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Does increased credibility of elections lead to higher political competition? Evidence from India ☆

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ABSTRACT

A large amount of administrative effort is directed towards making elections credible and reducing electoral fraud in large democracies. However, it is not clear if such policy efforts have a feedback effect on political competition. In this paper, we exploit plausibly exogenous variation in perceptions of electoral credibility following the introduction of a technology-induced voting reform in India and find significant impacts on political competition. Electronic voting machines in India were mandated to include an additional layer of transparency by the introduction of a Voter-Verified Paper Audit Trail (VVPAT). We find that with the introduction of VVPAT, the winning margins and vote share of winners decline whereas the number of candidates in the average race increases. The results are robust to econometric concerns arising out of staggered implementation of the program providing support to our identification design. Our results also point to heterogeneous effects of the VVPAT roll-out in constituencies that received it only once relative to those that got the VVPAT in two successive elections. Interestingly, we note that much of the welfare improvement through increased political competition is reversed with more experience, suggesting the presence of important learning effects.

1. Introduction

Higher political competition is typically associated with favorable implications for economic efficiency (Albornoz and Cabrales, 2013; Besley et al., 2010; Dash and Mukherjee, 2015; Bierbrauer and Boyer, 2016; Solé-Ollé and Viladecans-Marsal, 2012; Grossman and Helpman, 1996; Sørensen, 2014). Electoral competition, in particular, often raises the bar for politicians who end up making more promises and commit to more deliverables (Walkowitz and Weiss, 2017). However, the way political competition is operationalized in major democracies is often problematic. For instance, there may be a lack of adequate number of candidates commensurate with preferred policy positions of voters (Lizzeri and Persico, 2005); or micro-targeting of campaigns and polarization of electoral outcomes (Prummer, 2020; Galeotti and Mattozzi, 2011); poorer quality of candidates with worse outside options in the labor market (Caselli and Morelli, 2004); use of endogenous political institutions to weaken potential new entrants who could

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be electoral threats to incumbents (Baskaran and Lopes da Fonseca, 2016) and, perhaps most critically, an increased incidence of electoral fraud (Dawson, 2020; Nyblade and Reed, 2008; Nichter, 2008; Sidorkin and Vorobyev, 2020).

Establishing a causal relationship between political competition and electoral fraud, or conversely credibility of elections, is challenging. This is primarily because political competition and credibility of elections are likely jointly determined. As a result, any standard approach using ordinary least squares estimation is likely to run into reverse causality issues. Dawson (2020) uses ex-ante close elections to estimate the effect of competition on potential electoral fraud. In this paper, we are interested in estimating the reverse; i.e., the impact of making elections more credible on political competition. Understanding this relationship in a causal framework is important given that considerable government efforts are directed towards creating institutions and policies that make electoral processes free, fair and smooth. Aside from the instrumental benefits of having fair elections, an impact on political competition would also imply potential efficiency gains as those discussed above, thus providing a stronger rationale for such policies.

We exploit plausibly exogenous variation in credibility of elections generated by the introduction of a new technology in the voting process in India, which is the world's largest democracy. Following court verdicts in 2011, the Election Commission of India (ECI), the independent and autonomous body in charge of conducting major elections, introduced a Voter-Verified Paper Audit Trail (VVPAT) in the Electronic Voting Machines (EVMs) to enhance the reliability of votes recorded in EVMs and counter allegations of voter fraud and tampering. Although, the VVPAT system was experimentally rolled out in 2011, the universal mandate for VVPATs in all EVMs came much later. Using this phased introduction of VVPAT technology in voting and exploiting the temporal variation generated by the pre-determined electoral calendar of India where different sets of states go for elections at different times, we estimate the reduced-form impact of increased credibility of elections on political competition.

We examine outcomes such as winning margins and winners' vote-shares. Additionally, we study candidate-specific outcomes such as number of individuals choosing to run in a given constituency (equivalent to an electoral district), number of candidates forfeiting their deposits, composition of experienced candidates fielded by political parties etc. The results are noteworthy and ought to serve as a guide to future policy discussions. We find that average winning margins decline with introduction of the VVPAT technology suggesting that enhanced credibility of elections can lead to more competitive elections. We also find that the vote shares of the winner (ex-post) declines and number of candidates contesting in a given constituency increases. This is consistent with the idea that increased political competition implies more candidates are attracted to the race as well as a tighter race for the winner. There is significant heterogeneity in our results driven by past exposure to VVPAT. In general, the results are very different for constituencies that are exposed to VVPAT for the first time compared to those that have prior experience of voting under VVPAT. This suggests presence of some learning effects and that the impact of credibility on competition may be dampened when agents get used to the technology.

Our identification strategy relies on two main sources of exogenous variation. First, the institutional features of the VVPAT program itself, which entailed a phased roll-out of the technology over time. The VVPAT was experimentally introduced in some constituencies initially; before being gradually rolled out in other constituencies across states. This phased rollout provides administratively generated variation in exposure of constituencies to the VVPAT technology. Second, the pre-determined electoral calendar of India implies that states go to elections every 5 years (unless there are exceptional circumstances such as government losing majority in the legislative assembly) and not every state goes to elections at the same time. This provides a natural variation in the timing of elections and consequently in the timing of being exposed to VVPAT technology. Our identifying assumption regarding the counterfactual is that in the absence of VVPAT, the constituencies which were exposed to VVPAT earlier and the constituencies which were exposed later would not have differential trends in outcome variables of our interest, pre- and post-VVPAT implementation. For instance, one of our main outcomes of interest is the winning margins. Our assumption implies that the differences in average winning margins in early VVPAT receivers and late receiver constituencies would not be statistically different over time, in the counterfactual. We conduct robustness checks of our model vis-a-vis the weighting used in standard two-way fixed effects models by using the latest Bacon-decomposition techniques and find that our results do not change (Goodman-Bacon, 2021). This provides support to the validity of our identification strategy and the underlying counterfactual assumption.

The paper contributes to three important strands of literature in political economy and electoral accountability. First, the literature on credibility of elections beginning with voter behavior and voters' responses to various shocks to electoral credibility (Kamada and Kojima, 2014). While Bush and Prather (2017) show that election observers and their role can shape local beliefs about the credibility of the election process, Fearon (2011) documents the implications of a *self-enforcing democracy* where choices of governments can determine the incidence of citizen rebellion. From the point of view of candidates, however, the literature has been focussed on policy positions and responses based on accountability and credibility norms (Van Weelden, 2013; Sengupta and Sengupta, 2008; Duggan and Martinelli, 2017; Gagliarducci and Nannicini, 2013) or inducing political participation based on campaigns designed appropriately (Houser et al., 2011). Our paper contributes to a gap in this literature in understanding the direct implications of electoral credibility on political competition.

Second, the paper makes an empirical contribution to a large theoretical literature on political competition. Economists and political scientists over decades have debated on the determinants of candidate entry and the choice of citizens to contest in elections. The classical models of political competition date back to the Hotelling-Downs formulation of competitive markets (Hotelling, 1929; Downs et al., 1957; Osborne, 1995). Later, theoretical developments such as citizen-candidate models endogenized the decision of entry into the electoral race (Osborne and Slivinski, 1996; Besley and Coate, 1997). The basic idea behind such citizen-candidate models is that any citizen can choose to become a candidate by incurring some cost and implement their favorite policy (based on a robust maximization exercise) if elected to office. Gagliarducci and Nannicini (2013) show that better pay for politicians can attract better quality of candidates and such an idea can perhaps mitigate the problem of adverse selection as suggested by Caselli

and Morelli (2004). However, whether targeted administrative efforts at making the electoral process more credible can affect competition or candidate entry has not been well established, to the best of our knowledge.

Third, our paper complements the large literature on the impact of policy-driven changes in the voting process, particularly through technology induced innovations, on political and economic outcomes (Fujiwara, 2015; Ujhelyi et al., 2021; Chatterjee and Kamal, 2021; Baland and Robinson, 2008; Card and Moretti, 2007; Baerlocher and Schneider, 2021). The paper is most closely related to studies set in India which estimate the effects of EVMs on a wide range of outcomes (Desai and Lee, 2021; Debnath et al., 2017). The impacts of electronic voting technology is not India-specific and has also been studied in other developing country contexts, where the marginal value of free and fair elections are usually higher (Fujiwara, 2015). The similarity of the findings provides confidence in the generalizability and external validity of our results.

Interestingly, new literature points out that there could be alternate forms of fraud that emerge as a result of technological innovations to clean up the electoral process. For instance, Schneider (2020) discusses the case of disenfranchisement of poor voters and alternate fraudulent methods such as *ballot stuffing* in Brazil. The VVPAT intervention may be perceived as a potential policy to mitigate some of the threats from these alternative forms of fraud that may emerge with the introduction on electronic voting.

Debnath et al. (2017) find that introduction of EVMs made the electoral process more competitive and winning margins and vote shares of winners reduced. Our results are in line with Debnath et al. (2017), in that, we find that an additional layer of credibility through VVPAT leads to more competition. Desai and Lee (2021) study the impacts of EVMs on incidence of invalid votes and the veracity of electoral outcomes. They also find that EVMs with VVPAT are not necessarily different in terms of their performance compared to non-VVPAT EVMs. This is useful for our empirical methodology as it provides support to our underlying assumption that the variation generated in VVPATs affects electoral outcomes through perceptions of credibility of elections and not through intrinsic differences in the technology of the machines. Along these lines, using data from Brazil, Schneider and Senters (2018) finds that introduction of electronic voting led to a stronger concentration of votes among the leading candidates suggesting a change in the political competition.

The rest of the paper proceeds as follows. Section 2 provides details on the background and institutional context regarding the VVPAT implementation across India. Section 3.1 describes the data and the construction of our key variables. This is followed by the section on the empirical estimation and identification strategy in Section 3.2. Results are presented in Section 4 followed by robustness in Section 5.4. The paper ends with the conclusion in Section 7.

2. Background

Indian electoral process typically involves huge mobilization of staff, logistics, and security deployment. Despite such arrangements, under the paper ballot system, instances of polling booths being captured and ballot boxes being stuffed have been commonplace in several constituencies in the past (Debnath et al., 2017; Verma, 2005). Owing to such concerns about the country's electoral process, the Election Commission of India (ECI) introduced electronic voting machines (EVMs) in the late 90s to address electoral frauds and simplify the electoral procedure.[1] The idea was that EVM would significantly increase the cost of electoral fraud as well as improve the efficiency of tallying election results. However, overtime there has been growing disquiet about EVM's accuracy and reliability for recording votes, potential for fraudulent manipulation of the technologies, and the extent to which technology allows for secrecy of individual votes (Solanki and Meva, 2019; Avgerou et al., 2019). Several sources claim that the EVMs are not tamper-proof, thereby negatively affecting the perceptions of the trustworthiness in e-voting technologies. In many ways, the Indian economy is similar to Brazil, not least in terms of the EVM intervention and a wide range of concerns about voter fraud (Firpo et al., 2015).

The Supreme Court directed the Election Commission of India to introduce the Voter Verified Paper Audit Trail (VVPAT) in 2013 in a phased manner to remove these doubts and technical suspicions. The VVPAT technology is used in conjunction with the EVMs to verify that a citizen's vote is placed as intended.[2] In terms of transparency and public oversight of the electoral process, VVPATs provide a permanent paper record, which the voter has the opportunity to inspect. Amidst rumors of EVM tampering and use of unfair practices during elections, the VVPATs therefore, add a layer of transparency and reliability to the electoral process and ensure that voters' faith remains intact. The objective behind using e-voting technologies such as VVPATs and EVMs is that the electoral process may achieve better management of the logistics of elections and speedily produce election results (Fujiwara, 2015; Hidalgo, 2010).

The main features of the EVMs and VVPATs are as follows. EVMs are a Direct Recording Electronic (DRE) voting protocol. The EVM consists of a control unit (CU) which is placed on the presiding officer's desk at the polling booth. The CU is connected to the VVPAT printer which is connected to the ballot unit (BU). The VVPAT printer and the BU are kept in the voter booth. The VVPAT display unit is kept with the presiding officer and displays the status of the VVPAT printer. The different components authenticate each other using digital certificates and the mechanism is designed such that the communication between components is encrypted. As per the ECI mandate, it is a standalone system with no external communication channels, either wired or through radio and is also one-time programmable (Lokur et al., 2021).

Further, the voting process in India proceeds as follows. A voter, upon eligibility and identity checks by polling officials, proceeds to the voting booth. The presiding officer first enables the BU by pressing a button on the CU for a vote to be cast. The voter casts

[1] The first election was conducted using EVM technology at few polling stations during the 1982 Kerala Assembly elections (Solanki and Meva, 2019).

[2] Such kind of electronic voting systems that provide voter verified paper records have also been used in other countries like the United States of America, and Italy.

the vote by pressing a button on the BU selecting a candidate.[3] Once a button is pressed, an LED next to the button lights up and there is a long beep indicating that the vote has been recorded. The VVPAT simultaneously prints a small slip of paper that carries the symbol, name and serial number of the candidate selected by the voter. This slip is visible to the voter for seven seconds in the viewing window after which it drops into a secure box. Once a vote has been cast, the BU becomes inactive and does not respond to any more button presses, till the presiding officer schedules the next vote by again enabling the BU. There is a mandatory 12 s delay before the CU can enable the next vote to be cast. The casting of votes with key-presses are time stamped.

Upon announcement of election result sheet, any candidate, their election agent or their counting agents may apply in writing to the counting supervisor to count the printed VVPAT paper slips in any or all polling stations. In the event that the supervisor allows the counting of the VVPAT paper slips, the process entails inspecting whether the total number of votes polled in that polling station is greater or lesser than the margin of votes between winning candidate and candidate making the application; whether EVM had a problem and was replaced at that polling station during poll; or whether there was any complaint about VVPAT not printing or complaints by any voter in that polling station during the poll. Typically, a mandatory verification of VVPAT paper slips of one randomly selected polling station is conducted in all General and Bye Elections.

The VVPAT was used along with the EVMs on a large scale for the first time in 10 out of 40 constituencies during the 2013 Mizoram Legislative Assembly elections. Hereafter, it was rolled out in a staggered fashion across all states and union territories over time. We discuss the details on the staggered roll-out of VVPATs across constituency and time in Section 3.1.

3. Empirical framework

3.1. Data

We utilize administrative data from the statistical reports of the general elections published by the ECI for the state legislative assemblies of India.[4] Our dataset consists of 3826 assembly constituencies (or electoral districts) from 29 Indian states and union territories.[5] For each constituency, we have electoral information from at least two (and up to three) assembly elections conducted during these years. The parliamentary and assembly constituency boundaries were redrawn per the Delimitation Act of 2002 based on the 2001 Census and the Delimitation Commission implemented a Cabinet Committee on Political Affairs (CCPA) on January 4, 2008. The orders of the committee went into effect from February 19, 2008 with the Karnataka Assembly elections in May 2008 being the first to use the newly drawn borders. To maintain consistency with the new geographic borders, we use information on State Legislative Assembly (Vidhan Sabha) elections conducted between the years 2008 and 2019.

3.1.1. VVPAT

To our knowledge, there is no consolidated dataset providing information on the roll-out of VVPATs at the constituency-year level. For the purpose of our analysis, we manually scrape reports on State Legislative Assembly elections from the ECI to create our main explanatory variable, $VVPAT_{ct}$.[6] This is a binary indicator taking the value 1 if a constituency c had the VVPAT in year t and 0 otherwise.

While the VVPATs were introduced formally in a phased manner in 2013, they were first introduced as pilot interventions in certain constituencies before the full fledged introduction. Although, it not clear from the administrative records as to how the constituencies were chosen for the pilot, certain reports (PTI, 2017) suggest that lotteries were used for selecting the constituencies. This alleviates our concerns about potential endogenous program placement. In our data, none of the constituencies had the VVPAT before 2013, following which it was rolled out in a staggered manner, with many states getting the VVPAT in all constituencies by the end of 2019. However, for some states a 100% roll-out of VVPAT was not achieved by the end of 2019.[7]

3.1.2. Outcome variables

To evaluate the impact of the VVPAT implementation on political competition, we analyze two sets of outcomes in this paper. First, we look at winner specific characteristics, such as the *winner vote-share*, and *winning margin percentage*.[8] Second, we evaluate the impact of the VVPAT on some constituency-year level variables capturing the overall competitiveness of the election. The ECI database provides candidate level information for each assembly election, viz, whether s/he is re-contesting, whether s/he is a turncoat (i.e. shifted his allegiance from one political party to another), whether s/he has lost his deposit (i.e. received less than one-sixth of the valid votes polled) and the number of times s/he has contested an election. We aggregate this information such that

[3] The ballot unit does not contain any other information or item such as referenda, apart from the candidates and their symbol.

[4] Historical Indian election data since 1962 has been cleaned, validated and stored in a publicly available repository *Lok Dhaba* by the Trivedi Center for Political Data at Ashoka University, India.

[5] A part of Andhra Pradesh was separated and reconstituted into a new state called Telengana in 2014. Hence, some constituencies which were originally a part of Andhra Pradesh, moved to Telengana ever since. To avoid any confusion, we have dropped the states of Andhra Pradesh and Telengana from our analysis.

[6] Details on each assembly election in each State/UT are available at https://eci.gov.in.

[7] As of 2019, Jammu & Kashmir, Kerala, Bihar, Jharkhand, West Bengal, Tamil Nadu, Punjab, Uttar Pradesh, Assam, Manipur, Uttarakhand, Puducherry and Delhi were yet to get the VVPAT in all constituencies.

[8] *winner vote-share*= $\frac{\text{Votes polled by winner}}{\text{Total valid votes}}$;
winning margin= Votes polled by winner – Votes polled by runner-up;
winning margin percentage = $\frac{\text{winning margin}}{\text{Total valid votes}}$.

Table 1
Descriptive statistics.

Variable	Obs	Mean	SD	Min	Max
Outcomes:					
Winner Voteshare	9280.00	0.45	0.10	0.14	1.00
Winner margin percentage	9280.00	0.12	0.11	0.00	1.00
Number of candidates	9284.00	10.78	5.31	1.00	46.00
Number of candidates who lost deposit	9284.00	8.96	5.30	0.00	45.00
Average number of times contested	9284.00	3.58	4.07	1.00	16.00
Number of turncoats	9284.00	0.49	1.00	0.00	9.00
Number of candidates recontesting	9284.00	1.55	1.56	0.00	18.00
Explanatory variable:					
VVPAT	9284.00	0.17	0.37	0.00	1.00
Other controls					
Total registered voters (10,000s)	9244.00	19.64	9.08	0.29	86.57
Sex Ratio (females per 1000 males)	9284.00	948.33	41.54	853.90	1097.00
Literacy Rate (percent)	9284.00	76.86	7.96	60.32	97.04
Employment rate (Rural)- per 1000	9284.00	21.80	26.68	0.00	187.00
Employment rate (Urban)- per 1000	9284.00	44.86	44.11	2.00	354.80
Poverty Rate	9284.00	22.08	11.15	2.22	49.55
Net State Domestic Product per capita (10,000 Rs)	9284.00	4.63	2.77	1.06	15.29
Number of workers (10,000s)	9284.00	43.36	40.93	0.25	164.15
Total length of Roads (10,000 kms)	9284.00	23.05	16.74	0.27	70.40

Notes: Data on the outcome variables has been obtained from administrative records maintained by the Election Commission of India whereas the data on other controls have been collected from a variety of sources as mentioned in the text. Primary source of this data is the handbook of statistics on the Indian economy maintained by the central bank of the country. The data on the main explanatory variable has been collected by the authors.

for every constituency c and year t we obtain the number of turncoat candidates ($Turncoat$), number of candidates re-contesting ($Recontest$), number of candidates who lost their deposits ($DepositLost$) and the average number of times a candidate contested elections ($Times\_Contested$). In addition, we also consider the total number of candidates contesting an election ($N\_Candidates$).[9]

3.1.3. Other controls and analytical sample

Oster (2019) suggests that all non-experimental work in economics suffers from omitted variable bias and the most straightforward way to alleviate such concerns is by controlling for observable factors that may have an effect on the outcome variable. In our analysis, we have controlled for a collection of economic and demographic variables including the Net State Domestic Product (per capita), sex ratio (females per 1000 males), literacy rate (percent), employment rates per 1000 population in rural and urban areas, poverty rates, number of workers and length of roads (in kms) for each state and year. We retrieve this information from the Reserve Bank of India's *Handbook of Statistics on Indian States*.[10] We also control for the total number of registered voters for each constituency-year, obtained from the ECI database.

Consolidating the data, we arrive at our final analytical sample with 9284 observations. Our unit of analysis is a constituency c in year t. Table 1 presents detailed descriptive statistics of the variables utilized in our analysis. The eventual winner in an average election secures around 45% of the total number of votes polled, with a winning margin of over 15,000 votes (i.e. almost 12% of total votes polled). In an average assembly election, the number of registered voters is around 196,000. In terms of candidate characteristics, we see that there are around 11 candidates contesting an average election, with 9 of them ($\sim$ 82%) losing their election deposits, 4.5% being turncoats and 13.6% re-contesting. We also note that on average, the prospective candidates have contested around 3.6 times.

3.2. Estimation and identification strategy

We exploit the plausibly exogenous variation from the introduction of the VVPAT in conjunction with the EVMs in India's electoral process to estimate the causal effect of the VVPAT on political competition. VVPATs were introduced with the aim to improve the credibility of recorded votes, increase transparency for the voters and minimize the alleged tampering of the EVMs. Our outcomes include *winner* and *candidate* characteristics as described in Section 3.1.

Note that a simple comparison of average winner or candidate outcomes before and after the introduction of the VVPAT would lead to potential endogeneity concerns in our estimation as several unobservable differences may explain the outcomes at the

[9] This outcome is in line with Jones (1999) that documents that effective number of candidates or parties is a prominent method of calculating candidate competition in an election, CITE: Jones, Mark P. "Electoral laws and the effective number of candidates in presidential elections". The Journal of Politics 61.1 (1999): 171–184.

[10] The *Handbook* provides state-wise statistics on a wide range of social and demographic indicators of the regional economy of India. Please refer to https://rbi.org.in.

Table 2
Impact of VVPAT on winner characteristics.

Outcomes:	Win-share		Winning margin %	
	(1)	(2)	(3)	(4)
VVPAT	−0.017***	−0.013*	−0.026***	−0.015*
	(0.006)	(0.007)	(0.008)	(0.009)
Observations	9,280	9,240	9,280	9,240
R-squared	0.684	0.689	0.570	0.574
Demographic Controls	No	Yes	No	Yes
Constituency FE	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes

Notes: Each column corresponds to a separate regression, with a separate outcome. Electoral data has been taken from the Election Commission of India's statistical reports on Assembly elections. All regressions include a vector of social and demographic controls, taken from the RBI's "Handbook of Statistics in Indian States". These include NSDP per capita, sex ratio, literacy rate, poverty rate, rural and urban employment rates, number of workers, total length of roads and total registered voters. Standard errors have been clustered at the constituency level. ***p < 0.01; **p < 0.05; *p < 0.1.

constituency level. Furthermore, there may be a concern of any time invariant constituency level characteristics that may be correlated with the credibility of elections, in other words, with the VVPAT introduction. With political competition and credibility of elections likely jointly determined, there could also be reverse causality issues. Given these concerns, a simple OLS estimation will lead to biased and inconsistent estimates of introduction of VVPAT on our outcomes.

As such, we make use of the staggered roll-out of the VVPAT from the year 2013 in India to alleviate these endogeneity concerns. We are also able to exploit the temporal variation on account of the electoral calendar for state elections in the country conducted at different time periods. This allows for a natural variation in the timing of elections and hence in the timing of exposure to the VVPAT. Our identification therefore, relies on the exogenous constituency-time variation based on this administrative roll-out of the VVPAT. In essence, we compare the election outcomes at the constituency level after the phase-wise implementation of VVPAT in 2013 in different constituencies at different points in time. We include constituency fixed effects to address the concern of any time invariant constituency level characteristics that may be correlated with the VVPAT. In addition, we also control for year fixed effects to account for any time-varying characteristics that impact all constituencies equally.

We estimate the following model to obtain the effect of the VVPAT on our outcomes:

$$Y_{ct} = \alpha_0 + \alpha_1 VVPAT_{ct} + \gamma \mathbb{X}_{ct} + +\delta_t + \mu_c + \epsilon_{ct} \tag{1}$$

where Y_{ct} denotes the outcomes viz. *winner vote-share, winning margin percentage, number of turncoat candidates, number of candidates re-contesting, number of candidates who lost their deposit, average number of times a candidate contested, and total number of candidates contesting in an election* in constituency c at time t. $VVPAT_{ct}$ is the treatment indicator which takes the value 1 if the constituency c in time t has VVPAT in the assembly elections, and 0 otherwise. $\mathbb{X}_{ct}$ are the additional state/constituency level controls at time t described in Section 3.1. δ_t captures the year fixed effects and μ_c denotes constituency fixed effects. ϵ_{ct} summarizes the influence of all other unobserved variables that vary across constituencies, and time. The standard errors are clustered at the constituency level.

4. Results

In this section we present the main results from our preferred specification given by Eq. (1). First, Table 2 presents the effect of VVPAT implementation on *winner characteristics*. Columns (1) and (2) pertain to the impact on the winner's vote-share, measured by the total votes polled by the winner as a proportion of total valid votes. Columns (3) and (4) provide the impact on the winner's winning margin (i.e. the difference with the runner-up) as a percentage with respect to total valid votes. We find that in constituencies which got the VVPAT, the winner's vote-share decreases by approximately 1.3 percentage points (pp). We also find statistically significant evidence that the VVPAT roll-out led to a decrease in the winning margin resulting in a reduction in the margin percentage by 1.5 pp.

As reported in Table 1, our analytical sample suggests that in an average election, the winner secures around 45% of the total votes polled, with a winning margin of over 15,000 votes, implying a margin percentage of 12%. Our results indicate that in constituencies that got the VVPAT, the winner's vote-share decreased by 2.9%, the winning margin percentage went down by 12.5% as a proportion of their respective sample averages. Hence, the results point to the fact that greater credibility of elections through the VVPAT led to increased political competition and more closely fought elections, as is evident in the non-negligible reduction in the winner's vote-share as well as winning margin percentage.

Second, Table 3 reports the impact of the VVPAT implementation on *candidate outcomes*. In Columns (1) and (2) our outcome variable is the total number of candidates contesting the election in constituency c and year t. In Columns (3) and (4), the outcome variable is the number of candidates who lost their election deposit money. The results indicate that on average, an additional candidate is more likely to contest elections with the advent of the VVPAT and lose the deposit money by not being able to secure

Table 3
Impact of VVPAT on candidate outcomes.

Outcomes:	Total candidates		Lost deposit	
	(1)	(2)	(3)	(4)
VVPAT	1.522***	1.014***	1.671***	1.096***
	(0.301)	(0.334)	(0.302)	(0.331)
Observations	9,284	9,244	9,284	9,244
R-squared	0.804	0.809	0.803	0.808
Demographic Controls	No	Yes	No	Yes
Constituency FE	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes

Notes: Each column corresponds to a separate regression, with a separate outcome. These are all candidate level outcomes aggregated at the constituency-year level. Electoral data has been taken from the Election Commission of India's statistical reports on Assembly elections. All regressions include a vector of social and demographic controls, taken from the RBI's "Handbook of Statistics in Indian States". These include NSDP per capita, sex ratio, literacy rate, poverty rate, rural and urban employment rates, number of workers, total length of roads and total registered voters. Standard errors have been clustered at the constituency level. ***p < 0.01; **p < 0.05; *p < 0.1.

Table 4
Impact of VVPAT on candidate characteristics.

Outcomes:	Recontestants		Turncoats		Times contested	
	(1)	(2)	(3)	(4)	(5)	(6)
VVPAT	−0.905***	−0.706***	−0.748***	−0.594***	−0.752***	−0.431**
	(0.146)	(0.151)	(0.096)	(0.096)	(0.180)	(0.177)
Observations	9,284	9,244	9,284	9,244	9,284	9,244
R-squared	0.618	0.636	0.618	0.641	0.923	0.933
Demographic Controls	No	Yes	No	Yes	No	Yes
Constituency FE	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Each column corresponds to a separate regression, with a separate outcome. These are all candidate level outcomes aggregated at the constituency-year level. Electoral data has been taken from the Election Commission of India's statistical reports on Assembly elections. All regressions include a vector of social and demographic controls, taken from the RBI's "Handbook of Statistics in Indian States". These include NSDP per capita, sex ratio, literacy rate, poverty rate, rural and urban employment rates, number of workers, total length of roads and total registered voters. Standard errors have been clustered at the constituency level. ***p < 0.01; **p < 0.05; *p < 0.1.

enough popular votes. This suggests that fewer candidates run in the counterfactual when elections are likely to be perceived as less credible. With the VVPAT, fringe candidates are likelier to estimate higher probability of their success and decide to contest elections resulting in increased competition as a result of the credibility shock.

Table 4 presents the results for outcome variables on *candidate characteristics*. We find that the VVPAT led to a statistically significant decline in the number of repeat candidates fielded by political parties as evident from columns (1) and (2). From column (2), the negative and significant point estimate indicates that for every constituency, there are 0.7 fewer candidates who recontest. In other words, out of every 3 constituencies, there are 2 lesser candidates that re-run for office compared to the non-VVPAT constituencies. Given that there are no term limits for these offices, political parties seem to be actively responding to the credibility shock generated by the introduction of VVPAT by fielding newer candidates.

Viewing these estimates in conjunction with those in columns (3) and (4), the results are perhaps suggestive of political parties being more conscious about the image of politicians and preferring to field fresher faces to signal new energy or clean political history devoid of any inefficiency charges that may have arisen against incumbents. In columns (3) and (4) we find that political parties are less likely to field turncoat politicians who switch political parties prior to elections. Additionally, the results from columns (5) and (6) indicate that the average candidate in VVPAT constituencies seem to have contested fewer elections than their non-VVPAT counterparts. The general indication from this set of results is that political parties react to the introduction of VVPAT technology in a way that suggests an active thrust towards signaling credibility and fresh energy by fielding newer faces and fewer turncoats.

As reported in Table 1, in an average election in constituency c and year t, around 11 candidates contest. In reference to that, our results show that once a constituency gets the VVPAT, there is a 9.2% increase in the total number of candidates. With more candidates contesting, we also find evidence that there is a 9.9% increase in candidates failing to poll at least 6% of total votes and hence losing their election deposits. This evidence again points to the fact that the roll-out of VVPAT made the elections more competitive with votes getting distributed among a larger number of candidates. In constituencies which got the VVPAT, the number of candidates re-contesting elections reduced by 6.4% whereas the number of turncoats (candidates who have changed allegiance

from another political party) contesting the election also went down by 5.4% compared to the total number of candidates in an average election. This provides suggestive evidence that when facing a higher degree of political competition, political parties prefer to field fresh candidates rather than ones having a pre-established reputation which may have been compromised in the process. Also, they are less likely to place their bets on candidates previously affiliated to other parties and hence whose loyalty is questionable. In line with this shift from experienced candidates to fresh faces, we also find that after the implementation of VVPAT, the average number of times that running-candidates have contested elections decreases by 12% of the sample average.

5. Robustness

Here, we attempt to address some concerns with our identification strategy. First, we address the potential concern that the constituencies may be trending differently prior to VVPAT roll-out by examining the parallel trends for both winner and candidate characteristics. Second, we present a falsification test that provides evidence that our parameter of interest does in fact capture the effect of VVPAT. Third, the presence of outliers could be driving some of the results given that many Indian elections are sometimes skewed with overarching support for a strong candidate resulting in large vote shares for the winner. Second, estimating treatment effects using a two-way fixed effects model can be problematic when the treatment is dynamic in nature such as the VVPAT rollout. In such cases, the model is not a standard 2X2 model and hence can create issues with the weighting of the effects potentially leading to spurious inference.

5.1. Parallel trends

A primary concern with the identification strategy here would be that the constituencies may be trending differently prior to introduction of the VVPAT. Therefore, it is useful to analyze pre-trends in our outcomes across constituency and time dimensions. Such an analysis would aid in observing the pattern of our *winner* and *candidate* outcomes prior to the implementation of the VVPAT in the electoral process. Therefore, we compare our outcomes in the constituencies that introduced the VVPAT to those that did not from the years 2008 to 2012. Specifically, we define the *treatment* group to include constituencies which got the VVPAT at any point in 2013 or after that. We define the *control* group to include constituencies which never got the VVPAT till the end of our sample period, i.e. 2019. Given that the VVPAT was first rolled out in 2013, we compare these two groups in the preceding time period from 2008–2012, prior to the introduction of the VVPAT. We find little evidence of any pre-existing differential trends at the constituency level between these groups over this period. Fig. 1 and Fig. 2 plots the difference between the average winner characteristics, and average candidate outcomes and characteristics respectively, from 2008 to 2012. The difference between the treatment and control group outcomes seem to be stable through this period.

5.2. Falsification test

Another possible concern with the above estimation procedure is that the effect picked up by our regressions is not necessarily that of the VVPAT introduction. Based on our identification strategy, we expect that absent the introduction of VVPAT, we would not obtain statistically significant effects as picked up by our main $VVPAT$ dummy. However, such an assumption is not testable as the counterfactual never occurs. Therefore, we perform a falsification exercise to provide confidence in our identification strategy as a second-best solution. To ensure that our regression coefficient of the dummy $VVPAT_{ct}$ is not a result of any spurious relation but an effect of VVPAT introduction in the electoral process, we conduct a test for random simulation of treatment status as this falsification test. To do so, we randomly assign the VVPAT to constituencies over time instead of using the actual administrative roll-out data and run the same regression as in Eq. (1). We replicate this process 100 times for each of our outcome variables.

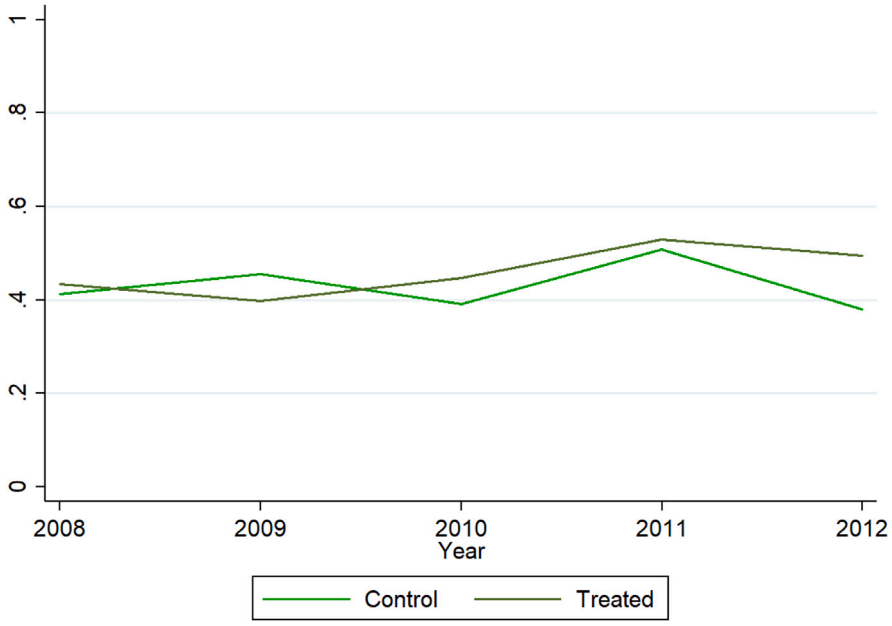
Ceteris paribus, this makes the association between our outcome variables and the VVPAT in our estimation random.[11] Figs. 3 and 4 plots the t-statistics obtained from this analysis for our outcomes in comparison to the 90% confidence limits to illustrate the proportion of times we do not find significant effects.[12] As is evident from Fig. 3, Panel (a) we do not find a statistically significant impact of VVPAT on the *winner's voteshare* 96 out of 100 times. Similarly, we find insignificant impacts of VVPAT on the *winning margin* and *margin percentage* 99% and 97% of times respectively. With respect to other candidate characteristics, in Fig. 4 we illustrate insignificant impacts of random VVPAT assignment on the *total number of candidates, average number of times they have contested elections, number of candidates losing deposits, number of turncoats* and *number of candidates re-contesting* in 99%, 98%, 98%, 96% and 97% of cases respectively. This falsification analysis reveals that repeated estimations with random assignments of the VVPAT to constituencies over time do not produce significant results in majority of the simulations on our outcomes of interest. This is evidence that our original specification is not picking up a spurious relation.

5.3. Winsorizing the sample

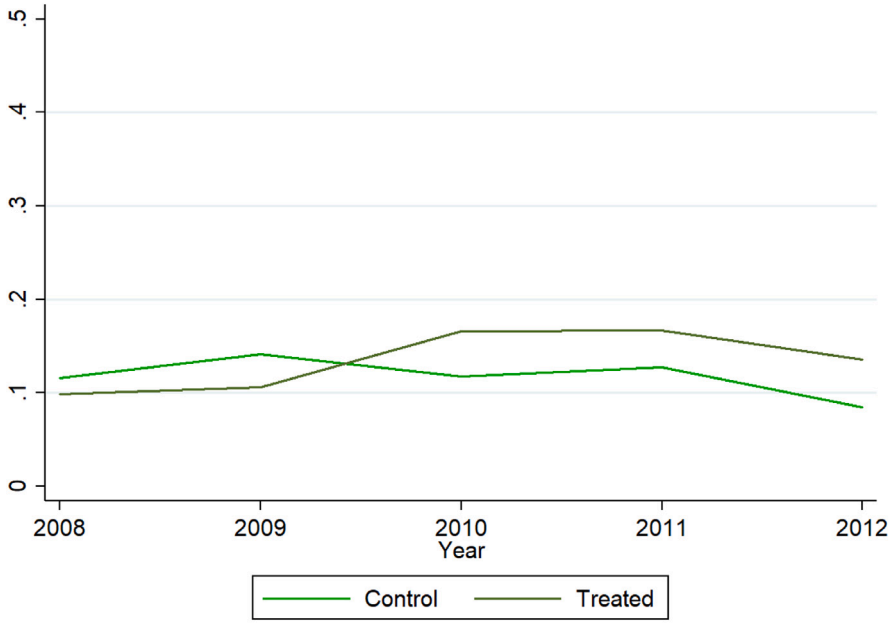
To limit the effect of outliers, we winsorize the sample and re-run our main regressions. Assigning a lower weight to outliers, we minimize the effect of the extreme 1% values as well as the 100 extreme observations at both tails. Tables 5–7 reports the results from the winsorized data.

[11] Bharadwaj et al. (2014) perform a similar placebo experiment for a difference-in-differences (DD) setup in a different context, and refer to it as a test of exact randomization.

[12] Please note that since the 95% and 99% confidence intervals are larger than that for 90%, we would have even fewer instances of significant effects at the 5% and 1% level of significance.



(a) Winner Share



(b) Winning Margin %

Fig. 1. Parallel trends—Winner characteristics.

We note that the point estimates are similar for each sets of regressions, and the general findings are identical to our baseline results from the full sample. This suggests that the main results are not necessarily driven by these large outliers, providing confidence in the generalizability of our results. We additionally winsorize the extreme 5% values of the sample, although the results

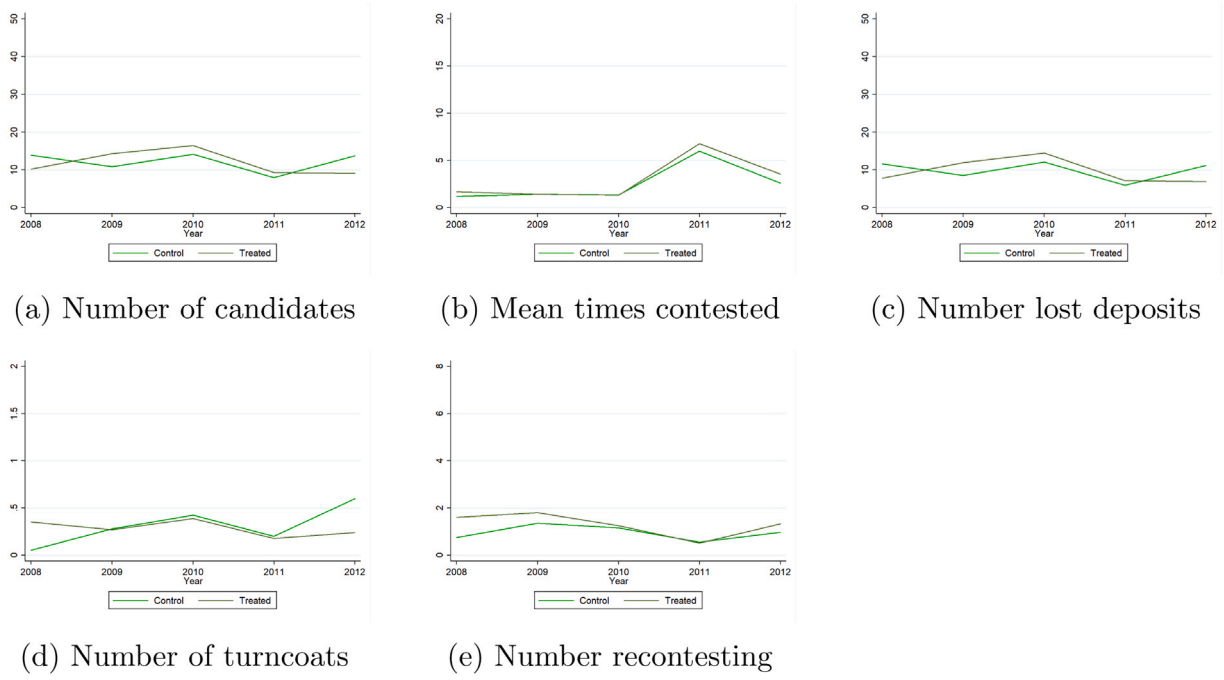


Fig. 2. Parallel trends—Candidate outcomes and characteristics.

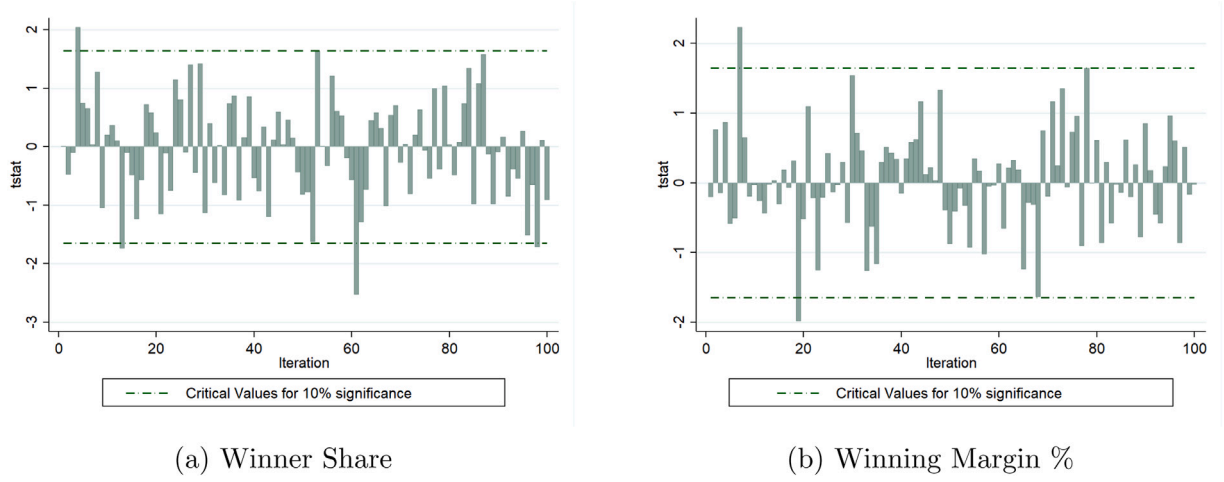


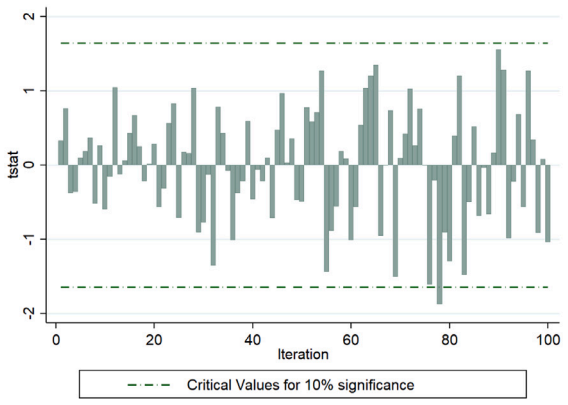
Fig. 3. Falsification—Winner characteristics.

are not reported here. The results largely remains consistent with the only exception of the point estimate on winning margin losing precision due to larger standard errors. However, the direction of the effects and the overall conclusions remain robust.[13]

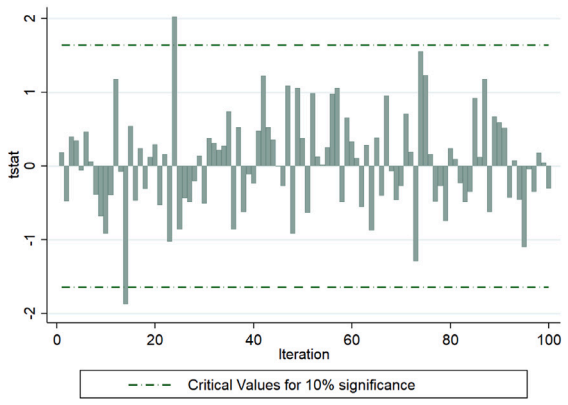
5.4. Issues with differential timing/staggered implementation

Recent literature on the econometric issues with estimating treatment effects using two-way fixed effects estimators suggests that the workhorse model, such as the one used in this paper, could be problematic owing to the possibility of negative weights. This may lead to inconsistent estimates (Athey and Imbens, 2006; Baker et al., 2021; Callaway and Sant'Anna, 2021; Goodman-Bacon, 2021). Of particular interest to applied microeconomics studies is the decomposition method proposed by Goodman-Bacon (2021)

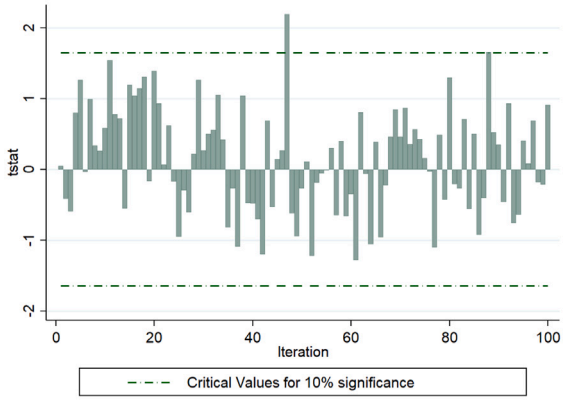
[13] These results can be made available upon request.



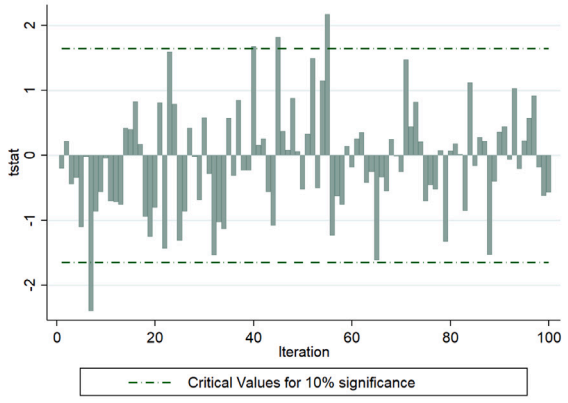
(a) Number of candidates



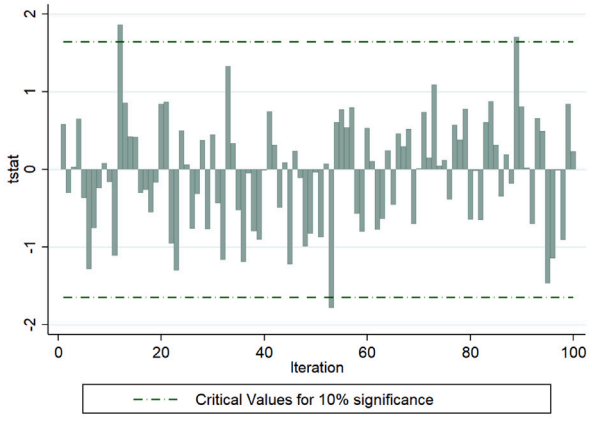
(b) Mean times contested



(c) Number lost deposits



(d) Number of turncoats



(e) Number recontesting

Fig. 4. Falsification—Candidate outcomes and candidate characteristics.

where the two-way fixed effects estimator is simply a weighted average of all potential 2X2 DD estimates. These weights depend on size of the groups of treatment as well as the variance in the treatment. Goodman-Bacon (2021) essentially indicates that consistent estimates require that dynamic treatment effects are absent in addition to the parallel trends.

Table 5
Robustness—Winsorized winner outcomes.

Outcomes:	Win-share		Winning margin %	
	Extreme 1%	Extreme 100	Extreme 1%	Extreme 100
	(1)	(2)	(3)	(4)
VVPAT	−0.013*	−0.013*	−0.016*	−0.016*
	(0.007)	(0.007)	(0.009)	(0.009)
Observations	9,240	9,240	9,240	9,240
R-squared	0.688	0.687	0.567	0.566
Demographic Controls	Yes	Yes	Yes	Yes
Constituency FE	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes

Notes: Each column corresponds to a separate regression, with a separate outcome. In Columns (1) and (3) we have winsorized the extreme 1% of values of the outcome variable whereas in Columns (2) and (4) we have winsorized the extreme 100 values. Electoral data has been taken from the Election Commission of India's statistical reports on Assembly elections. All regressions include a vector of social and demographic controls, taken from the RBI's "Handbook of Statistics in Indian States". These include NSDP per capita, sex ratio, literacy rate, poverty rate, rural and urban employment rates, number of workers, total length of roads and total registered voters. Standard errors have been clustered at the constituency level. ***p < 0.01; **p < 0.05; *p < 0.1.

Table 6
Robustness—Winsorized candidate outcomes.

Outcomes:	Total candidates		Lost deposit	
	Extreme 1%	Extreme 100	Extreme 1%	Extreme 100
	(1)	(2)	(3)	(4)
VVPAT	1.091***	1.091***	1.156***	1.156***
	(0.300)	(0.300)	(0.299)	(0.299)
Observations	9,244	9,244	9,244	9,244
R-squared	0.814	0.814	0.813	0.813
Demographic Controls	Yes	Yes	Yes	Yes
Constituency FE	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes

Notes: Each column corresponds to a separate regression, with a separate outcome. In Columns (1) and (3) we have winsorized the extreme 1% of values of the outcome variable whereas in Columns (2) and (4) we have winsorized the extreme 100 values. Electoral data has been taken from the Election Commission of India's statistical reports on Assembly elections. All regressions include a vector of social and demographic controls, taken from the RBI's "Handbook of Statistics in Indian States". These include NSDP per capita, sex ratio, literacy rate, poverty rate, rural and urban employment rates, number of workers, total length of roads and total registered voters. Standard errors have been clustered at the constituency level. ***p < 0.01; **p < 0.05; *p < 0.1.

With the idea that every group is potentially a control group at some point in time, the *Bacon Decomposition* for two-way fixed effects estimator with staggered treatment implies that the main effect is a combination of four different effects viz. early implementers versus untreated, late implementers versus untreated, early implementers versus late implementers before the treatment and the same after the treatment. With controls, there exists a *within* effect that captures the impact of the control variables on the treatment assignment probability. We perform the Bacon decomposition for all our main outcome variables and report the resultant scatter plots in Fig. 5.

We find very little heterogeneity in the decomposed effects for all the outcomes. The majority of the 2X2 DD estimates are clustered around the main point estimate, which is the weighted average of all of these 2X2 estimates. This suggests that the major concerns with staggered implementation are not necessarily relevant in our specification and provides reasonable support to the identification strategy. Re-assuringly, we find negative weights for very few of the 2X2 DD estimates, thus alleviating our concern about the inconsistency of our estimates using the standard two-way fixed effects model.

6. Heterogeneity and learning effects

We explore the possibility of heterogeneous effects of the VVPAT on our outcomes by prior exposure or experience of voting with the VVPAT. The timeline of our dataset allows us to observe two different types of VVPAT-exposed constituencies. First, the constituencies from states which only have one post-VVPAT election. Second, some early mover constituencies which have had exposure to VVPAT twice within the span of our data. Slicing our analysis by these two different types of treated groups, we analyze

Table 7
Robustness—Winsorized candidate characteristics.

Outcomes:	Recontestants		Turncoats		Times contested	
	Extreme 1%	Extreme 100	Extreme 1%	Extreme 100	Extreme 1%	Extreme 100
	(1)	(2)	(3)	(4)	(5)	(6)
VVPAT	−0.700***	−0.678***	−0.560***	−0.560***	−0.431**	−0.431**
	(0.121)	(0.114)	(0.083)	(0.083)	(0.177)	(0.177)
Observations	9,244	9,244	9,244	9,244	9,244	9,244
R-squared	0.645	0.646	0.644	0.644	0.933	0.933
Demographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Constituency FE	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Each column corresponds to a separate regression, with a separate outcome. In Columns (1), (3) and (5) we have winsorized the extreme 1% of values of the outcome variable whereas in Columns (2), (4) and (6) we have winsorized the extreme 100 values. Electoral data has been taken from the Election Commission of India's statistical reports on Assembly elections. All regressions include a vector of social and demographic controls, taken from the RBI's "Handbook of Statistics in Indian States". These include NSDP per capita, sex ratio, literacy rate, poverty rate, rural and urban employment rates, number of workers, total length of roads and total registered voters. Standard errors have been clustered at the constituency level. ***p < 0.01; **p < 0.05; *p < 0.1.

the heterogeneous treatment effects of VVPAT on the two groups of constituencies. Essentially, we run two different regressions for every outcome variable. One, which only compares constituencies which never received the VVPAT to the ones that received the VVPAT only once. Two, we compare the never-VVPAT constituencies to the ones that received the VVPAT in two successive elections. We report the results in the following figures and table.

6.1. Effects on winner characteristics and candidate outcomes

Using the full sample, our results show that introduction of the VVPAT leads to increased political competition on average by way of an average decline in winners' vote shares and a consequent decline in winning margins. Interestingly however, the heterogeneous effects seem to suggest that this average decline in winners' vote shares is driven by constituencies that receive the VVPAT once whereas the decline in winning margins seems to be driven by experienced constituencies that receive the VVPAT in two successive elections. In Fig. 6, we plot these coefficients and find stark contrasts in the results for winner share and winning margins for experienced constituencies and first-time exposed constituencies. A possible rationale for such behavior could be the following.

If political parties are able to consolidate their positions and find ways to traverse through the credibility shock caused by the advent of VVPAT, then they may be able to regress to their mean levels of vote shares as would have been the case in the counterfactual. This would be consistent with the finding that experienced constituencies report higher post-VVPAT vote shares despite lower vote shares for winners for first time exposed constituencies. This may be of concern from a policy perspective as the effect of credibility on enhancing political competition seems to be nullified with learning. The findings on winning margin can be reconciled by some conjecture on the substitution patterns of the winners' vote shares. If the introduction of the VVPAT for the first time leads to a decline in vote shares for both the winner and the runner-up, who were likely the ex-ante frontrunners in the race, and it disproportionately affects the eventual runner-up in favor of new entrants, the winning margin may increase despite declining vote shares of the winner.

We already know that the VVPAT led to more competition in the form of newer entrants. With learning, this seems to be reversed as more of the fringe candidates lose out their vote shares which get substituted to the frontrunners. Fig. 7 confirms this. We see that the coefficient on candidates losing deposit is positive and significant in experienced constituencies. This means more candidates lose their deposits in experienced constituencies suggesting massive declines in their vote shares, potentially in favor of the frontrunners. The figure also confirms that there are no effects on new entrants in experienced constituencies although candidates seem to be attracted to the race in first-time exposed constituencies.

6.2. Effects on candidate characteristics

In the baseline, we document that the average constituency exposed to the VVPAT is more likely to bring new and fresh candidates and less likely to have recontestants and turncoat politicians with aspersions on their long-term loyalty and credibility. The heterogeneous analysis suggests that these effects are entirely driven by the first-time exposed constituencies. The introduction of the VVPAT for the first time perhaps generates a general attitude among political parties to field fresh faces and more credible politicians with less concerns about their loyalty.

However, we note that experienced constituencies are likelier to get more recontestants, more turncoat politicians and candidates who have more experience of contesting elections. While drawing welfare consequences are difficult based on a pure reduced form exercise, this indicates that with learning, the effect of the credibility shock on political competition and associated behavioral response by political parties are nullified and even reversed with continued exposure to the technology. Fig. 8 illustrates these results.

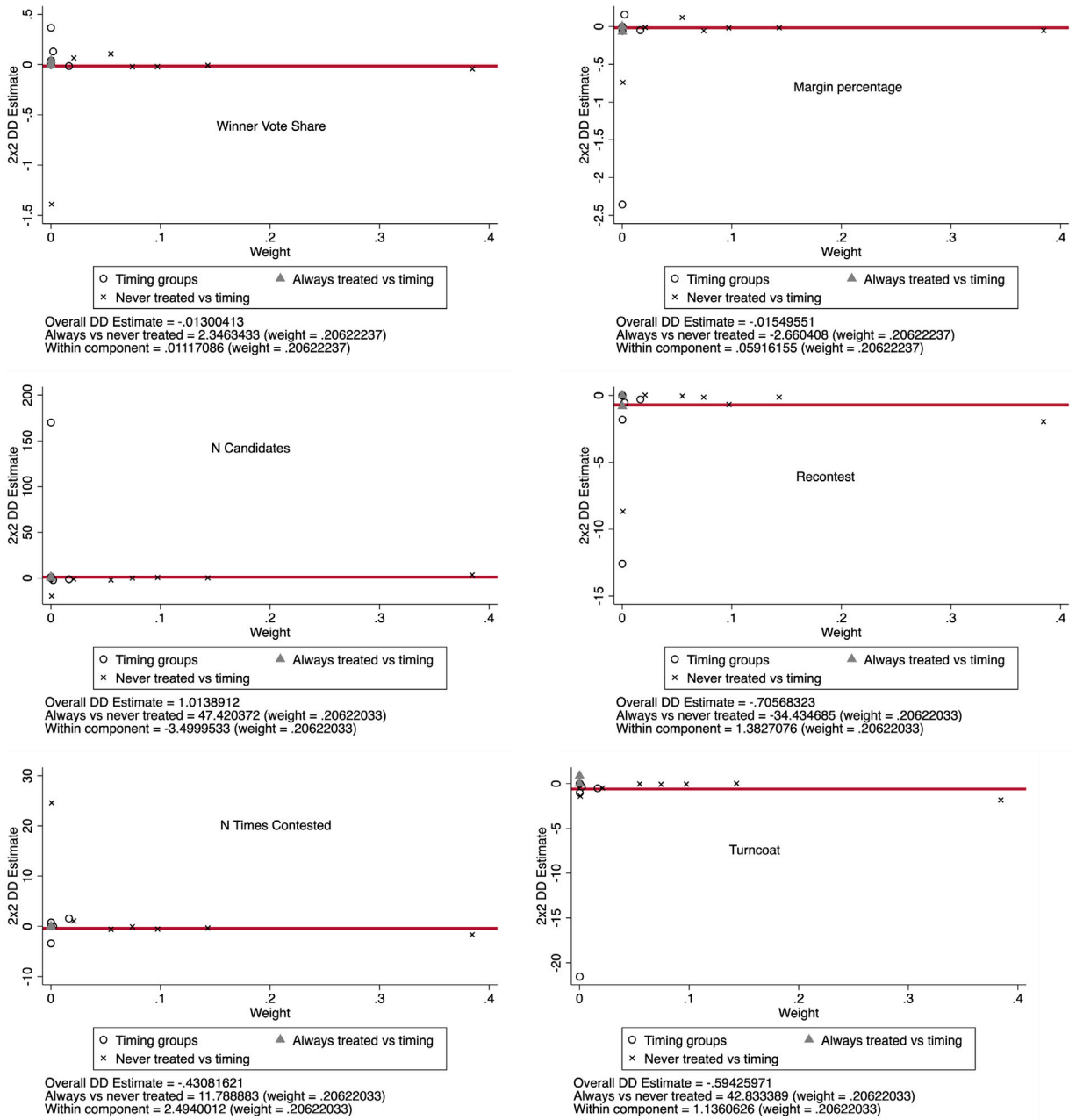


Fig. 5. Bacon decomposition.

6.3. *Effects on voter turnout*

While the main focus of our paper is on candidate outcomes, it may be worthwhile to examine voter outcomes as well. Here, we attempt to shed some light on voter turnout percentage as a result of the VVPAT roll-out. Table 8 presents the results. Overall, from columns (1) and (2), we observe that the VVPAT introduction leads to a statistically significant fall in voter turnout percentage. While we do not believe that VVPAT would have an impact on individual voter behavior per se or the preferences of the average voter, this effect could be driven by the actions of political parties. To examine this claim further, we study the heterogeneous effects of the VVPAT in columns (3) and (4). From column (3), comparing constituencies which never received the VVPAT to those that received it once, we notice that the turnout percentage reduces by larger extent. We assert that the result in column (2) is mostly driven by the first-time exposed constituencies. The reduction in turnout is perhaps motivated by a spontaneous reaction by the political parties who choose to reduce false voting owing to fear of increased credibility through the VVPAT. That said,

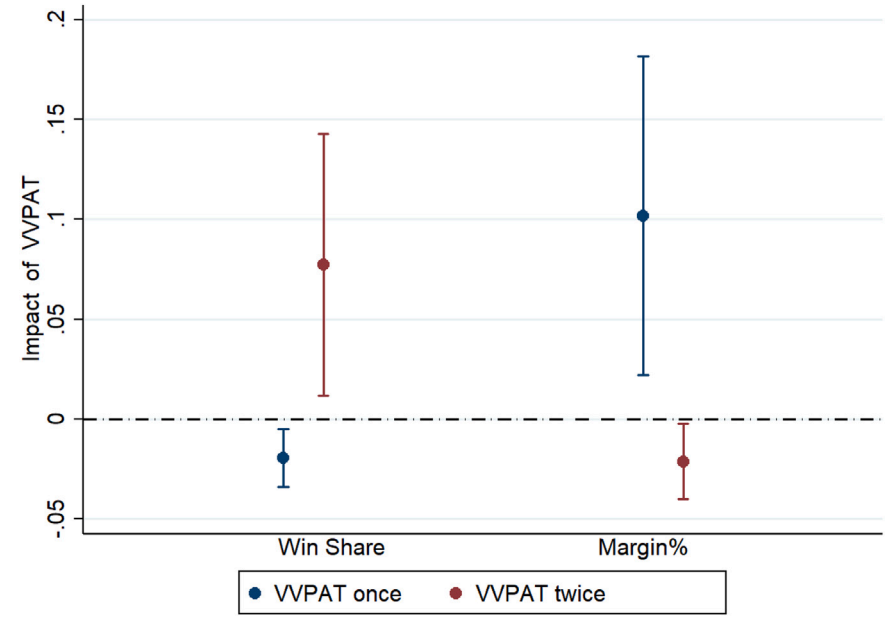


Fig. 6. Heterogeneous effects: election outcomes.

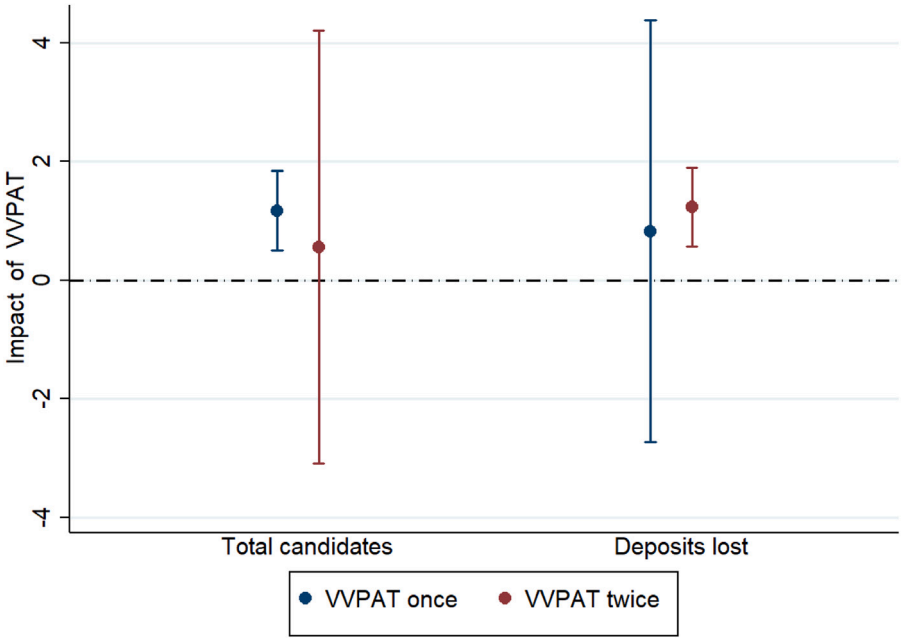


Fig. 7. Heterogeneous effects: candidate outcomes.

from column (4), we note that the effect disappears for the experienced constituencies potentially indicating that the effect on voter turnout dampens once the political parties understand that VVPAT is not in fact designed to capture false or fake votes.

7. Conclusion

Changes in voting technology are interesting for research in political economy and has been surprisingly under-studied. We explore a major addition to the voting technology in the world's largest democracy and show that it has significant impacts on political competition, not only in form of closer races but also with more candidates running. This is consistent with the idea that more credible electoral environment brought in by the technology aimed to improve transparency in the electoral process can

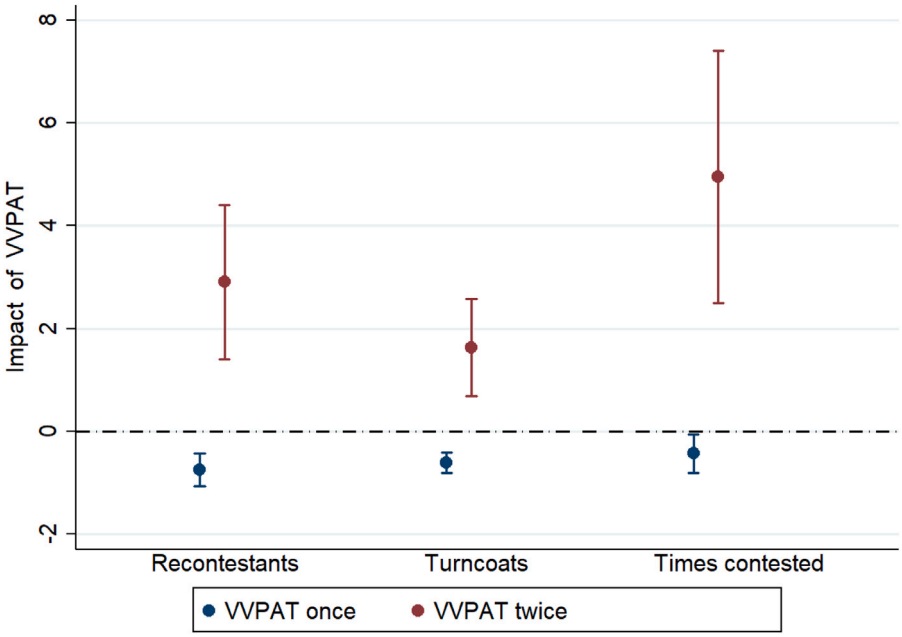


Fig. 8. Heterogeneous effects: candidate characteristics.

Table 8
Effect of VVPAT on turnout percentage.

Outcome:	Turnout %		Turnout%: Heterogeneous effects	
	(1)	(2)	(3)	(4)
VVPAT	−2.425***	−2.978***	−3.641***	1.259
	(0.308)	(0.380)	(0.357)	(2.031)
Observations	9,244	9,244	9,174	5,282
R-squared	0.920	0.926	0.927	0.925
Demographic Controls	No	Yes	Yes	Yes
Constituency FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Notes: Each column corresponds to a separate regression where the outcome variable is turnout percentage. In Columns (1) and (2) we have used our preferred sample and have sequentially added all our controls. To study heterogeneous effects of VVPAT introduction, in Column (3) we estimate our preferred specification on a sample of constituencies which never received the VVPAT or received it once only; similarly Column (4) reports the effect of receiving the VVPAT twice vs never receiving it. Electoral data has been taken from the Election Commission of India's statistical reports on Assembly elections. All regressions in Columns (2)–(4) include a vector of social and demographic controls, taken from the RBI's "Handbook of Statistics in Indian States". These include NSDP per capita, sex ratio, literacy rate, poverty rate, rural and urban employment rates, number of workers, total length of roads and total registered voters. Standard errors have been clustered at the constituency level. ***p < 0.01; **p < 0.05; *p < 0.1.

generate to lower costs of entering elections and make the elections tighter. Our findings are in line with existing findings on the impacts of electronic voting machines on Indian elections.

We take advantage of the plausibly exogenous administrative rollout of the technology of the voter-verified paper audit trail (VVPAT) in electronic voting machines in India and perform two-way fixed effects estimation to show that winners' vote shares decline and winning margins shrink in response. We also find that more candidates contest in the average election. Our results are robust to new techniques addressing issues with differential timing of policies and its estimated treatment effects. Using Bacon decomposition methods we show that our estimates rarely have negative weights. With that being said, we recognize that the VVPAT might have very different effects in different electoral systems depending on the extent of control parties have or on the structural elements that govern the number of candidates and parties.

The results have important implications. First, there may be direct or indirect impacts on electoral violence, direct or indirectly induced. For instance, if there is an increase in the expected frequency of incumbents being unseated, depending on the magnitude of such an effect there may be favorable or unfavorable impacts on electoral violence. There may also be a potential for a larger political power to have negotiated with the administration to ensure the implementation (or delay thereof) to extract rents in terms

of electoral benefits. In general, if fraud is prevalent in elections, did new voting technology lead to further or more innovative approaches in terms of voter fraud? Our study provides an early insight into such introspections that are relevant for academic research in political science and economics of voting behavior and ought to be explored in future research.

Furthermore, the heterogeneous effects of the VVPAT technology and potential learning raise important policy concerns. We find that much of the supposedly positive welfare effects of the introduction of the new technology, by way of increased political competition and better quality of candidates being fielded by political parties, is reversed with experience of the technology. In constituencies that receive the technology for the second time, most of the impacts are nullified. This indicates that any potential welfare gains from the introduction of the VVPAT on the overall democratic environment of the country is unlikely to be persistent and may create hindrances in the long-run deterrence of electoral fraud. Perhaps that other socio-political institutions need to be active to achieve this goal and technology induced supply-side policy interventions may at best provide short-lived welfare gains.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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