Technology and Protest: The Political Effects of Electronic Voting in India

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Abstract

Electronic voting technology is often proposed as translating voter intent to vote totals better than alternative systems such as paper ballots. We suggest that electronic voting machines (EVMs) can also alter vote choice, and, in particular, the way in which voters register anti-system sentiment. This paper examines the effects of the introduction of electronic voting machines in India, the world's largest democracy, using a difference-in-differences methodology that takes advantage of the technology's gradual introduction. We find that EVMs are associated with dramatic declines in the incidence of invalid votes, and corresponding increases in vote for minor candidates. There is ambiguous evidence for EVMs decreasing turnout, no evidence for increases in rough proxies of voter error or fraud, and no evidence that machines with an auditable paper trail perform differently from other EVMs. The results highlight the interaction between voter technology and voter protest, and the substitutability of different types of protest voting.

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1 Introduction

Social scientists have long been aware that voting technology may have important effects on elections, making valid voting harder or easier, and favoring some candidates over others. In particular, many studies have sought to study the impact of the fastest-growing voting technology in the 21st century, electronic voting machines, or EVMs (sometimes called DRE machines, or e-voting machines).[1] These studies mostly look at the impact of electronic voting machines on valid and invalid votes, finding that, in general, voting machines lead to small reductions in invalid or "residual" votes (Alvarez et al., 2001; Allers and Kooreman, 2008; Ansolabehere and Stewart, 2005; Card and Moretti, 2007; Fujiwara, 2015; Hanmer et al., 2010; Knack and Kropf, 2003). This reduction is interpreted in a normatively positive fashion, since invalid votes are assumed to be the result of unintentional error, and thus reducing such errors should increase overall political participation.

However, many have argued that invalid ballots are often consciously cast by voters to signal their dissatisfaction with the electoral system (Cohen, 2018; Katz and Levin, 2016; Moral, 2016; Power and Garand, 2007; Uggla, 2008). This literature argues that invalid votes are used by voters to protest against poor government performance (Cohen, 2018), a manifestation of discontent with the electoral alternatives on the ballot (Uggla, 2008), or the lack of distinguishable policy offerings (Moral, 2016). Of course, voters have other means of protest at their disposal, such as voting for insurgent parties (Alvarez, Kiewiet and Núñez, 2018). Scholars have argued that votes for extra-parliamentary parties – parties that are not expected to gain representation in the parliament – and votes for niche parties may be affected by the same variables as for invalid votes (Uggla, 2008; Moral, 2016).

A natural question to pose is thus: If electronic voting machines make invalid voting difficult, what do the voters who would previously have cast invalid ballots do after their introduction? Knowing that invalid votes could serve as a tool of voter protest, if EVMs force a decrease in invalid voting could it manifest itself in another form? In this paper, we develop and test a simple theory of the effect of the introduction of electronic voting machine on vote choice, and, in particular, on the ways in which voters express discontent. We suggest that many of the voters who spoiled their ballots did so deliberately, to protest the political system or the set of candidates presented to them. After the introduction of voting machines, these voters should begin to vote for candidates of non-viable and/or non-establishment parties. To use Alvarez, Kiewiet and Núñez's (2018) terminology, the

[1] In this paper, we prefer the term "EVM" to the often used terms "direct recording electronic voting," or "e-voting" to distinguish technologies where voters vote on electronic machines in person to systems where they vote over the internet (Alvarez, Hall and Trechsel, 2009, e.g), and to follow standard usage in India.

change in voting technology leads to a decline in "BNS protest voting" (blank, null, or spoiled ballots) and a corresponding increase in "insurgent party protest voting." This implies that the various types of protest voting are fungible, and that invalid voting may represent voter dissatisfaction as much as voter confusion.

We test this theory using data from India. To identify the causal effect of electronic voting machines in India, we take advantage of their gradual introduction in the national Lok Sabha (parliament) elections, using a difference-in-differences design with both constituency and year fixed effects to account for confounding spatial and temporal effects. While the subset of 45 "pilot" constituencies in which the voting machines were introduced early (in 1999) was not representative of the country, we show that the two types of constituencies have fairly similar trends in electoral behavior before the introduction of EVMs. This strategy is supplemented by the use of a set of time-varying controls, and the use of alternative samples with less variance between the treatment and control conditions. This is the first study to our knowledge to examine the effect of EVMs on any outcome in India, or in any country with an income significantly below the world's average income. The effects of Indian EVMs are also of direct significance: The inexpensive Indian model is the world's second most used voting technology of any kind (after paper ballots), and is currently in use for elections in India, Kenya, Namibia, Nepal, and Bhutan.

We find that the introduction of EVMs in India had substantial effects on voter behavior. The rate of invalid voting was slashed by more than 90%. This stems directly from the design of Indian voting machines, which make invalid voting impossible without notifying polling staff. More interestingly, we find evidence consistent with a move from BNS protest voting to insurgent party protest voting. The introduction of voting machines is associated with a sharp rise in voting for minor parties, on the order of between one and three percentage points, leading to increased fragmentation of the overall vote.

We present several additional pieces of evidence that this result is a product of deliberate action by protest voters. Firstly, candidates that receive a *very* small vote share, do not benefit from the introduction of voting machines, suggesting that the increase in minor party vote share is not a product of random button pressing. Secondly, this effect holds even within parties: The vote share for the left parties and the Bahujan Samaj Party (BSP) rise or stay constant with voting machines in states where they are insignificant electorally, but fall with the introduction of electronic voting machines in states where these parties are contenders for office. Thirdly, the effect on minor candidate vote share is moderated by the invalid voting rate in the constituency in 1998, suggesting that invalid votes are being funneled to minor candidates after the advent of voting machines. Finally, the introduction of a "None of the Above" (NOTA) option (an "officially sanctioned protest voting" option in Alvarez, Kiewiet and Núñez's (2018) terminology) in 2014 is associated with a fall in minor party vote of similar size to the rise that occurred at EVM introduction.

Our results thus broadly suggest that the various forms of protest voting discussed by Alvarez, Kiewiet and Núñez (2018) are fungible, and that these substitutions are affected by technology. They also imply that a large portion of invalid votes in some countries may be protest votes. To the best of our knowledge, this is the first study that analyzes the potential substitutability between different forms of protest votes, and provides evidence in favor of this claim. This is also the first study that investigates the interaction between electronic voting technology and protest voting. In the context of India, our results also indicate that one of the unanticipated consequences of the introduction of EVMs in India was the subsequent removal of the possibility of casting an invalid vote as a method of voter protest. The decision to add a NOTA option to Indian voting machines now allows a more direct reflection of voter preferences for protest.

By contrast, we find little evidence for other possible second order effects of EVM introduction. Electronic voting machines are associated with reductions in voter turnout, but these results are not robust, and may stem from unobserved differences between constituencies. Similarly, there is little or no evidence that voting machines have altered the number of voters who unintentionally vote for the wrong candidate, as measured by the tendency of voters to choose based on ballot position. We find no evidence for voting machines favoring specific parties, including state incumbents, or the major national parties. Similarly, there is no evidence that turnout was reduced in constituencies that could be prone to ballot box stuffing. These results focus on the introduction of machines that did not have any form of paper receipt or auditable record, which was only introduced in some constituencies in 2014. We find that voter verifiable paper audit trail (VVPAT) enabled machines have no effect on any major electoral outcome.

The rest of the paper is organized as follows. Section 2 provides a brief review of the literature and develops a theoretical framework discussing the potential substitutability of different forms of protest votes. Section 3 develops additional hypotheses regarding voting errors, turnout, and fraud. Section 4 describes electronic voting technology and the way it was introduced in India, while Section 5 discusses the data, models, and identification strategy. Section 6 describes the main results for invalid voting and minor party voting, while Section 7 discusses the potential consequences of this reduction for other election outcomes. Section 8 concludes with a discussion of the implications of the Indian experience.

2 Theoretical Framework

2.1 Protest voting as an empirical phenomenon

Invalid voting may be either *intentional* or *unintentional*. Unintentional invalid voting may reflect voter confusion with the voting technology, which leaves them to deviate from the proper voting procedure even though they wished to cast a valid ballot. However, invalid voting may also reflect a deliberate choice of a voter who dislikes the candidates on offer. To quote Katz and Levin (2016), spoiled ballots "arise from a combination of voter errors and deliberate attempts to signal political discontent." The act of using an invalid vote to protest the political system could be *expressive* in nature. In this scenario, casting an invalid ballot is akin to proclaiming one's discontentment with the political system (Uggla, 2008; Power and Roberts, 1995; Power and Garand, 2007; Cohen, 2018; Moral, 2016). The literature on spoiled ballots has found evidence that voters in Brazil (Power and Roberts, 1995), Germany (Stiefbold, 1965), France (Rosenthal and Sen, 1973), among others, use a spoiled ballot to register their protest with the political system, or with the lack of political alternatives. Uggla (2008), in particular, uses data from more than 200 elections in Western Europe, Australia, New Zealand and the Americas for 1980-2000 and finds that the structure of political competition best explains the level of invalid voting. He finds that a political system that does not offer voters clear alternatives is most likely to lead to suffer from high levels of invalid voting.

Intentional casting of invalid ballots is not the only type of way that voters cast protest votes. Alvarez, Kiewiet and Núñez (2018) provide a typology of such protest voting, which includes both "BNS protest voting" and "insurgent party protest voting," in which voters choose parties that are "anti-establishment, unorthodox, ideologically extreme, frivolous, or some convex combination of these characteristics." As this definition makes clear, the definition of a protest party is usually ad hoc and context specific. Often, particularly in first-past-the-post systems, these candidates will be highly unlikely to be electorally viable.[2]

Insurgent party protest voting can be seen as a result of voter dissatisfaction with major political parties, or the party system as a whole (Bardi, 1996; Bélanger, 2004; Denemark and Bowler, 2002). For example, Bélanger (2004) finds that third parties in Australia, Britain and Canada, or parties that are outside the two-party dominance in these countries, benefit from a general dislike of major party alternatives. Similarly, Uggla (2008)

[2] Alvarez, Kiewiet and Núñez (2018) mention three other forms of protest voting, "tactical," "organized," and "officially sanctioned." The first two of these are difficult to measure and will not be discussed here. For a discussion of the third see Section 6.

also examines whether "extra-parliamentary" votes – that is votes for minor parties that are unlikely to get representation in the parliament – are affected by alienation. He finds that, like with invalid voting, these votes are also affected by the structure of political competition. Moreover, since these parties rarely win elections, or are rarely included in electoral coalitions, they do not have any effect on policies implemented by governments (Bélanger, 2004). As a result, votes cast for them tend to only increase the overall fractionalization of the vote. However, despite the commonalities between the variables determining the support for minor parties and for invalid ballots (Uggla, 2008), no study focuses on the potential substitutability of these two forms of voter protest.

2.2 Potential substitutability between different forms of protest votes

In this section, we build on the decision theoretic model from Katz and Levin (2016), and show that invalid voting and voting for minor parties may be substitutable. Consider an election in a first-past-the-post system. The voters face a choice between voting for one of the candidates presented to them, casting an invalid ballot, or abstaining. The rational choice literature on electoral participation has identified certain instrumental and non-instrumental benefits to voting (Riker and Ordeshook, 1968). These include benefits from getting a preferred candidate to win the election, denoted by pB where p is the probability that the voter is pivotal to the election, and B refers to the relative benefit that the voter gets in return for the preferred candidate winning the election. In addition to the instrumental benefit from voting, there are intrinsic benefits to the act of casting a vote, denoted by D_V. These benefits stem from the very act of casting a vote, which could be related to, but not limited to, fulfilling their civic duty of voting.

As Katz and Levin (2016) outline, a voter wishing to cast a valid vote must also bear informative and cognitive costs, which are related to spending effort figuring out the right choice to vote for, and to follow the instructions to mark ballots correctly. These are labelled C_C. In general, all voters face costs to go to the polling station, represented by C_P. Taking into account that voters may also cast invalid ballots in order to express their discontentment with the political establishment (Uggla, 2008; Cohen, 2018), a voter can derive expressive benefits, E, from voting in this fashion. As with valid votes, there may be some intrinsic benefits from casting an invalid vote, which we denote by D_I. A voter wishing to intentionally cast a invalid vote does not face cognitive costs of choosing the right candidate or to make sure that ballot meets the stipulated conditions to be counted as valid. Normalizing the benefit from abstaining to 0, the decision calculus faced by the voter is to compare the expected utility from casting a valid vote for a candidate on the ballot, $\mathbb{E}(U_V)$, to that for submitting an invalid vote, $\mathbb{E}(U_I)$:

$$\mathbb{E}(U_V) = pB + D_V - C_C - C_P \tag{1}$$

$$\mathbb{E}(U_I) = E + D_I - C_P. \tag{2}$$

Thus, the voters choice, Y, reflects the following decision rule (Katz and Levin, 2016):

$$Y = \begin{cases} \text{Valid} & \text{if } pB + D_V - C_C \geq \max\{E + D_I, C_P\} \\ \text{Invalid} & \text{if } E + D_I \geq \max\{pB + D_V - C_C, C_P\} \\ \text{Abstain} & \text{Otherwise} \end{cases} . \tag{3}$$

Thus, in this framework, a voter casts an invalid vote if the expressive benefit, E, is relatively high, or if the cognitive cost of voting in a valid way, C_C, is relatively high.

Now suppose that the option of invalid voting is taken away exogenously, potentially through the introduction of a voting technology that makes it nearly impossible to cast such a ballot. The literature on insurgent party protest voting suggests that voters may vote for parties that are "extra-parliamentary" as an expression of their disenchantment with parties that win elections more regularly (Uggla, 2008; Bélanger, 2004). Thus, voting for such party also carries with it an expressive component, E_M, like in the case of invalid voting. Furthermore, since these parties are not part of the major political system, they are very unlikely to win the election (Bélanger, 2004). This would be even more likely in a first-past-the-post system. Thus, pB is likely to be close to 0 if an individual votes for a minor party. Moreover, the cognitive costs of voting for such a party are likely to be close to 0, because it is relatively easy to identify a party that is not part of the major party system. Thus, the expected utility from voting for a minor party is given by the following

$$\mathbb{E}(U_M) = pB + E_M + D_V - C_C - C_P \approx E_M + D_V - C_P. \tag{4}$$

Compare the expected utility from casting an invalid ballot in (2) to the expected utility from voting for a minor party (4). Faced with a forced choice, a voter who intentionally used to cast an invalid vote can choose to vote for a minor party if the expressive benefit from doing so (E_M) is relatively similar to that from invalid voting (E). The literature suggests that both options carry equivalent expressive forces (Uggla, 2008; Moral, 2016). This would imply that both these options are substitutable.

Many authors find that the introduction of voting machines reduce the level of invalid voting (Hanmer et al., 2010; Stewart, 2006; Fujiwara, 2015; Katz and Levin, 2016; Alvarez et al., 2001), often due to the design of the machines. In general, the literature has concluded that the reduction in residual votes is normatively good, because of the implicit assumption that invalid votes were mostly unintentional, and cast by poor and unsophisticated voters. However, no study focuses on explaining what happens to *intentionally* cast invalid ballots after the introduction of voting machines. Given the preceding discussion regarding the potential substitutability between invalid votes and minor party voting as forms of protest, we derive our core hypothesis:

Hypothesis 1. *The introduction of EVMs is associated with increases in electoral fragmentation and in the vote share of minor parties, through a forced decline in invalid votes.*

3 Subsidiary Effects of Electronic Voting: Confused Voting, Turnout and Fraud

3.1 Confused "Valid" Voting

We have already noted that EVMs usually reduce the number of invalid votes, and that this has usually been interpreted as a decline in *unintentional* errors. However, any reduction in unintentional invalid voting associated with voting machines may be apparent rather than real. Note that a voter with high cognitive costs (C_C) might, instead of casting an invalid ballot, "validly" vote for the wrong candidate. Voters, confused by technology, might press buttons randomly or unskillfully, and these inputs are interpreted by the "forced choice" framework of the machines as votes for candidates other than their preferred one.

How would a confused voter deal with an EVM? If they merely press buttons at random, the introduction of voting machines would lead to a corresponding increase in "random" voting. This may lead to votes being distributed to candidates evenly across the board, thereby increasing vote fragmentation within the constituency. Alternatively, buttons in certain positions may be more likely to be chosen by confused voters. For example, Dee (2007) finds that the users of punch cards were more likely to vote for bookend candidates compared with users of other technologies. Such patterns would accord with the large literature that shows that voters often cast ballots using arbitrary heuristics, such as the ballot position of the candidate (Krosnick, Miller and Tichy, 2003; Ho and Imai, 2008; Alvarez et al., 2004). The introduction of electronic voting machines could thus be associated with increases in vote for candidates in "favored" ballot positions—at the top of the machine, or around the eventual winner.

3.2 Turnout

The preceding discussion assumed that former protest voters would still go to the polls and make a choice after the introduction of EVMs. It is certainly possible that voters unable to cast protest ballots would choose not to turn out at all. This is especially pertinent in cases like India, where voting is not mandatory. Note that given that their protest vote in the form of an invalid ballot did not affect the outcome of the result in the first place, however, it is not likely that this would be the case. Furthermore, if the expressive benefit from voting for minor parties (E_M) are relatively similar to that from invalid votes (E), then the introduction of EVMs should not have a major effect on turnout.

3.3 Electoral Manipulation

A large literature in computer science has found a large number of security issues that render voting machines susceptible to fraud. Kumar and Walia (2011) provide a thorough comparative overview of technological and security features of voting machines around the world. According to them, most machines that are currently being used face significant security shortfalls. Wolchok et al. (2010) specifically look at Indian machines and point out the many security shortcomings, leaving it vulnerable to electoral manipulation. Kohno et al. (2004) and Feldman, Halderman and Felten (2006) find that several brands of voting machines in use in the United States are susceptible to manipulation by both election officials ("insiders") and ordinary voters ("outsiders"). However, empirical studies of EVM introduction have found little evidence of systematic fraud (Fujiwara, 2015; Card and Moretti, 2007; Herron and Wand, 2007).

To counter the possibility of mass electoral fraud, security experts have often recommended the introduction of some sort of paper record of vote, to allow the totals reported by the machines to be crosschecked. Many US states now ban the use of voting machines without some form of paper trail. Theoretically, we should expect the introduction of this feature to enhance any security advantage, and any disadvantage to be lessened.

Proponents of voting machines, by contrast, have declared that EVMs are less susceptible to fraud than other forms of election technology. In particular, the complexity of the machines, or their built-in security features, may make it more difficult to suddenly insert votes in large numbers (ballot box stuffing), which is easy with paper ballots. Indian voting machines, for instance, do not allow the casting of more than five votes a minute. Since the probability of law enforcement intervention increases over time, this feature makes brief "booth captures"[3] more difficult. If this is correct, the introduction of voting machines should be associated with reductions in turnout, not because voters are not turning out, but because the number of fraudulently cast ballots has been reduced. Unlike the general decline in turnout discussed in the last section, this should be concentrated in regions that were relatively more corrupt (since the number of fraudulently cast ballots to be eliminated is larger). This would further imply that the introduction of voting machines should reduce the vote share of candidates who were best positioned to commit fraud, such as candidates from the party which controls the state government.

4 Electronic Voting in India

4.1 Background

India is a federal parliamentary republic, and the world's largest democracy by population. Its electoral system closely mirrors that of Britain, with single-member districts whose members are elected using a first-past-the-post system. The directly elected lower house of the national parliament, the Lok Sabha, contains 543 single member districts, each with a population of approximately two million. Since only the lower house of the legislature is directly elected, and because national, state, and local elections are on different cycles, in most cases Indian voters only vote in one race in any given election.

State and national elections in India are administered by an independent national body, the Election Commission of India (ECI), which is granted wide powers over the bureaucracy and police during the election period. The ECI also supervises the creation of a register of eligible voters, enrollment in which is automatic. The commission is widely regarded as politically neutral and relatively efficient (McMillan, 2012), and takes extensive measures to guarantee the security of voters and the neutrality of the electoral process. Note that the national administration of election and common ballot structure means that these factors are unlikely to cause spatial variation in elections, unlike the United States (Herrnson, Hanmer and Niemi, 2012; Stein et al., 2008). Furthermore, voting in India is not compulsory, and a sizeable proportion of voters choose to abstain. In general, the turnout rate is around 60% in national elections.

[3] Booth capturing refers to the practice of armed criminals scaring voters away, and then intimidating poll booth officers into giving up ballot papers so that they can be cast in favor of the candidate of their choice (Verma, 2005).

Prior to 1998, all elections in India used paper ballots, with the names of candidates and printed on ballots. To help illiterate voters, all parties and independent candidates were distinguished by symbols.[4] The voters marked the square next to the symbol of their preferred candidate and folded the ballot first vertically and then horizontally before putting it in the ballot box. The ballots were then counted in the presence of ECI officials and the parties, with "invalid votes" being those where no candidate preference could be assigned. Voters were not allowed to write in candidate names, or vote for a "none of the above" option without notifying the returning officer.[5]

There were two main concerns with the use of traditional paper ballots in India. First, a large portion of the electorate in India are illiterate–48% of adults in 1991, and 35% in 2001. Despite extensive information campaigns by the ECI and the parties, India's very simple ballot structure, and the heavy use of party symbols, illiterate voters may sometimes have found it difficult to navigate and mark written ballots. This may plausibly have increased their likelihood of casting invalid or residual votes. In 1998, 1.86% of voters cast invalid ballots, though (as we will see) many of those invalid ballots may have been intentional.

Second, despite the ECI's best efforts, post-independence India has seen occasional accusations of electoral fraud (Verma, 2005, 2009). While registration of nonexistent voters and vote buying have also been prominent, the most flagrant technique was the "capture" of polling booths.

4.2 Electronic Voting in India

The ECI decided to implement the use of voting machines in national elections in 1999. Forty five constituencies were selected in 17 states and 3 union territories. Importantly, these constituencies were *not* randomly selected. In general, they appear to have been more urban and wealthy than the country as a whole. The treated constituencies included all constituencies in Delhi, all but one constituency in Mumbai, and larger cities in many other states. All other constituencies continued to use paper ballots.

Because of the perceived success of EVMs in this election, the ECI decided to use the machines nationwide from 2004 onwards. In this paper, we focus on three elections: 1998, 1999, and 2004. To review, in 1998 none of the parliamentary constituencies (PCs) had

[4] These symbols are a major part of political advertising. Candidates may attempt to select symbols that are similar to famous symbols in order to confuse voters. However, since symbols do not vary with election technology, we do not discuss this strategic aspect in this paper.

[5] "None of the above" (NOTA) became an option on Indian ballots in 2013.

voting machines, in 1999 only 45 PCs did, and in 2004 all PCs used EVMs.

The EVM adopted in India is manufactured by two government owned companies, Electronics Corporation of India (ECIL) and Bharat Electronics Limited (BEL). It differs considerably from the electronic voting machines in use in the United States, having a much simpler design, with only a basic set of programing instructions hardwired into the circuit board. The units are portable, can operate on battery power, and are (at approximately US $200 a unit) relatively cheap (Wolchok et al., 2010). There is space for 16 candidates on each ballot unit. If, for any constituency, there are more than 16 candidates, additional ballot units are linked together. Each polling booth can hold four ballot units and so up to 64 candidates can be accommodated. If there are more than 64 candidates, (a very rare event) then paper ballots are used.

The basic design of the machine includes two main parts, a control unit and a ballot unit. By pressing a button on the control unit, the returning officer authorizes one vote from a particular ballot unit. The voter then presses the button on the ballot unit next to the symbol of their preferred candidate. This choice is then transmitted back to the control unit, where it is stored before the total votes for each booth are read out during the counting process. Using Indian voting machines, overvoting (the casting of multiple votes that invalidate a ballot) is thus impossible, since only the first press of the button is recorded. Undervoting (casting no valid votes for a particular office) also impossible without a cumbersome and public procedure, since the voter cannot leave the booth without the returning officer being aware that she did not cast a ballot.[6]

Indian machines are dramatically simpler than the DRE machines discussed in the American literature, a simplicity made possible by India's one office, first-past-the-post elections. Indian voters only have to press a single button to vote, rather than navigating through the complex set of menus and offices found in some US voting machines. Indian machines also place even higher barriers to invalid voting than American EVMs, which eliminate overvoting but leave open the possibility of intentional or unintentional undervoting.

Wolchok et al. (2010) suggest that Indian voting machines, like elsewhere in the world, suffer from security issues, and that a technically sophisticated group with access to the machines could modify the hardware to produce desired results. These theoretical concerns parallel widespread rumors about attempts by the parties to modify the machines (Wolchok et al., 2010), and occasional reports of technical problems. Wolchok et al. (2010) are also

[6]Returning officers are required to record blank ballots upon a public declaration from the voter, though this procedure is a violation of ballot secrecy.

critical of the ECI's procedures surrounding the storage of the machines, and skeptical that certain ECI security procedures (the random assignment of machines to booths, and the conduct of mock elections with machines before polling) address these concerns. It should be noted, however, that even if EVMs are vulnerable to fraud, this does not mean that they are more vulnerable than alternative technologies. After all, a fraudster with access to stored boxes of paper ballots could produce a fraudulent result with considerably less effort and technical knowledge than is necessary to manipulate stored machines.

5 Data and Specifications

The primary data used for this project is a three year panel (1998, 1999 and 2004) of Lok Sabha elections,[7] though we will also examine some trends involving earlier and later Lok Sabha elections.[8] There are 543 elected seats in the Lok Sabha, so our sample contains 1629 constituency-year observations. The data is taken from Kollman et al. (2011), and is supplemented by information taken directly from the Election Commission's reports. India had no constituency reapportionment between 1977 and 2004, so the unit of analysis remains constant.[9]

There are obvious difficulties in interpreting even a strong association between presence of EVMs on political outcomes as causal since "treated" constituency-years are both later in time, and (within years) disproportionately urban and wealthy. For this reason, we use a difference-in-differences design to estimate the causal effect of electronic voting.[10] The econometric specification is as follows:

$$y_{it} = \phi_i + \delta_t + \beta EVM_{it} + \epsilon_{it},$$

[7]We do not consider State Assembly elections in this project.

[8]The 1998 election was inconclusive, and resulted in a fragile coalition government led by the Hindu nationalist BJP. The snap 1999 elections resulted in a stronger BJP-led coalition government, which lost the 2004 elections to a coalition led by the Congress party.

[9]A reapportionment between the 2004 and 2009 elections affects comparability between these two periods. One potential concern is the state of Uttaranchal, which was created in 2000. The Uttar Pradesh Reorganisation Act of 2000 called for the creation of a legislative assembly for the new state and consequently the ECI delimited 70 constituencies in 2001. The following constituencies were affected by the delimitation of the new state of Uttaranchal: Nainital, Hardwar (SC), Saharanpur, Muzaffarnagar, and Bareilly. None of these constituencies were pilot constituencies in 1999. We removed them all from our main models that look at invalid vote rates and minor party vote shares. Our results are robust to removing these constituencies from the analysis. We do not report these results in the paper, but tables are available on request. Many constituencies in Chhattisgarh and Jharkhand were renumbered in this period as well. However, we use the names of the constituencies to identify constituencies rather than their numbers, and so all these constituencies are included in the analysis.

[10]See Section 6.5 in Imbens and Wooldridge (2009) for a concise description of this estimation approach.

where y_{it} is the dependent variable, EVM_{it} is treatment assignment, δ_t is a vector of time fixed effects, ϕ_i is a vector of constituency fixed effects and ϵ_{it} is a noise term. Under the assumption that δ_t is the same for all i (treated or non-treated), the treatment effect is $\mathbb{E}(y_{it}|EVM_{it} = 1) - \mathbb{E}(y_{it}|EVM_{it} = 0) = \beta$. In the next section, we will discuss in greater detail the assumption that time trends in election dynamics are similar across the two groups.

To the further guard against confounding by differing time trends, some models include a set of time-varying controls. These include the proportion of the vote for each of the two largest national parties, the Bharatiya Janata Party (BJP) and the Indian National Congress (INC), the total number of candidates within the constituency, the margin of victory of the winning candidate, and turnout (in models where turnout is not the dependent variable).

A second set of tests uses phase-year fixed effects. In each national election, the ECI divides the constituencies into 4-5 phases, each with its own polling day. This is done to make the task of the ECI easier and to ensure that adequate security measures can be implemented. Altogether, the data from the three elections in our study can be divided in 14 phase years. Disaggregating the data in this fashion allows us to account for confounders specific to particular elections days, such as rain, season, or national news events.

An additional set of tests limits the sample to only urban constituencies, defined as those where the largest district in the constituency had an urban population of more than 40% at the 2001 census.[11] Overall, 27 of the 45 early treatment constituencies met this criterion, as did 57 of the 398 late treatment constituencies. While this approach does not create even quasi-random assignment, it does reduce the observed (and, possibly, unobserved) differences in political trends between the two groups.

As an additonal test, we created two subsamples, through two different approaches, to alleviate selection bias concerns. In the first approach, we selected urban pilot constituencies, and all non-pilot urban constituencies that bordered these pilot constituencies. This allowed us to compare constituencies with the EVM pilot to proximate constituencies, with similar urban population rates. This gives us a sample of 27 early treatment constituencies and 21 neighboring constituencies. We also created a matched sample using propensity score matching. The propensity score of being a pilot constituency was calculated with respect to 1998 characteristics, such as turnout rates, vote shares of major parties, the fractionalization of the constituency, the number of candidates, eventual margin of victory, urban population, literacy rate, agricultural labour rate, and unemployment rate. We then

[11]The census defines urban status in a relatively stringent fashion, coding many large and urbanized villages as rural.

used caliper matching on the logit of the propensity score, with an optimal caliper of 0.2 standard deviations of the logit, using the method advocated by Austin (2011), to generate a matched subsample. This subsample contains 27 early treatment constituencies and 27 late treatment constituencies. We also report the results from one-to-one nearest neighbor matching in the appendix.

Finally, standard errors, unless otherwise stated, have been clustered at the constituency level. The unit of observation in our econometric model is the constituency-year and treatment is at the constituency level. There could be potential correlation of error terms across different years for the same constituency. This can lead to inconsistent standard errors (Bertrand, Duflo and Mullainathan, 2004). Thus, whenever possible, we account for this problem by clustering standard errors at the constituency level. Clustering at the state-year, or state level generally leads to larger standard errors. Since all core results are robust to either clustering strategy, and because treatment is at the parliamentary constituency level, we report constituency-clustered standard errors. Tables with standard errors clustered at the state or state-year level are available on request. In a few models (noted in the table notes), there are very few observations and clusters and so we report robust standard errors for these models.

6 Results

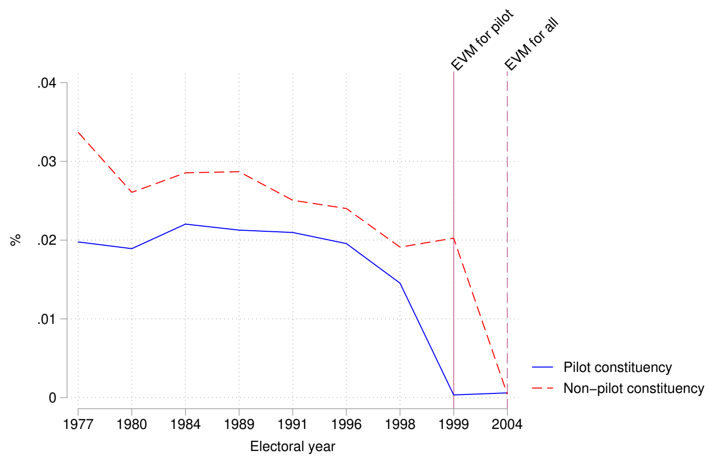
6.1 Effects on Invalid Voting

The identifying assumption in a difference-in-differences model is that the treatment group and the control group have parallel trends. This means that, absent the intervention, average changes would be the same across the treated and non-treated units. Below, we provide evidence that pre-treatment trends were similar between the treatment and control groups.

Our identifying strategy relies on the fact that while all constituencies used paper ballots in 1998, 45 pilot constituencies used voting machines in 1999. Thus, these 45 pilot constituencies serve as our treatment group, and the rest are grouped as a control. Figure 1 shows over-time trends for invalid voting (calculated as the difference between turnout and the number of valid votes for candidates as a proportion of turnout) for the early-treatment and control groups.[12] The trends tend to move together over time, with the relatively

[12] A small number control-group constituencies, mostly in Kashmir and Northeast India, either did not have elections or are missing data for certain years before 1996. These constituencies have been dropped from the pre-trend analyses to make over-time comparisons valid.

Figure 1: Pre-trends for invalid vote rate



Notes. The blue solid line plots the average invalid rate in all pilot constituency across election years while the red dashed line plots the average invalid vote rate in non-pilot constituencies. The year 1998 marks the last election before the introduction of EVMs. Thus, 1999 is the first post-treatment year for the pilot constituencies. In the year 2004, the non-pilot constituencies also used EVMs.

wealthy early-treatment constituencies tending to have lower levels of invalid voting.[13] This evolution is interrupted in 1999, when invalid voting rates fell sharply in the early-treatment constituencies, with no corresponding effect in the control constituencies. These findings are supported by Table A.21, which compares the effect of the intervention in the treatment districts to the lagged and led treatment, which should have no effect. The first column of that table compares the effect on invalid vote rates in the pilot constituencies in the treatment year (1999) versus all other election years. All of the placebo treatments are statistically insignificant, and all are much smaller in magnitude. These results suggest that the parallel-trends assumption is justified for invalid votes.

Table 1 shows that the introduction of EVMs is associated with a large, statistically significant reduction in the rate of invalid voting. This holds in the baseline OLS regression (Column 1), the standard difference-in-differences model (Column 2), the model with controls (Column 3), and the urban subsample (Column 4). The substantive size of the

[13] In Figure A.3, we show that pilot and non-pilot constituencies have similar trends not just in invalid voting, but in other outcomes as well. We show results for vote share for state incumbents, vote share for local incumbents, vote shares for the BJP and Congress, and the number of candidates. Note that the year to year variation in the number of candidates seems to track very closely changes in the real value of the electoral deposit. In Section A.3, we discuss the one outcome (turnout) for which the two groups do not appear to have parallel pre-trends.

Table 1: Effects of EVMs on invalid vote rates

	(1)	(2)	(3)	(4)	(5)
EVM	-0.0196***	-0.0173***	-0.0174***	-0.0185***	-0.0169***
	(0.000463)	(0.00113)	(0.00124)	(0.00154)	(0.00300)
Year FE		Yes	Yes		Yes
Constituency FE		Yes	Yes	Yes	Yes
Controls			Yes	Yes	
Phase-year FE				Yes	
Constant	0.0201***	0.0243***	-0.00141	0.00552	0.0255***
	(0.000461)	(0.000393)	(0.00783)	(0.00852)	(0.00115)
N	1629	1629	1628	1601	252
R^2	0.456	0.698	0.733	0.769	0.676

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. This table shows the impact of EVMs on invalid vote rates in Lok Sabha electoral constituencies. Column (1) runs a simple OLS model, Column (2) reports the results of a basic diff-in-diff regression with constituency specific fixed effects and electoral year fixed effects, Column (3) includes time-varying control variables such as the INC vote share, BJP vote share, number of candidates in the constituency, the eventual margin of victory, and turnout rate, Column (4) replaces electoral year fixed effects by phase-year fixed effects. Finally, Column (5) conducts a basic diff-in-diff regression with constituency and year fixed effects on constituencies with more than 40% of its population living in urban areas. Standard errors have been clustered by constituency for all models.

coefficient is very high. Overall, the rate of invalid voting in India at the constituency level declined from 1.93% in 1998 to .04% in 2004. In Table A.13, the effect of electronic voting machines is significantly negative even when restricting the sample to the urban geographically proximate constituencies, or constituencies matched on 1998 electoral variables.

These results indicate that EVMs succeed in reducing the rate of invalid voting—in fact, invalid voting appears to have been virtually eliminated. This result stems directly from the design of the machine: Indian EVMs, with their finite menu of buttons, make it almost impossible to cast an invalid ballot, whether deliberately or accidentally.

6.2 Effects on Minor-Party Voting

If voters previously intentionally casting spoilt ballots now cannot do so, they may now wish to cast valid votes in such a way as to protest the political system. However, at least in the late 1990s, there existed no major party that could unambiguously be described as an anti-system party, and thus an attractive target for insurgent party protest votes. At least at the national level, there existed a high degree of ideological agreement between the parties on many issues, with a general tendency towards a "moderate pluralism" that supports the legitimacy of the regime (Sridharan and Varshney, 2001). Moreover, parties have difficulty becoming electorally viable without becoming involved in the system of funding irregularities, violence, over-centralization, and clientelism that might repel a protest voter (Vaishnav, 2017).[14] Indian protest voters, then, must vote for small parties, who do not have high chances of winning the election.

We show here that, consistent with insurgent party protest voting, the vote for minor candidates increased in constituencies that used voting machines. We use several measures of a "minor candidate," all based on a certain threshold of vote share that the candidate managed to gain in the election.[15] As such, it is an *ex post* measure of minor candidates.[16] We ran 4 different models where we designated candidates that received less than 2.5%, 5%, 7.5%, and 10% of votes in the district as minor candidates. We looked at the effects of EVMs on the sum of the vote shares of such candidates. These candidates included independents and candidates of minor local or regional parties. However, the many strong regional party candidates were effectively excluded from the analysis. Note that the average effective number of parties in the 1998, 1999, and 2004 Lok Sabha elections was 2.69, while the average vote share of the candidate coming third in the election was 10.94%. Thus, all our measures of minor candidates capture the vote shares of candidates that placed on average worse than 3rd in the election, and most include candidates who are even less relevant.

As with other dependent variables, we first present the pre-trends of the early-treatment and control groups. Figure 2 shows how these trends evolved before and after the treatment year in 1999 for all four measures of minor party vote share. All pre-trends appear parallel. The jump in the average minor party vote share in pilot constituencies in the year 1999 is perceptible, as is the jump for the late-treatment constituencies (or the non-pilot constituencies) in 2004, when all constituencies used voting machines. The claim

[14]The recent history of the Aam Aadmi Party presents an interesting case study of the difficulties in creating a successful anti-system party in India.

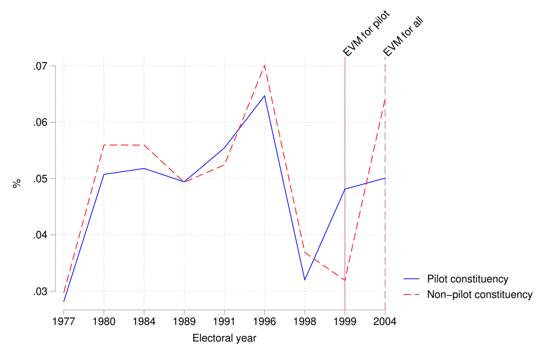
[15]While India does classify candidates (into national parties, state parties, unrecognized parties, and independents), these classifications are at best an imperfect guide to the viability and reputation of the candidates: Many national party candidates win tiny vote shares (and receive no help from the party organization), while many independents come in first or second, and have strong links to one or other of the parties. The boundary between independents and unrecognized parties is especially hazy.

[16]An ex-ante measure of minor party status is difficult because of the high level of variation in party viability from constituency to constituency and from election to election in India.

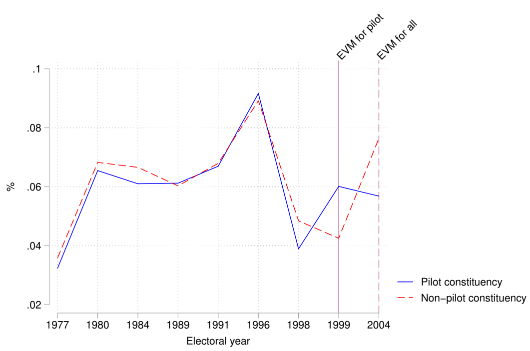
Figure 2: Pre-trends for vote share of “minor parties”

(a) < 2.5%

(b) < 5%



(c) < 7.5%



(d) < 10%

Notes. The blue solid line plots the average summed minor party/candidate vote share (with different thresholds) in all pilot constituency across election years while the red dashed line plots the average summed minor party/candidate vote shares in non-pilot constituencies. The year 1998 marks the last election before the introduction of EVMs. Thus, 1999 is the first post-treatment year for the pilot constituencies. In the year 2004, the non-pilot constituencies also used EVMs.

that pilot and non-pilot constituencies had parallel trends with regards to minor-candidate vote shares is further bolstered by the results in Table A.21, where the coefficients on the interaction of pilot constituency and treatment leads are insignificant in all models.

The results of the difference-in-differences analysis are presented in Table A.2. Overall, we estimate that EVM introduction was associated with a 1.5-3.5 percentage point increase in the vote share of minor candidates in the Lok Sabha elections. There are four separate panels in the table. The first panel presents the result of the base difference-in-differences analysis of all four models. Every model has a significant positive coefficient on EVM. This positive effect of voting machines on minor party vote shares is robust and remains significant after the addition of control variables, the disaggregating of the data by phase-year, and running the standard difference-in-differences regression (without control variables) on the urban sub-sample. Additionally, Table A.9 looks at the effect of voting machines in the geographically proximate constituency subsample as well as the matched constituency subsample. In both panels, the machines have a positive and significant effect on all minor party vote share variables except for the "$< 10\%$" model. The results in Table A.10 from one-to-one nearest neighbor matching further bolsters our results. In Section A.2, we show that decline in minor party vote share led to increases in levels of electoral fragmentation.

One interesting observation is that the estimated increase in minor party vote associated with EVM introduction in Table A.2 is very similar to the estimated decrease in invalid voting associated with voting machine introduction in Table 1. This would imply that the entire decrease in invalid voting was transferred to minor parties, and that most invalid voting in India before 1999 was deliberate and expressive rather than a product of confusion. We should note, however, that these findings suffer from typical problems of ecological inference. The data that we use in our analysis are aggregated at the constituency level. It is thus possible that our results do not reflect individual behavior.

6.3 Voter Confusion as an Alternative Mechanism

One potential interpretation of these results is that they reflect unintentional voting: That is, confused voters vote for each candidate with an equal probability. Since there are many more electorally unviable candidates than there are major candidates in a single member electoral system, these minor candidates gain more vote share, thereby increasing fractionalization as well as votes for minor candidates (and all candidates in general). However, we provide evidence against the purely random voting claim. In Table A.7, we show that voting machines have no effect on the summed vote share of candidates receiving less than

Table 2: Effects of EVMs on Minor party vote shares

(a) **Standard diff-in-diff**

	(1)	(2)	(3)	(4)
	< 2.5%	< 5%	< 7.5%	< 10%
EVM	0.0140***	0.0257***	0.0321***	0.0224**
	(0.00324)	(0.00423)	(0.00517)	(0.00706)
Constant	0.0109***	0.0464***	0.0466***	0.0468***
	(0.000649)	(0.00101)	(0.00134)	(0.00164)
N	1629	1629	1629	1629
R^2	0.622	0.607	0.569	0.548

Standard errors in parentheses
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(b) **Includes controls**

	(1)	(2)	(3)	(4)
	< 2.5%	< 5%	< 7.5%	< 10%
EVM	0.0198***	0.0316***	0.0387***	0.0289***
	(0.00318)	(0.00379)	(0.00506)	(0.00685)
Constant	0.00705	0.0685***	0.0649***	0.0869***
	(0.00819)	(0.0127)	(0.0180)	(0.0227)
N	1628	1628	1628	1628
R^2	0.713	0.666	0.608	0.581

Standard errors in parentheses
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(c) **Phase-year fixed effects**

	(1)	(2)	(3)	(4)
	< 2.5%	< 5%	< 7.5%	< 10%
EVM	0.0203***	0.0319***	0.0380***	0.0281***
	(0.00316)	(0.00403)	(0.00538)	(0.00718)
Constant	0.0170+	0.0697***	0.0741***	0.0903***
	(0.00889)	(0.0145)	(0.0192)	(0.0266)
N	1601	1601	1601	1601
R^2	0.726	0.680	0.622	0.588

Standard errors in parentheses
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(d) **Standard diff-in-diff on urban subsample**

	(1)	(2)	(3)	(4)
	< 2.5%	< 5%	< 7.5%	< 10%
EVM	0.0159***	0.0250***	0.0310***	0.0212*
	(0.00418)	(0.00590)	(0.00733)	(0.00942)
Constant	0.0207***	0.0180***	0.0175***	0.0493***
	(0.00175)	(0.00247)	(0.00332)	(0.00453)
N	252	252	252	252
R^2	0.579	0.560	0.469	0.456

Standard errors in parentheses
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. Panel (a) conducts a basic diff-in-diff regression for all 5 measurements of minor candidate vote share on EVM, Panel (b) includes controls, Panel (c) replaces electoral year fixed effects with phase-year fixed effects, and Panel (d) focuses on the urban subsample (without controls). All standard errors have been clustered at the constituency level.

0.5% of votes. Furthermore, in Table A.9, which displays the results of a difference-in-differences analysis in the geographically proximate and matched subsamples, we see that the effect of voting machines is focused on candidates who receive less than 7.5% of vote share, with the final column, looking at vote shares of candidates receiving less than 10% of votes, showing no effect. This is also the case in Table A.10, where one-to-one nearest neighbor matching also suggests that the effects of EVMs are concentrated on candidates who receive less than 7.5% of the vote share. Thus, the effect of voting machines is not uniform across the candidates, suggesting that voters may be focusing on a set of minor candidates with some level of name recognition, rather than all names on the ballot.

6.4 Within-Party Results

The consequences of the increase in protest voting can be illustrated for two political parties or groups of parties that might appeal to some groups of protest voters. The Bahujan Samaj Party (BSP) was founded upon the grievances of voters from the formerly "untouchable" Scheduled Castes, and is vocal in its belief that other political parties cannot properly represent these voters (Chandra, 2007). Similarly, India's major left wing parties[17] are all vocal in their condemnation of the other parties, who they see as tools of global capitalism and rural "feudalism." These parties' ideologies would thus seem a good fit for the type of anti-establishment views usually associated with protest parties.

However, the nature of these parties differs from state to state. In many states, both the BSP and the left resemble classic protest parties, winning few elections, dispensing no patronage, and depending upon the support of the poor. In the states where they are strongest, however, (Uttar Pradesh for the BSP, and, at the time of study, West Bengal, Kerala, and Tripura for the left) they are the establishment, frequently winning elections and forming the state government—in 1999 the Left Front had governed West Bengal for 22 years. As a consequence, the parties in these areas include many more "normal" office-seeking politicians, win support from a wide variety of social groups, and form mutually profitable relationships with the states' business communities. For these reasons, voters in these states with a grudge against the party system would be unlikely to choose these parties. Thus, our protest-voting hypothesis would imply that the vote share of these parties should increase in states where they are considered to be "minor" and weakly decrease in states where they are competitive.

[17] Communist Party of India, Communist Party of India (Marxist), Communist Party of India (Marxist-Leninist) Liberation, Revolutionary Socialist Party, and Forward Bloc.

Table 3: Differentiated effects of EVMs for the BSP and the Left in and out of strongholds

(a) **BSP in Uttar Pradesh**

	(1)	(2)	(3)	(4)
EVM	0.0153	-0.0281	-0.0114	-0.00412
	(0.0118)	(0.0190)	(0.0308)	(0.0310)
Constant	0.216***	0.234***	0.377***	0.227*
	(0.00633)	(0.00742)	(0.0807)	(0.0913)
N	255	255	255	236
R^2	0.007	0.804	0.832	0.882

Standard errors in parentheses
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(b) **BSP outside Uttar Pradesh**

	(1)	(2)	(3)	(4)
EVM	0.00769***	0.00730*	0.00748*	0.00796*
	(0.00226)	(0.00306)	(0.00339)	(0.00377)
Constant	0.0141***	0.000597	0.00227	0.00189
	(0.00167)	(0.00157)	(0.0171)	(0.0183)
N	1374	1374	1373	1365
R^2	0.007	0.756	0.766	0.773

Standard errors in parentheses
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(c) **Left parties in West Bengal, Kerala, and Tripura**

	(1)	(2)	(3)	(4)
EVM	0.0380	-0.0400	-0.0421^{+}	-0.0497*
	(0.0301)	(0.0252)	(0.0219)	(0.0209)
Constant	0.377***	0.445***	0.389	0.483
	(0.0175)	(0.0108)	(0.301)	(0.297)
N	192	192	192	192
R^2	0.009	0.918	0.926	0.929

Standard errors in parentheses
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(d) **Left parties outside West Bengal, Kerala, and Tripura**

	(1)	(2)	(3)	(4)
EVM	-0.00171	0.00635	0.00565	0.00900
	(0.00401)	(0.00589)	(0.00657)	(0.00791)
Constant	0.0203***	0.0176***	0.0588^{+}	0.0796*
	(0.00225)	(0.00225)	(0.0338)	(0.0311)
N	1437	1437	1436	1409
R^2	0.000	0.675	0.679	0.688

Standard errors in parentheses
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. In all panels, Column (1) runs a simple OLS model, Column (2) reports the results of a basic diff-in-diff regression with constituency specific fixed effects and electoral year fixed effects, Column (3) includes time-varying control variables such as the INC vote share, BJP vote share, number of candidates in the constituency, the eventual margin of victory, and turnout, Column (4) replaces electoral year fixed effects by phase-year fixed effects. Standard errors have been clustered by constituency for all models except for the OLS model.

Table 3 shows that the effect of voting machines on support for the BSP depends on what state the BSP candidate is competing in. While their vote share decreases in their strongholds in Uttar Pradesh (where they identified with the establishment) it increases in other (where their rhetoric may qualify the BSP as a protest party). Similarly, Table 3 also shows that the vote share of a candidate affiliated to a communist party is falling in states where these parties are well-established, and increasing in states where the Communist parties are minor parties. While two out of the four models report insignificant coefficients, the signs on all models are in the expected direction.[18]

6.5 Moderated Effects

If our core hypothesis holds, then invalid votes should translate to votes for minor parties due to the voters' preference for protest voting. While it is difficult to test the assumption that invalid votes served as a tool for protest for Indian voters given the aggregate nature of our data, it is clear that in order for our hypothesis to hold, voting machines should have a greater impact on minor party vote shares where past invalid vote rates were high. That is, past invalid vote rates should moderate the effect of voting machines: Minor party vote shares should increase by a higher rate in constituencies that used a voting machine and that had more invalid voting in the pre electronic voting era.

In order to test this claim, we interact EVM with the 1998 constituency level invalid vote rate. We also include the interaction of invalid vote rate with the electoral cycle to control for the year specific impact of the past level of invalid vote rates on minor party vote shares. More specifically, we run the following regression:

$$\begin{aligned} y_{it} =& \phi_i + \delta_t + \beta_1 EVM_{it} + \beta_2 EVM_{it} * Inv98_i + \gamma_1 Inv98_i * \mathbb{I}_{t=1999} \\ &+ \gamma_2 Inv98_i * \mathbb{I}_{t=2004} + \epsilon_{it}, \end{aligned}$$

where y_{it} is the measure of minor party vote share, EVM_{it} is an indicator of whether a constituency i used an EVM at date t, $Inv98_i$ is the invalid vote rate of constituency i in 1998, and $\mathbb{I}_{t=s}$ is an indicator function. If β_2 is positive, then past invalid vote rates positively moderate the effect of EVMs on minor party vote shares.

Table 4 shows that the moderating effect of invalid vote rates in 1998 on the effect of EVMs on minor party vote share is positive. As is evident, the coefficients on the interaction of the invalid vote rate in 1998 and the presence of electronic voting machines in the

[18]Non-clustered robust standard errors render the EVM coefficient in the core difference-in-differences model in Column (2) statistically significant at, at least, the 10% level, for all panels except for Panel (d).

Table 4: The moderated effect of EVMs on minor party vote shares by invalid vote rates in 1998

	(1)	(2)	(3)	(4)
	$< 2.5\%$	$< 5\%$	$< 7.5\%$	$< 10\%$
EVM	0.00103^{+}	0.0145^{+}	0.0148	0.0172
	(0.00546)	(0.00770)	(0.0101)	(0.0150)
EVM*Invalid98	0.226	0.583^{+}	1.001^{+}	0.187
	(0.304)	(0.335)	(0.524)	(0.772)
Year FE	Yes	Yes	Yes	Yes
Constituency FE	Yes	Yes	Yes	Yes
Year*Invalid98	Yes	Yes	Yes	Yes
Constant	0.290^{***}	0.504^{***}	0.501^{***}	0.858^{***}
	(0.00145)	(0.00212)	(0.00272)	(0.00324)
N	1629	1629	1629	1629
R^2	0.623	0.615	0.575	0.550

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. This table shows the impact of EVMs on minor party vote shares in Lok Sabha electoral constituencies, moderated by invalid vote rates as recorded in 1998. Each column reports results for a different measure of minor candidate. Standard errors have been clustered by constituency for all models.

constituency in the $< 5\%$ and $< 7.5\%$ models are significant at the 10% level, and close to 1. There is thus evidence which suggests that the effect of EVMs on vote share of minor parties was moderated by the past level of invalid rates. This implies that the votes that were previously discarded as invalid are being funnelled instead to minor parties.

6.6 Introduction of "None of the Above" (NOTA) on the ballot

The introduction of electronic voting machines in India effectively ended the possibility for a voter to anonymously participate in the election without voting for any of the candidates on the ballot. With the advent of electronic voting machines, the only way for an invalid vote to be recorded was to inform the clerk in the polling booth of one's intention to do so. The NGO People's Union for Civil Liberties (PUCL) filed a petition in the Supreme Court of India in 2004 advocating the inclusion of an option "None of the Above" (NOTA) for voters who wish to participate in the election but do not want to vote for any candidate

Table 5: Effect of NOTA introduction in 2014 on minor party vote shares

	(1)	(2)	(3)	(4)
	< 2.5%	< 5%	< 7.5%	< 10%
NOTA introduction	-0.0122***	-0.0127***	-0.0151**	-0.0118+
	(0.00252)	(0.00375)	(0.00533)	(0.00668)
Constituency FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Constant	0.00676	0.0921***	0.148***	0.253***
	(0.0184)	(0.0258)	(0.0343)	(0.0432)
N	1086	1086	1086	1086
R^2	0.832	0.796	0.758	0.730

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. This table shows the impact of the introduction of a NOTA option on the vote share of minor parties in Lok Sabha electoral constituencies. Each column looks at a specific definition of minor party, controls for election specific variables, and includes constituency fixed effects.

on the ballot. In 2013, the Supreme Court of India directed the Election Commission of India to add a NOTA button to electronic voting machines, noting that it was important in a democracy to have the right not to vote for any candidate.

The impact of this policy measure is related to our analysis here because NOTA is an effective tool for regularizing protest voting. NOTA voting is essentially an "officially sanctioned" protest vote (Alvarez, Kiewiet and Núñez, 2018). Ujhelyi, Chatterjee and Szabó (2018) look at the introduction of NOTA in Indian state legislative assembly elections in a structural model of voter demand. They find that while the introduction of NOTA increases turnout, it also reduces the vote share of small "fringe" parties, which often have anti-system campaigns. This ties in with our core hypothesis that invalid votes served as a tool for protest for Indian voters, and the removal of such an option led to a spike in the vote share of minor parties. We consequently look at whether NOTA introduction in the 2014 national Lok Sabha elections also resulted in a decrease of vote shares of minor parties.

Note that, since the Supreme Court's decision in 2013 meant that every parliamentary constituency included a NOTA option in 2014 elections, we cannot use a difference-in-differences methodology to estimate the effect of NOTA on minor party vote shares. There is no "control" group which did not use NOTA in the 2014 elections. We instead regress our different measures of minor party vote shares on Lok Sabha elections in 2009 and 2014, with a dummy for the year 2014, time varying controls, as well as constituency fixed effects. The results presented in Table 5 highly suggest that the introduction of NOTA did lead to a reduction in the vote shares of minor parties. Note that the coefficients estimated in Table 5 are very similar to the coefficients estimated in Table 1 which looks at the effect of the introduction of electronic voting machines on invalid vote rates. This would imply that the introduction of electronic voting machines in 1999 induced the transfer of BNS protest votes to minor or fringe parties, and then to the officially sanctioned NOTA protest voting option after 2014.

7 Results for Subsidiary Hypotheses

Do voting machines lead to increases in valid votes cast in error, even as the number of invalid votes decreases? In Section 6.3 we showed that voters do not press buttons randomly. However, there is additional evidence that EVMs had little effect on confusion. We rely on the intuition that confused voters would be more likely to press buttons in certain positions than in others, even if they are unfamiliar with the candidate at that position. One possibility is that voting machines would increase "donkey voting": Choosing the candidate first on the machine. A large literature has shown that voting based on ballot order is a common heuristic among voters (Krosnick, Miller and Tichy, 2003; Ho and Imai, 2008), and we have some anecdotal evidence that voters in India use EVMs in this way (Banerjee, 2015). Ballot order in India is not random, with the candidates of nationally recognized parties being listed first (in alphabetical order in the state's official language) followed by the candidates of state recognized parties, and then all other candidates. Using this structure, we were able to reconstruct the ballot order for all the Hindi-speaking states during our time period. Table A.15 shows the relationship between EVMs and voting for the first placed candidate. There is little or no relationship between EVMs and the vote share of the candidate placed first on the ballot in all models. Another common voting error is to cast votes for candidates immediately above or below their actual preferred choice (Alvarez et al., 2004). Table A.16 and Table A.17 examine whether such "proximity effects" are exacerbated by EVMs. There is no evidence that candidates immediately above or below the winner on the ballot benefit from the introduction of voting machines.

Do voters who previously cast invalid ballots still turn out? In the Indian case, since EVMs make it impossible to cast an invalid ballot, voters who intentionally casted spoiled ballots could now lose their incentive to go to the polls. In Section A.3, we estimate the effects of EVM introduction on turnout, though this estimation is complicated by the fact the turnout date does not show evidence of parallel pre-trends. We find evidence that EVMs are associated with slight reductions in voter turnout, though we are cautious interpreting these results due to the possibility of time-varying confounders. Furthermore, comparison with the matched control group, or with geographically proximate urban constituencies, shows that electronic voting machines did not lead to any change in turnout rates, as summarised in Table A.13.

For reasons of space, our tests of variables connected with fraud are discussed in Section A.4 of the online appendix. To summarize, we find little evidence for any of the various predictions: EVM introduction is not associated with increases in the vote for state incumbent parties or particular national parties, the effect of voting machines does not differ when the machines are provided with an auditable paper trail, and EVM introduction is not associated with decreased turnout in areas that might be thought to be at risk for fraud. This evidence indicates that either fraud is a less serious problem in Indian elections than the qualitative literature might suppose, or fraud exists but its incidence was not altered by the introduction of electronic voting machines.

8 Conclusion

These results show that the switch from paper to electronic voting in India was associated with substantial political effects. Invalid voting was virtually eliminated, with this decline also being associated with an increase in the vote for smaller political parties, often from outside the traditional party system. At the same time, electronic voting machines had modest or null effects on voter error and voter turnout. There is also little evidence that electronic voting machines had an impact on fraud, either for better or for worse. Furthermore, despite fears of partisan or pro-incumbent results, voting machines have no systematic effect on state incumbent party vote shares, or vote shares of specific national parties.

In several respects, these results, particularly the decline of invalid voting, echo the findings of the existing literature. However, they show that this effect represents less of a reduction in votes cast in error than a redirection of protest votes. A fairly constant section of Indian voters are dissatisfied with the Indian political system and wish to cast protest ballots. They do so by casting blank or spoiled ballots before 1998, voting for minor parties when electronic voting was introduced, and then switching to NOTA after the introduction of this option. This type of protest voting appears to be large in magnitude relative to the unintentional casting of invalid or confused ballots. The results thus indicate that the addition of a NOTA option to the machines in 2014 was a step in the right direction, as it provided voters with an avenue to explicitly cast protest votes.

These results suggest that protest votes are fungible across different forms of protest, and that voting technology can transform generalized anti-system sentiment into support for specific candidates. Taken more broadly, the findings suggest that voting technology, can have a substantial, and consequential, effect on how anti-system sentiments are expressed within the electoral system.

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Online Appendix - Not for Publication

The online Appendix is organized as follows. We first present analyses of additional hypotheses developed in the main paper. Section A.1 and Section A.2 discuss whether EVMs had an effect on the number of valid votes and whether EVMs increased fragmentation in a constituency. We then address the question on turnout in Section A.3. We also address the impact of electronic voting machines on fraud in Section A.4. Finally, we report tables including results about control variables from the main text in Section A.5.1, and all other tables are reported in Section A.5.2.

A.1 Effects on Valid Voting

The claim that the fall in invalid voting is normatively important hinges on the assumption that the voters who previously cast invalid votes now cast valid votes. If voters who previously cast invalid votes simply stopped turning out after the introduction of EVMs, the reform would have no political effect, and only a very doubtful normative value. This concern is especially valid because it appears that turnout may decrease with the introduction of EVMs (see Section A.3).

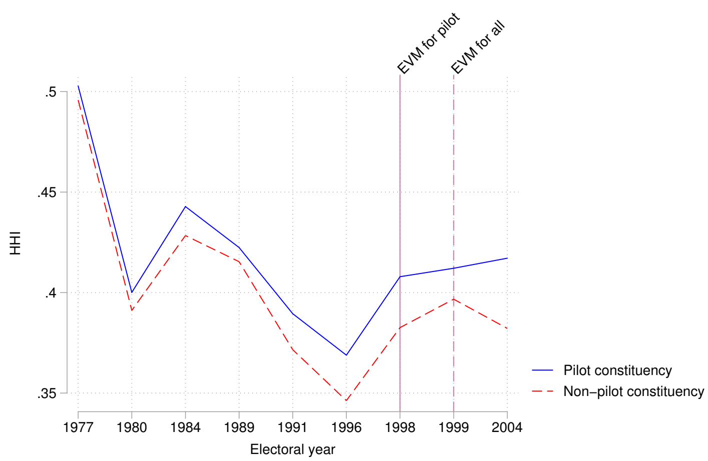
However, the results seem to suggest that EVMs had a net positive effect in terms of "enfranchisement," with the decline in invalid votes swamping the poorly estimated decline in turnout. These results are presented in Table A.6, which shows the results of a difference-in-differences model with the number of valid votes cast in a constituency as a dependent variable. The coefficient on EVMs is positive in all models, although it is not always significant. Thus, we can reasonably conclude that EVMs have an overall non-negative effect on enfranchisement of Indian citizens since they resulted in a smaller number of votes being disregarded as invalid.

Note that this estimated effect may represent an underestimate of the enfranchising effects of EVMs. To the extent that EVMs successfully prevent ballot box stuffing (their primary intended purpose), they should lead to a reduction in the number of legally valid but fraudulent votes, which would lead to EVM introduction having a spurious "disenfranchising" effect. The fact that the number of valid votes increases regardless is strong evidence that EVM introduction led many voters who would previously have cast invalid votes to cast valid ones.

A.2 Fragmentation

The Herfindahl-Hirschman Index (HHI) is the sum of the squared vote shares of all candidates in a constituency. It is an indicator of the relative fractionalization in the electoral district. Thus, in the case of a small number of parties dominating the election, the HHI is close to 1, and if there are many parties with similar vote shares, then it is close to 0. As before, we first present evidence on the pre-trends of HHI in Figure A.1. The trends seem to move together, with the relatively urban and richer pilot constituencies showing more concentration of vote shares and the non-pilot, rural constituencies being more competitive (in terms of the fragmentation of the vote). The trends are relatively parallel for pilot and non-pilot constituencies, and the effect of lags and leads of the treatment is statistically insignificant (Table A.14).

Figure A.1: Pre-trends for HHI



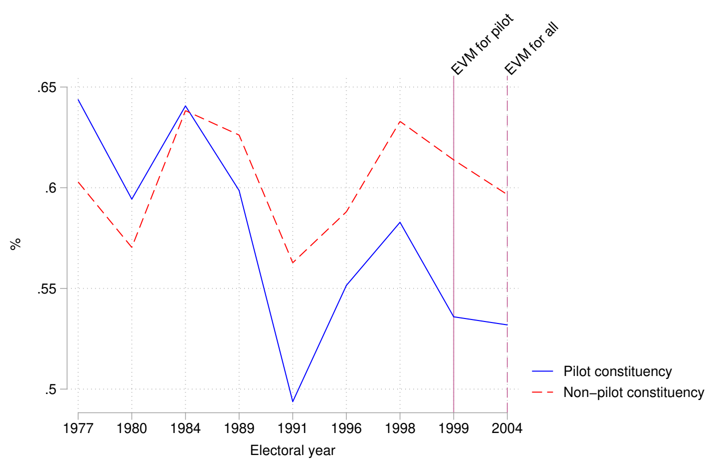
Notes. The blue solid line plots the average HHI in all pilot constituency across election years while the red dashed line plots the average HHI in non-pilot constituencies. The year 1998 marks the last election before the introduction of EVMs. Thus, 1999 is the first post-treatment year for the pilot constituencies. In the year 2004, the non-pilot constituencies also used EVMs.

Table A.11 shows the effect of electronic voting machines (EVMs) on the HHI. EVMs have a negative effect on HHI in all models considered. The smaller the HHI, the more the fragmentation within the electoral district (as votes are divided among more candidates). Thus, a negative coefficient indicates that EVMs increase fractionalization. However, the coefficient in Column (2), the standard difference-in-differences model, is not significant. This is because HHI is affected by other time varying variables such as the number of candidates in the district. After having controlled for these variables, Columns (3) and (4) indicate that EVMs had a significant negative effect on the HHI. This effect is robust to phase-year controls.

A.3 Turnout

Do voters who previously cast invalid ballots still turn out? In the Indian case, since EVMs make it impossible to cast an invalid ballot, voters who intentionally casted spoiled ballots could now loose their incentive to go to the polls. As before, we examine the pre-trends of the early treatment pilot constituencies and the non-pilot constituencies. Compared to the pre-trends of invalid vote rates, the pre-trends for turnout do not show evidence of parallel trends.

Figure A.2: Pre-trends for turnout



Note: The blue solid line plots the average turnout rate in all pilot constituency across election years while the red dashed line plots the average turnout vote rate in non-pilot constituencies. The year 1998 marks the last election before the introduction of EVMs. Thus, 1999 is the first post-treatment year for the pilot constituencies. In the year 2004, the non-pilot constituencies also used EVMs.

In particular, figure A.2 shows that there was a perceptible negative trend in turnout in the treatment districts relative to the control districts in the early 1990s,[19] though the gap did not appear to be increasing in the two elections before 1999. This trend may reflect

[19]The perceptible drop in turnout in pilot constituencies in 1991 could be because of the assassination of Rajiv Gandhi midway through the elections.

the growing turnout gap in India between poor and rich voters, with rich voters tending to be less involved (Ahuja and Chhibber, 2012). The second column in Table A.21 conducts a placebo analysis by comparing the effects of the EVM treatment on turnout in the year 1999 versus other electoral years. According to the results, while the pilot constituencies have consistently smaller turnout rates compared to the non-pilot constituencies across all electoral years, the difference in the treatment year is larger than any other year.

Table A.12 examines the effect of EVM introduction on voter turnout. The results suggest that EVMs have a slight negative effect on turnout. Substantively, the effect is a little over two percentage points, a little smaller than the overall observed decline in turnout during this period, from 62.5% in 1998 to 59% in 2004.

However, we are cautious about whether EVMs affect turnout. Firstly, the pre-trends seem to suggest that the parallel trends assumption is not valid in the case of turnout. Secondly, an analysis of lags and leads of treatment in Table A.21 shows that the pilot constituencies consistently were different from non-pilot constituencies in terms of turnout. Third, these results are not robust to clustering standard errors at the state level, or the state-year level. Thus, it seems likely that turnout rates within each state-year dyad are not independent. And, finally, Panel (c) of Table A.13 in particular shows that voting machines have no effect on turnout when the analysis is restricted to the geographically proximate constituency subsample and the matched constituency subsample.

A.4 EVMs and Fraud

A.4.1 Partisan Effects

If EVMs were in fact altering the chances of successful electoral fraud, we should expect their introduction to increase the vote for specific parties or types of parties, especially those likely to be able to fraudulently manipulate the machines. Note that while study of whether different voting technologies favor or disfavor particular political parties has been the topic of discussion in the literature, there is little proof of systematic effects (as opposed to analyses of particular races) (Stewart, 2011).

We do not find any systematic effects on the vote shares of specific political parties, such as the INC or the BJP, or on the vote shares of electoral alliances such as the BJP-led National Democratic Alliance (NDA), the INC-led United Progressive Alliance (UPA),[20] or

[20] While the UPA was formally created after the 2004 election, the INC was allied with several regional parties during the 1998 and 1999 elections. We also examined whether EVMs had any effect on the vote shares of the INC+allies, and found no systematic effects.

the Third Front. These results are not reported for reasons of space, but are available on request from the authors.

Table A.18 analyzes the effect of EVMs on the vote share of the incumbent party of the state government. In the Indian context, the state government is the agency with effective control over the police and the district administration, which they might use for electoral advantage. Despite the ECI's careful attempts to limit such influence, the state incumbents clearly have a much greater opportunity to engage in fraud than any other party, and a decline of the vote for this party in areas with EVMs would be strong evidence for fraud. Conversely, if EVMs had a positive effect on state incumbent vote share, we might suspect the sort of systematic machine tampering feared by Kumar and Walia (2011).

However, Table A.18 shows that there is little evidence for such an effect. EVMs have a small positive relationship with state incumbent vote share, but this effect is statistically insignificant at conventional levels. State incumbents thus appear not to be affected by the introduction of EVMs, either because of the quality of the ECI's precautions or because EVMs in ineffective in preventing the types of fraud they use.

A.4.2 Voter Verification

One of the defining features of "direct recording" EVMs is that votes are recorded on the memory unit of the machine, rather than on paper. This makes it impossible for voters to directly verify that their vote has been cast in the way that they wish, and theoretically possible to alter vote totals within the machine in ways that would be difficult to detect. The most commonly recommended solution to this problem is a voter-verified paper audit trail (VVPAT) (Kohno et al., 2004). VVPAT machines differ from other EVMs in that the voter receives a paper "receipt" for her vote, which can then be compared to the machine-reported totals in a post-election audit.

In 2013, the Indian supreme court ordered the election commission to introduce VVPAT technology in all elections. In the 2014 national election, eight constituencies had VVPAT. This makes possible a difference-in-differences analysis similar to that in Section A.4.1, using two years (2009 and 2014). Since the announced goal of VVPAT is the reduction in fraud, we will focus on the results for two outcomes that might plausibly be correlated with fraud: The level of voting for the state incumbent party and the turnout rate.[21]

Tables A.19 and A.20 show the results of this analysis. Relative to ordinary machines, the introduction of VVPAT machines appears to have no negative effect on turnout or vote

[21] Results showing VVPAT has no association with invalid voting are not reported for reasons of space.

for incumbents: If anything, turnout appears to increase very slightly in treated constituencies. The fact that the effect of VVPAT machines is indistinguishable from that of non-auditable eletronic voting machines does not mean that these innovations are useless, since this technology may possibly prevent election fraud in the future. It does, however, indicate that these machines are not associated with changes in political outcomes relative to 2004 and 2009, either because no large-scale fraud occurred during this period or because VVPAT has not decreased the types of fraud that did take place.

A.4.3 Turnout and Fraud

It is possible that the effect of EVMs can be found not in the vote totals but in the turnout figures. We especially focus on regional variation in the turnout effect, given that we expect to see decreases in turnout in constituencies that are more prone to booth-capturing. If booth capturing was common before 1999, some portion of the turnout recorded by the ECI represents fraudulent votes, entered into the voter register and ballot box by armed goons. If the introduction of EVMs reduced the incidence of booth capture (as it was designed to do), we should expect turnout to decline with their introduction in areas where this practice was common.

Interestingly, the effect of EVMs on turnout is not larger in areas that would intuitively be identified as more corrupt. One commonly used measure of corruption in Indian public life is the tendency of many candidates to face serious criminal charges (Vaishnav, 2017; Aidt, Golden and Tiwari, 2011). Using Aidt, Golden and Tiwari's (2011) data on the criminal status of candidates in the 2004 and 2009 elections, we define a constituency as "criminal" if there was at least one criminal who ran for election. Table A.14 results show that there is no estimated effect of EVMs on turnout in these constituencies. Similar results (not reported for reasons of space) could be obtained by interacting EVM introduction with state-level poverty, insurgency, or location in the Hindi belt.

These weak results are consistent with design of the machines, since EVMs do not make it impossible for political parties to capture polling booths, but only increase the time it takes to do so. While it is still possible to take control of polling booths, the delay built into the machines means control must be maintained for a longer time if all the booth's ballots are to be casted. Anecdotal evidence suggests that political parties still indulge in fraudulent voting, even with the presence of EVMs (Rohde, 2004).

A.5 Additional Tables

A.5.1 Tables including results on control variables from the main text

Table A.1: Effects of EVMs on invalid vote rates

	(1)	(2)	(3)	(4)	(5)
EVM	-0.0196***	-0.0173***	-0.0174***	-0.0185***	-0.0169***
	(0.000463)	(0.00113)	(0.00124)	(0.00154)	(0.00300)
INC vote share			-0.00226	-0.00396	
			(0.00318)	(0.00324)	
BJP vote share			-0.0114**	-0.0113**	
			(0.00376)	(0.00365)	
Victory margin			0.0131*	0.00806	
			(0.00518)	(0.00497)	
# of candidates			-0.000347**	-0.000434***	
			(0.000112)	(0.000115)	
Turnout			0.0389***	0.0355**	
			(0.0110)	(0.0119)	
Constituency FE		Yes	Yes	Yes	Yes
Year FE		Yes	Yes		Yes
Phase-year FE				Yes	
Constant	0.0201***	0.0243***	-0.00141	0.00552	0.0255***
	(0.000461)	(0.000393)	(0.00783)	(0.00852)	(0.00115)
N	1629	1629	1628	1601	252
R^2	0.456	0.700	0.722	0.762	0.676

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. This table shows the impact of EVMs on invalid vote rates in Lok Sabha electoral constituencies. Column (1) runs a simple OLS model, Column (2) reports the results of a basic diff-in-diff regression with constituency specific fixed effects and electoral year fixed effects, Column (3) includes time-varying control variables such as the INC vote share, BJP vote share, number of candidates in the constituency, the eventual margin of victory, and turnout rate, Column (4) replaces electoral year fixed effects by phase-year fixed effects. Finally, Column (5) conducts a basic diff-in-diff regression with constituency and year fixed effects on constituencies with more than 40% of its population living in urban areas. Standard errors have been clustered by constituency for all models.

Table A.2: Effects of EVMs on Minor party vote shares

(a) **Diff-in-diff + controls**

	(1)	(2)	(3)	(4)
	< 2.5%	< 5%	< 7.5%	< 10%
EVM	0.0198***	0.0316***	0.0387***	0.0289***
	(0.00318)	(0.00379)	(0.00506)	(0.00685)
INC vote share	-0.0114*	-0.0272***	-0.0220*	-0.0232^{+}
	(0.00484)	(0.00747)	(0.00990)	(0.0121)
BJP vote share	-0.00473	-0.0121	-0.0151	-0.0289
	(0.00610)	(0.0109)	(0.0148)	(0.0202)
Victory margin	0.00344	-0.0164	-0.0384*	-0.0324
	(0.00665)	(0.0115)	(0.0149)	(0.0200)
# of candidates	0.00267***	0.00290***	0.00294***	0.00327***
	(0.000315)	(0.000405)	(0.000548)	(0.000653)
Turnout	-0.0113	-0.0407*	-0.0348	-0.0657*
	(0.0106)	(0.0164)	(0.0233)	(0.0297)
Constituency FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Constant	0.00705	0.0685***	0.0649***	0.0869***
	(0.00819)	(0.0127)	(0.0180)	(0.0227)
N	1628	1628	1628	1628
R^2	0.713	0.666	0.608	0.581

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(b) **Phase-year fixed effects**

	(1)	(2)	(3)	(4)
	< 2.5%	< 5%	< 7.5%	< 10%
EVM	0.0203***	0.0319***	0.0380***	0.0281***
	(0.00316)	(0.00403)	(0.00538)	(0.00718)
INC vote share	-0.0127*	-0.0259**	-0.0200^{+}	-0.0219^{+}
	(0.00500)	(0.00784)	(0.0104)	(0.0126)
BJP vote share	-0.00424	-0.00957	-0.0158	-0.0183
	(0.00658)	(0.0113)	(0.0156)	(0.0200)
Victory margin	0.00296	-0.0127	-0.0370*	-0.0359^{+}
	(0.00669)	(0.0118)	(0.0156)	(0.0213)
# of candidates	0.00271***	0.00307***	0.00298***	0.00320***
	(0.000307)	(0.000424)	(0.000565)	(0.000673)
Turnout	-0.0205^{+}	-0.0432*	-0.0441^{+}	-0.0696*
	(0.0111)	(0.0181)	(0.0237)	(0.0328)
Constituency FE	Yes	Yes	Yes	Yes
Phase-year FE	Yes	Yes	Yes	Yes
Constant	0.0170^{+}	0.0697***	0.0741***	0.0903***
	(0.00889)	(0.0145)	(0.0192)	(0.0266)
N	1601	1601	1601	1601
R^2	0.726	0.680	0.622	0.588

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. Panel (a) conducts a basic diff-in-diff regression for all 5 measurements of minor candidate vote share on EVM, and includes controls, Panel (b) replaces electoral year fixed effects with phase-year fixed effects. All standard errors have been clustered at the constituency level.

Table A.3: Differentiated effects of EVMs for the BSP in and out of strongholds

(a) **BSP in Uttar Pradesh**

	(1)	(2)	(3)	(4)
EVM	0.0153	-0.0281	-0.0114	-0.00412
	(0.0118)	(0.0190)	(0.0308)	(0.0310)
INC voteshare			-0.208**	-0.229**
			(0.0663)	(0.0723)
BJP voteshare			-0.137*	-0.0640
			(0.0628)	(0.0817)
Victory Margin			-0.0511	-0.108*
			(0.0562)	(0.0478)
# of candidates			-0.00105	-0.00119
			(0.00117)	(0.00101)
Turnout			-0.140	0.105
			(0.143)	(0.152)
Constituency FE		Yes	Yes	Yes
Year FE		Yes	Yes	
Phase-year FE				Yes
Constant	0.216***	0.234***	0.377***	0.227*
	(0.00633)	(0.00742)	(0.0807)	(0.0913)
N	255	255	255	236
R^2	0.007	0.804	0.832	0.882

Standard errors in parentheses
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(b) **BSP outside Uttar Pradesh**

	(1)	(2)	(3)	(4)
EVM	0.00769***	0.00730*	0.00748*	0.00796*
	(0.00226)	(0.00306)	(0.00339)	(0.00377)
INC voteshare			-0.0453**	-0.0429**
			(0.0161)	(0.0151)
BJP voteshare			-0.0154	-0.00918
			(0.00994)	(0.00974)
Victory Margin			-0.00741	0.00229
			(0.0128)	(0.0138)
# of candidates			0.000111	0.000229
			(0.000456)	(0.000468)
Turnout			0.0144	0.0113
			(0.0200)	(0.0193)
Constituency FE		Yes	Yes	Yes
Year FE		Yes	Yes	
Phase-year FE				Yes
Constant	0.0141***	0.000597	0.00227	0.00189
	(0.00167)	(0.00157)	(0.0171)	(0.0183)
N	1374	1374	1373	1365
R^2	0.007	0.756	0.766	0.773

Standard errors in parentheses
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. In all panels, Column (1) runs a simple OLS model, Column (2) reports the results of a basic diff-in-diff regression with constituency specific fixed effects and electoral year fixed effects, Column (3) includes time-varying control variables such as the INC vote share, BJP vote share, number of candidates in the constituency, the eventual margin of victory, and turnout, Column (4) replaces electoral year fixed effects by phase-year fixed effects. Standard errors have been clustered by constituency for all models.

Table A.4: Differentiated effects of EVMs for the Left in and out of strongholds

(a) **Left in West Bengal, Kerala, and Tripura**

	(1)	(2)	(3)	(4)
EVM	0.0380	-0.0400	-0.0421^{+}	-0.0497*
	(0.0301)	(0.0252)	(0.0219)	(0.0209)
INC voteshare			-0.264^{+}	-0.221
			(0.145)	(0.133)
BJP voteshare			-0.182^{+}	-0.175^{+}
			(0.104)	(0.100)
Victory Margin			0.208*	0.162
			(0.0938)	(0.108)
# of candidates			-0.000757	0.000581
			(0.00318)	(0.00328)
Turnout			0.261	0.122
			(0.475)	(0.457)
Constituency FE		Yes	Yes	
Year FE		Yes	Yes	
Phase-year FE				Yes
Constant	0.377***	0.445***	0.389	0.483
	(0.0175)	(0.0108)	(0.301)	(0.297)
N	192	192	192	192
R^2	0.009	0.918	0.926	0.929

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(b) **Left outside West Bengal, Kerala, and Tripura**

	(1)	(2)	(3)	(4)
EVM	-0.00171	0.00635	0.00565	0.00900
	(0.00401)	(0.00589)	(0.00657)	(0.00791)
INC voteshare			-0.0458**	-0.0502**
			(0.0146)	(0.0162)
BJP voteshare			-0.0260	-0.0267
			(0.0212)	(0.0235)
Victory Margin			-0.00858	-0.0207
			(0.0227)	(0.0223)
# of candidates			0.000239	-0.000161
			(0.000560)	(0.000559)
Turnout			-0.0398	-0.0527
			(0.0443)	(0.0396)
Constituency FE		Yes	Yes	
Year FE		Yes	Yes	
Phase-year FE				Yes
Constant	0.0203***	0.0176***	0.0588^{+}	0.0796*
	(0.00225)	(0.00225)	(0.0338)	(0.0311)
N	1437	1437	1436	1409
R^2	0.000	0.675	0.679	0.688

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. In all panels, Column (1) runs a simple OLS model, Column (2) reports the results of a basic diff-in-diff regression with constituency specific fixed effects and electoral year fixed effects, Column (3) includes time-varying control variables such as the INC vote share, BJP vote share, number of candidates in the constituency, the eventual margin of victory, and turnout, Column (4) replaces electoral year fixed effects by phase-year fixed effects. Standard errors have been clustered by constituency for all models.

Table A.5: Effect of NOTA introduction in 2014 on minor party vote shares

	(1)	(2)	(3)	(4)
	< 2.5%	< 5%	< 7.5%	< 10%
NOTA introduction	-0.0122***	-0.0127***	-0.0151**	-0.0118+
	(0.00252)	(0.00375)	(0.00533)	(0.00668)
INC voteshare	0.00235	-0.00792	-0.0207	-0.0387+
	(0.00908)	(0.0125)	(0.0164)	(0.0213)
BJP voteshare	-0.00856	-0.00507	-0.0131	-0.0289
	(0.0105)	(0.0162)	(0.0231)	(0.0284)
Victory Margin	-0.00912	0.00337	0.0414+	0.0493+
	(0.0104)	(0.0152)	(0.0222)	(0.0297)
# of candidates	0.00240***	0.00252***	0.00270***	0.00301***
	(0.000351)	(0.000421)	(0.000748)	(0.000770)
Turnout	0.0320	-0.0546	-0.0876+	-0.166**
	(0.0242)	(0.0350)	(0.0450)	(0.0591)
Constituency FE	Yes	Yes	Yes	Yes
Constant	0.00676	0.0921***	0.148***	0.253***
	(0.0184)	(0.0258)	(0.0343)	(0.0432)
N	1086	1086	1086	1086
R^2	0.832	0.796	0.758	0.730

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. This table shows the impact of the introduction of a NOTA option on the vote share of minor parties in Lok Sabha electoral constituencies. Each column looks at a specific definition of minor party, controls for election specific variables, and includes constituency fixed effects.

A.5.2 Other Tables

Table A.6: Effect of EVMs on valid votes

	(1)	(2)	(3)	(4)	(5)
EVM	37587.5***	13693.7	19611.9^{+}	21811.9^{+}	21793.0
	(5611.8)	(11213.4)	(11801.8)	(11495.78)	(18052.1)
Year FE		Yes	Yes		Yes
Constituency FE		Yes	Yes	Yes	Yes
Controls			Yes	Yes	
Phase-Year FE				Yes	
Constant	675191.1***	760420.1***	564393.8***	560744.5***	567489.2***
	(6338.7)	(2469.2)	(62507.41)	(66407.9)	(7037.4)
N	1629	1629	1628	1601	252
R^2	0.012	0.926	0.931	0.941	0.968

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. This table shows the impact of EVMs on valid votes in Lok Sabha electoral constituencies. Column (1) runs a simple OLS model, Column (2) reports the results of a basic diff-in-diff regression with constituency specific fixed effects and electoral year fixed effects, Column (3) includes time-varying control variables such as the INC vote share, BJP vote share, number of candidates in the constituency, the eventual margin of victory, the HHI score and total number of electors, Column (4) replaces electoral year fixed effects by phase-year fixed effects. Finally, Column (5) conducts a basic diff-in-diff regression with constituency and year fixed effects on constituencies with more than 40% of its population living in urban areas. Standard errors have been clustered by constituency for all models.

Table A.7: Effect of EVMs on vote share of candidates receiving less that 0.5% of votes

	(1)	(2)	(3)	(4)	(5)
EVM	0.000887**	-0.00274**	0.000608	0.000724	-0.00247
	(0.000324)	(0.00105)	(0.000929)	(0.000957)	(0.00160)
Year FE		Yes	Yes		Yes
Constituency FE		Yes	Yes	Yes	Yes
Controls			Yes	Yes	
Phase-year FE				Yes	
Constant	0.00754***	0.000908***	-0.0130***	-0.0115***	0.0117***
	(0.000243)	(0.000229)	(0.00267)	(0.00309)	(0.000714)
N	1629	1629	1628	1601	252
R^2	0.003	0.642	0.823	0.828	0.634

Standard errors in parentheses

$^+$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. This table shows the impact of EVMs on the vote share of candidates receiving less than 0.5% of vote share in Lok Sabha electoral constituencies. Column (1) runs a simple OLS model, Column (2) reports the results of a basic diff-in-diff regression with constituency specific fixed effects and electoral year fixed effects, Column (3) includes time-varying control variables such as the INC vote share, BJP vote share, number of candidates in the constituency, the eventual margin of victory, the HHI score and total number of electors, Column (4) replaces electoral year fixed effects by phase-year fixed effects. Finally, Column (5) conducts a basic diff-in-diff regression with constituency and year fixed effects on constituencies with more than 40% of its population living in urban areas. Standard errors have been clustered by constituency for all models.

Table A.8: Effect of EVMs on vote share of candidates receiving less that 20% of votes

	(1)	(2)	(3)	(4)	(5)
EVM	0.0231***	0.0237	0.00537	0.00445	0.0317
	(0.00432)	(0.0164)	(0.0130)	(0.0135)	(0.0193)
Year FE		Yes	Yes		Yes
Constituency FE		Yes	Yes	Yes	Yes
Controls			Yes	Yes	
Phase-year FE				Yes	
Constant	0.111***	0.0507***	0.456***	0.440***	0.0580***
	(0.00349)	(0.00347)	(0.0495)	(0.0563)	(0.00831)
N	1629	1629	1628	1601	252
R^2	0.012	0.582	0.715	0.726	0.555

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. This table shows the impact of EVMs on the vote share of candidates receiving less than 20% of vote share in Lok Sabha electoral constituencies. Column (1) runs a simple OLS model, Column (2) reports the results of a basic diff-in-diff regression with constituency specific fixed effects and electoral year fixed effects, Column (3) includes time-varying control variables such as the INC vote share, BJP vote share, number of candidates in the constituency, the eventual margin of victory, the HHI score and total number of electors, Column (4) replaces electoral year fixed effects by phase-year fixed effects. Finally, Column (5) conducts a basic diff-in-diff regression with constituency and year fixed effects on constituencies with more than 40% of its population living in urban areas. Standard errors have been clustered by constituency for all models.

Table A.9: Effect of EVMs on minor party vote shares in subsamples of the data

(a) Proximate constituency subsample

	(1)	(2)	(3)	(4)
	$< 2.5\%$	$< 5\%$	$< 7.5\%$	$< 10\%$
EVM	0.0150^{**}	0.0184^{*}	0.0269^{*}	0.00763
	(0.00523)	(0.00811)	(0.0100)	(0.0144)
Constituency FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Constant	0.0230^{***}	0.0208^{***}	0.0201^{***}	0.0520^{***}
	(0.00180)	(0.00270)	(0.00375)	(0.00574)
N	144	144	144	144
R^2	0.582	0.562	0.461	0.393

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(b) Matched constituencies subsample

	(1)	(2)	(3)	(4)
	$< 2.5\%$	$< 5\%$	$< 7.5\%$	$< 10\%$
EVM	0.0192^{**}	0.0257^{***}	0.0313^{**}	0.00510
	(0.00592)	(0.00665)	(0.0104)	(0.0154)
Constituency FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Constant	0.0346^{***}	0.0467^{***}	0.0667^{***}	0.0739^{***}
	(0.00273)	(0.00388)	(0.00415)	(0.00625)
N	162	162	162	162
R^2	0.502	0.610	0.567	0.452

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. Panel (a) conducts a basic diff-in-diff regression of all measures of minor party vote share on EVM within the proximate constituency subsample, Panel (b) conducts a basic diff-in-diff regression of all measures of minor party vote share on EVM within the matched constituency subsample. All standard errors have been clustered at the constituency level.

Table A.10: Propensity score matching results

	(1)	(2)	(3)	(4)
	$< 2.5\%$	$< 5\%$	$< 7.5\%$	$< 10\%$
EVM	0.0156**	0.0218***	0.0307***	0.0114
	(0.00391)	(0.00587)	(0.00893)	(0.0106)

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. This table shows the results from one-to-one propensity score matching. Each column shows the effect estimated through the matching procedure for each measure of minor party.

Table A.11: Effects of EVMs on HHI

	(1)	(2)	(3)	(4)	(5)
EVM	-0.00331	-0.0148	-0.0274**	-0.0252*	-0.0179
	(0.00287)	(0.0106)	(0.0103)	(0.0107)	(0.0170)
Year FE		Yes	Yes		Yes
Constituency FE		Yes	Yes	Yes	Yes
Controls			Yes	Yes	
Phase-year FE				Yes	
Constant	0.390***	0.399***	0.384***	0.395***	0.457***
	(0.00289)	(0.00238)	(0.0285)	(0.0323)	(0.00521)
N	1629	1629	1628	1601	252
R^2	0.000	0.690	0.760	0.765	0.568

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. This table shows the impact of EVMs on the HHI in Lok Sabha electoral constituencies. Column (1) runs a simple OLS model, Column (2) reports the results of a basic diff-in-diff regression with constituency specific fixed effects and electoral year fixed effects, Column (3) includes time-varying control variables such as the INC vote share, BJP vote share, number of candidates in the constituency, the eventual margin of victory and turnout rate, Column (4) replaces electoral year fixed effects by phase-year fixed effects. Finally, Column (5) conducts a basic diff-in-diff regression with constituency and year fixed effects on constituencies with more than 40% of its population living in urban areas. Standard errors have been clustered by constituency for all models.

Table A.12: Effect of EVMs on turnout

	(1)	(2)	(3)	(4)	(5)
EVM	-0.0346***	-0.0238**	-0.0219*	-0.0177*	-0.0140
	(0.00326)	(0.00854)	(0.00883)	(0.00817)	(0.0108)
Year FE		Yes	Yes		Yes
Constituency FE		Yes	Yes	Yes	Yes
Controls			Yes	Yes	
Phase-year FE				Yes	
Constant	0.619***	0.727***	0.741***	0.766***	0.465***
	(0.00404)	(0.00238)	(0.0193)	(0.0203)	(0.00509)
N	1629	1629	1628	1601	252
R^2	0.024	0.847	0.849	0.873	0.908

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. This table shows the impact of EVMs on turnout rates in Lok Sabha electoral constituencies. Column (1) runs a simple OLS model, Column (2) reports the results of a basic diff-in-diff regression with constituency specific fixed effects and electoral year fixed effects, Column (3) includes time-varying control variables such as the INC vote share, BJP vote share, number of candidates in the constituency, the eventual margin of victory, and the HHI score, Column (4) replaces electoral year fixed effects by phase-year fixed effects. Finally, Column (5) conducts a basic diff-in-diff regression with constituency and year fixed effects on constituencies with more than 40% of its population living in urban areas. Standard errors have been clustered by constituency for all models.

Table A.13: Results from subsamples of the data

(a) Invalid rate

	(1) Proximate constituencies	(2) Matched constituencies
EVM	-0.0122***	-0.0192***
	(0.00281)	(0.00428)
Constituency FE	Yes	Yes
Year FE	Yes	Yes
Constant	0.0240***	0.0166***
	(0.00141)	(0.00122)
N	144	162
R^2	0.719	0.704

Standard errors in parentheses
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(b) Turnout

	(1) Proximate constituencies	(2) Matched constituencies
EVM	-0.00758	0.000777
	(0.0107)	(0.0165)
Constituency FE	Yes	Yes
Year FE	Yes	Yes
Constant	0.467***	0.533***
	(0.00608)	(0.00621)
N	144	162
R^2	0.930	0.931

Standard errors in parentheses
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. Panel (a) conducts a basic diff-in-diff regression of invalid rates on EVM within two subsamples of the data, Panel (b) conducts a basic diff-in-diff regression of HHI on EVM within two subsamples of the data, Panel (c) conducts a basic diff-in-diff regression of invalid rates on EVM within two subsamples of the data. All standard errors have been clustered at the constituency level.

Table A.14: Effect of EVM*criminal constituency on turnout

	(1)	(2)	(3)	(4)	(5)
EVM	-0.0265***	-0.0272+	-0.0256+	-0.0177	-0.00839
	(0.00652)	(0.0155)	(0.0150)	(0.0132)	(0.0123)
EVM*criminal constituency	-0.0139**	0.00565	0.00636	0.000243	-0.0108
	(0.00647)	(0.0184)	(0.0177)	(0.0160)	(0.0143)
Year FE		Yes	Yes		Yes
Constituency FE		Yes	Yes	Yes	Yes
Year*criminal constituency FE		Yes	Yes	Yes	Yes
Controls			Yes	Yes	
Phase-year FE				Yes	
Constant	0.636***	0.624***	0.647***	0.670***	0.469***
	(0.00634)	(0.00409)	(0.0222)	(0.0246)	(0.00797)
N	1629	1629	1628	1601	252
R^2	0.0510	0.849	0.851	0.876	0.908

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. This table shows the impact of EVMs on turnout rates in constituencies that had a criminal candidate run in 2004. Column (1) runs a simple OLS model, Column (2) reports the results of a triple differences regression with constituency specific fixed effects, electoral year fixed effects, and an interaction of year dummies and criminal constituency dummy, Column (3) includes time-varying control variables such as the INC vote share, BJP vote share, number of candidates in the constituency, the eventual margin of victory, the HHI score and turnout rate, Column (4) replaces electoral year fixed effects by phase-year fixed effects. Finally, Column (5) conducts the triple difference regression on constituencies with more than 40% of its population living in urban areas. Standard errors have been clustered by constituency for all models.

Table A.15: Effect of EVM on vote share of candidate placed 1st on the ballot list in the Hindi belt

	(1)	(2)	(3)
EVM	-0.0130	-0.000638	-0.0483
	(0.0128)	(0.0767)	(0.0794)
Year FE		Yes	Yes
Constituency FE		Yes	Yes
Controls			Yes
Constant	0.249***	0.138***	0.253
	(0.00998)	(0.0260)	(0.155)
N	675	675	674
R^2	0.001	0.520	0.549

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. This table shows the impact of EVMs on the vote share of the 1st placed candidate in the Hindi belt. Column (1) runs a simple OLS model, Column (2) reports the results of a basic diff-in-diff regression with constituency specific fixed effects and electoral year fixed effects, Column (3) includes time-varying control variables such as the INC vote share, BJP vote share, number of candidates in the constituency, the eventual margin of victory, the HHI score and the turnout rate. Standard errors are clustered at the constituency level.

Table A.16: Effect of EVM on vote share of candidate placed below the eventual winner on the ballot list in the Hindi belt

	(1)	(2)	(3)
EVM	-0.00854	-0.0313	-0.0313
	(0.0111)	(0.0520)	(0.0569)
Year FE		Yes	Yes
Constituency FE		Yes	Yes
Controls			Yes
Constant	0.109***	0.0262	-0.0995
	(0.00801)	(0.0192)	(0.145)
N	651	651	650
R^2	0.001	0.454	0.480

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. This table shows the impact of EVMs on the vote share of the candidate placed below the winner in the Hindi belt. Column (1) runs a simple OLS model, Column (2) reports the results of a basic diff-in-diff regression with constituency specific fixed effects and electoral year fixed effects, Column (3) includes time-varying control variables such as the INC vote share, BJP vote share, number of candidates in the constituency, the eventual margin of victory, the HHI score and the turnout rate. Standard errors have been clustered at the constituency level.

Table A.17: Effect of EVM on vote share of candidate placed above the eventual winner on the ballot list in the Hindi belt

	(1)	(2)	(3)
EVM	-0.0271*	0.0165	0.0355
	(0.0135)	(0.0727)	(0.0690)
Year FE		Yes	Yes
Constituency FE		Yes	Yes
Controls			Yes
Constant	0.137***	0.0882**	-0.0264
	(0.00974)	(0.0273)	(0.183)
N	499	499	498
R^2	0.007	0.587	0.629

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. This table shows the impact of EVMs on the vote share of the candidate placed below the winner in the Hindi belt. Column (1) runs a simple OLS model, Column (2) reports the results of a basic diff-in-diff regression with constituency specific fixed effects and electoral year fixed effects, Column (3) includes time-varying control variables such as the INC vote share, BJP vote share, number of candidates in the constituency, the eventual margin of victory, the HHI score and the turnout rate. Standard errors have been clustered at the constituency level.

Table A.18: Effect of EVMs on state incumbent vote share

	(1)	(2)	(3)	(4)	(5)
EVM	0.00162	0.000623	-0.00332	-0.00709	-0.00454
	(0.00183)	(0.00479)	(0.00482)	(0.00498)	(0.00751)
Year FE		Yes	Yes		Yes
Constituency FE		Yes	Yes	Yes	Yes
Controls			Yes	Yes	
Phase-year FE				Yes	
Constant	0.0429***	0.0785***	0.104***	0.0922**	0.0322***
	(0.00166)	(0.00134)	(0.0253)	(0.0298)	(0.00309)
N	1617	1617	1616	1589	243
R^2	0.000	0.621	0.682	0.693	0.595

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. This table shows the impact of EVMs on state incumbent vote share in Lok Sabha electoral constituencies. Column (1) runs a simple OLS model, Column (2) reports the results of a basic diff-in-diff regression with constituency specific fixed effects and electoral year fixed effects, Column (3) includes time-varying control variables such as the INC vote share, BJP vote share, number of candidates in the constituency, the eventual margin of victory, the HHI score and turnout rate, Column (4) replaces electoral year fixed effects by phase-year fixed effects. Finally, Column (5) conducts a basic diff-in-diff regression with constituency and year fixed effects on constituencies with more than 40% of its population living in urban areas. Standard errors have been clustered by constituency for all models.

Table A.19: Effect of VVPAT on turnout

	(1)	(2)	(3)	(4)
VVPAT	-0.0235	0.0195	0.0234	0.0112
	(0.0339)	(0.0391)	(0.0344)	(0.0624)
Year FE		Yes	Yes	Yes
Constituency FE		Yes	Yes	Yes
Controls			Yes	
Constant	0.634***	0.720***	0.649***	0.532***
	(0.00510)	(0.00186)	(0.0174)	(0.00895)
N	1086	1086	1086	75
R^2	0.000	0.944	0.954	0.929

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. This table shows the impact of EVMs on invalid vote rates in Lok Sabha electoral constituencies. Column (1) runs a simple OLS model, Column (2) reports the results of a basic diff-in-diff regression with constituency specific fixed effects and electoral year fixed effects, Column (3) includes time-varying control variables such as the INC vote share, BJP vote share, number of candidates in the constituency, the eventual margin of victory, the HHI score and turnout rate. Finally, Column (4) conducts a basic diff-in-diff regression with constituency and year fixed effects on constituencies with more than 40% of its population living in urban areas. Standard errors have been clustered by constituency for all models.

Table A.20: Effect of VVPAT on state incumbent vote share

	(1)	(2)	(3)	(4)
VVPAT	-0.00880*	0.000552	-0.00144	-0.00269
	(0.00438)	(0.00591)	(0.00493)	(0.0100)
Year FE		Yes	Yes	Yes
Constituency FE		Yes	Yes	Yes
Controls			Yes	
Constant	0.0228***	0.0351***	0.0245*	0.0315***
	(0.000868)	(0.000519)	(0.0119)	(0.00220)
N	1078	1078	1078	73
R^2	0.001	0.851	0.889	0.773

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes. This table shows the impact of EVMs on invalid vote rates in Lok Sabha electoral constituencies. Column (1) runs a simple OLS model, Column (2) reports the results of a basic diff-in-diff regression with constituency specific fixed effects and electoral year fixed effects, Column (3) includes time-varying control variables such as the INC vote share, BJP vote share, number of candidates in the constituency, the eventual margin of victory, the HHI score and turnout rate, Column (4) replaces electoral year fixed effects by phase-year fixed effects. Finally, Column (5) conducts a basic diff-in-diff regression with constituency and year fixed effects on constituencies with more than 40% of its population living in urban areas. Standard errors have been clustered by constituency for all models.

Table A.21: Leads of the treatment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable	Invalid votes	HHI	Turnout	2.5%	5%	7.5%	10%
Pilot*1989	-0.00265	-0.00527	-0.0215^{+}	-0.000447	0.00387	0.00577	0.0114
	(0.00386)	(0.0182)	(0.0113)	(0.00414)	(0.00621)	(0.00807)	(0.0132)
Pilot*1991	0.00125	0.00381	-0.0718***	-0.00326	0.00683	0.00399	-0.00297
	(0.00279)	(0.0186)	(0.0183)	(0.00431)	(0.00725)	(0.00844)	(0.0118)
Pilot*1996	0.000881	0.00234	-0.0399*	-0.00575	-0.00177	0.00932	0.00627
	(0.00267)	(0.0153)	(0.0165)	(0.00538)	(0.00895)	(0.0118)	(0.0138)
Pilot*1998	0.00134	0.00503	-0.0445**	-0.00378	-0.00123	-0.00262	-0.0000735
	(0.00270)	(0.0137)	(0.0141)	(0.00463)	(0.00719)	(0.00865)	(0.0108)
Pilot*1999	***-0.0131******	***-0.00490***	***-0.0758******	***0.00738***	***0.0198******	***0.0245*****	***0.0182****
	(0.00285)	***(0.0157)***	***(0.0172)***	***(0.00476)***	***(0.00561)***	***(0.00740)***	***(0.00905)***
Pilot*2004	0.00719**	0.0147	-0.0596***	-0.00956*	-0.0105	-0.0127	-0.00841
	(0.00275)	(0.0151)	(0.0141)	(0.00442)	(0.00642)	(0.00874)	(0.0110)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constituency FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.0366***	0.446***	0.697***	0.0299***	0.0461***	0.0530***	0.0640***
	(0.00192)	(0.00306)	(0.00285)	(0.000850)	(0.00129)	(0.00170)	(0.00223)
N	3777	3777	3775	3777	3777	3777	3777
R^2	0.312	0.586	0.779	0.543	0.486	0.449	0.422

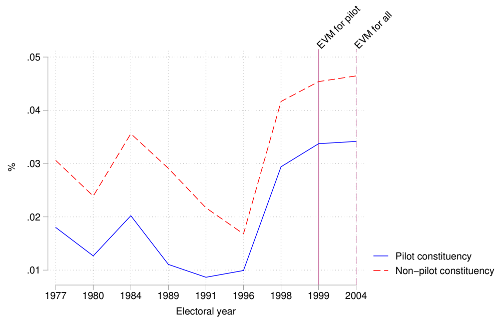
Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

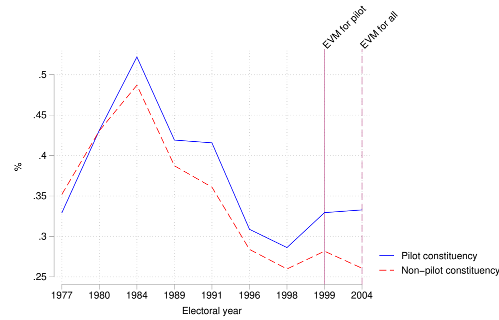
Notes. This table assigns placebo treatments to pilot constituencies in electoral years prior to 1999. Column (1) investigates the effect of placebo EVM treatment on invalid vote rates, Column (2) looks at the HHI, Column (3) does the same for turnout rates, and Columns (4)-(7) look at the leads of treatment for the different measures of minor party vote share. The actual treatment year for pilot constituencies is 1999, and is marked by the bold and italic row. All errors have been clustered at the constituency level.

Figure A.3: Pre-trends for other variables

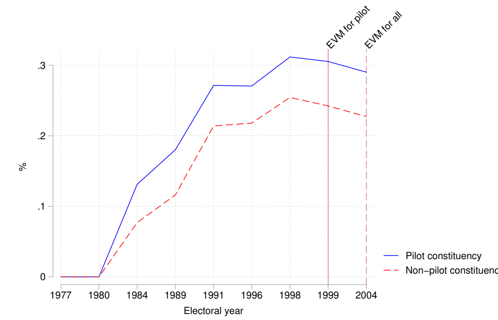
(a) State incumbent vote share



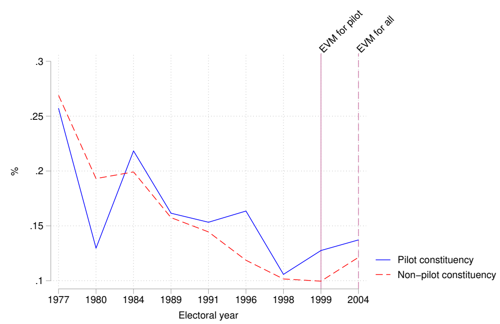
(b) INC vote share



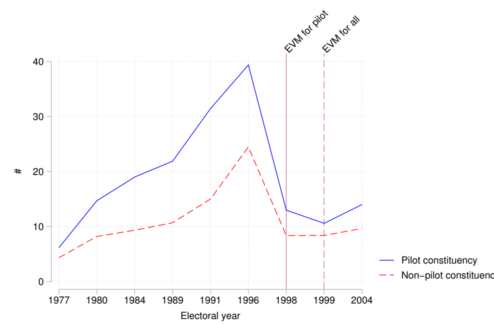
(c) BJP vote share



(d) Margin of victory



(e) Number of candidates



Notes. The blue solid line plots the average values of the different variables in all pilot constituency across election years while the red dashed line plots the average of the control variables in non-pilot constituencies. The year 1998 marks the last election before the introduction of EVMs. Thus, 1999 is the first post-treatment year for the pilot constituencies. In the year 2004, the non-pilot constituencies also used EVMs.