust standard clustered by polling station.

Table D7: Turnout: Heterogeneity by unemployment rate

	Turnout / registered voters	
	(1) Below-median unemployment rate	(2) Above-median unemployment rate
Machine-only voting	-0.0278	-0.0562***
	(0.0221)	(0.0133)
Province × election FEs	Yes	Yes
Mean dep var	0.42	0.41
Effective observations left	538	816
Effective observations right	608	975
Bandwidth	98	82
p-value (1) = (2)		0.27

	Turnout / registered voters	
	(1) Below-median unemployment rate	(2) Above-median unemployment rate
Choice machine or paper	0.0241	-0.0164
	(0.0212)	(0.0114)
Province × election FEs	Yes	Yes
Mean dep var	0.43	0.43
Effective observations left	640	1,534
Effective observations right	691	1,878
Bandwidth	87	112
p-value (1) = (2)		0.09

Notes: β coefficients estimated from Equation 1 for polling stations with different characteristics – stations in municipalities with below-median minority share in Column (1) and above-median minority share in Column (2). The sample consists of the three elections with machine voting in polling stations above the cutoff. The dependent variable is turnout over the number of registered voters. The bandwidth is chosen using the MSE optimal procedure suggested by Calonico et al. (2014b). Robust standard clustered by polling station.

Table D8: Turnout: Heterogeneity by share without secondary education

	Turnout / registered voters	
	(1) Below-median share without secondary ed.	(2) Above-median share without secondary ed.
Machine-only voting	-0.00273	-0.0512***
	(0.0239)	(0.0130)
Province × election FEs	Yes	Yes
Mean dep var	0.45	0.40
Effective observations left	263	1,036
Effective observations right	443	1,136
Bandwidth	105	80
p-value (1) = (2)		0.07

	Turnout / registered voters	
	(1) Below-median share without secondary ed.	(2) Above-median share without secondary ed.
Choice machine or paper	0.00929	-0.00883
	(0.0220)	(0.0121)
Province × election FEs	Yes	Yes
Mean dep var	0.45	0.43
Effective observations left	380	1,406
Effective observations right	644	1,458
Bandwidth	108	80
p-value (1) = (2)		0.47

Notes: β coefficients estimated from Equation 1 for polling stations with different characteristics – stations in municipalities with below-median share without secondary education in Column (1) and above-median share without secondary education in Column (2). The sample consists of the three elections with machine voting in polling stations above the cutoff. The dependent variable is turnout over the number of registered voters. The bandwidth is chosen using the MSE optimal procedure suggested by Calonico et al. (2014b). Robust standard clustered by polling station.

Table D9: Turnout: Heterogeneity by share of ethnic minorities

	Turnout / registered voters	
	(1) Below-median minority share	(2) Above-median minority share
Machine-only voting	-0.0561***	-0.0498***
	(0.0155)	(0.0165)
Province × election FEs	Yes	Yes
Mean dep var	0.46	0.38
Effective observations left	674	690
Effective observations right	714	833
Bandwidth	99	78
p-value (1) = (2)		0.78

	Turnout / registered voters	
	(1) Below-median minority share	(2) Above-median minority share
Choice machine or paper	-0.00227	-0.00806
	(0.0151)	(0.0149)
Province × election FEs	Yes	Yes
Mean dep var	0.47	0.41
Effective observations left	739	989
Effective observations right	720	1,196
Bandwidth	82	83
p-value (1) = (2)		0.78

Notes: β coefficients estimated from Equation 1 for polling stations with different characteristics – stations in municipalities with below-median minority share in Column (1) and above-median minority share in Column (2). The sample consists of the three elections with machine voting in polling stations above the cutoff. The dependent variable is turnout over the number of registered voters. The bandwidth is chosen using the MSE optimal procedure suggested by Calonico et al. (2014b). Robust standard clustered by polling station.

Table D10: Turnout: Heterogeneity by share of individuals 65 and above

	Turnout / registered voters	
	(1) Below-median share elderly	(2) Above-median share elderly
Machine-only voting	-0.0377	-0.0463***
	(0.0306)	(0.0125)
Province × election FEs	Yes	Yes
Mean dep var	0.42	0.41
Effective observations left	211	1,144
Effective observations right	512	1,140
Bandwidth	101	85
p-value (1) = (2)		0.80

	Turnout / registered voters	
	(1) Below-median share elderly	(2) Above-median share elderly
Choice machine or paper	-0.00901	0.0000792
	(0.0304)	(0.0117)
Province × election FEs	Yes	Yes
Mean dep var	0.43	0.43
Effective observations left	260	1,439
Effective observations right	621	1,349
Bandwidth	93	79
p-value (1) = (2)		0.78

Notes: β coefficients estimated from Equation 1 for polling stations with different characteristics – stations in municipalities with below-median share of individuals 65 years of age and above in Column (1) and above-median minority share in Column (2). The sample consists of the three elections with machine voting in polling stations above the cutoff. The dependent variable is turnout over the number of registered voters. The bandwidth is chosen using the MSE optimal procedure suggested by Calonico et al. (2014b). Robust standard clustered by polling station.