The Impact of Electronic Voting Machines on Electoral Frauds, Democracy, and Development*

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Abstract

Free and fair elections are cornerstones of democracy. In India, electronic voting machines (EVMs) were introduced with the objective of reducing electoral fraud. We exploit the phased roll-out of the EVMs in state assembly elections to study its impact on electoral fraud, democracy, and development. Our main findings are: (i) Introductions of EVMs led to a significant decline in electoral frauds, particularly in politically sensitive states which were subjected to frequent re-polls due to electoral rigging. (ii) It strengthened the weaker and the vulnerable sections of the society (women and the scheduled castes and tribe) who were now more likely to cast their vote. (iii) It made the electoral process more competitive whereby the winning margin and the vote share of the winning party declined. (iv) Using the luminosity data, we find that EVMs led to an increase in the provision of electricity. (v) Lastly, we find evidence that EVMs resulted in significant decline in crimes, such as murder and rape (violence against women).

Keywords: Voting Technology, Electoral Fraud, Democracy, Development, Political Responsiveness

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1 Introduction

Free and fair elections to choose political representatives are a cornerstone of a democracy and a fundamental human right of the people. Article 21 of the Universal Declaration of Human Rights (UDHR),[1] states:

> *Everyone has the right to take part in the government of his country, directly or through freely chosen representatives. Everyone has the right of equal access to public service in his country. The will of the people shall be the basis of the authority of government; this will shall be expressed in periodic and genuine elections which shall be by universal and equal suffrage and shall be held by secret vote or by equivalent free voting procedures.*

Voting procedures play a significant role in the conduct of free and fair elections in a democracy. It converts voters' preferences into a political mandate which in turn forms the basis for policy-making. In practice, however, illegal efforts to shape electoral outcomes in a democracy are not uncommon (Lehoucq, 2003).[2] Electoral fraud not only undermines public trust in democratic institutions by electing political leaders that have the greatest capacity to organize electoral fraud but it also adversely affects the provision of public goods. In presence of electoral fraud, there are no checks and balances on the political leaders to stop them from spending disproportionately on private goods, at the expense of public goods, to buy the loyalty of a small fraction of people with whose support they commit the fraud.[3]

In India, the largest democracy with more than 800 million registered voters and a complex multi-party system, electoral fraud has been one of the leading causes of concern.[4] For example, in several constituencies under the paper ballot system, polling booths would be captured, and ballot boxes would be stuffed (Verma, 2005).[5] To address frauds and simplify the electoral procedure, the Election Commission of India (ECI) introduced electronic voting machines (EVMs) in the late 90's. An important feature of the EVMs was that it could register only five votes per

[1] UDHR is a historical document that sets out "for the first time, fundamental human rights to be universally protected."

[2] Kousser (1974) provides examples of the Democratic Party's use of fraud and violence to regain control of southern politics in the United States at the end of the nineteenth century.

[3] Bueno de Mesquita *et al.* (1999).

[4] In terms of the electorate India is more than four times larger than the second largest democracy, the Unites States (US).

[5] Srinivas (1993) attributed the rise in violence in the early nineties to the politico-economic system and especially to 'booth capturing'. Herstatt and Herstatt (2014) observes that "Not only was the paper ballot system perceived as expensive and inefficient, it also had major security problems. One of the major problems is called booth capture. Often it happened that criminal groups, delegated by political parties, captured a polling station and literally stuffed the ballot box with large numbers of votes for the favoured candidate."

minute. This feature had significant adverse implications for electoral fraud as polling booths had to be captured for a longer period to rig elections, thereby significantly increasing the cost of electoral fraud. Besides enhancing the fairness of the electoral process, the ECI also envisaged that EVMs would improve the efficiency of tallying the electoral results thereby reducing the incidence of human error.[6]

EVMs were introduced on an experimental basis in 1998 in a few constituencies in the state assembly elections. Given the preliminary success of the machines, they were then rolled out in a phased manner for subsequent assembly elections. Post-2001 EVMs replaced paper ballots for all state elections. The timing of the assembly elections is state-specific, mandated by the Constitution, and are held quinquennially. We exploit these intra- and inter- state variations to study the causal impact of EVMs on electoral outcomes, democracy, and development.

Using state assembly elections results between 1976 to 2007 and post-poll survey data, we provide strong evidence that introduction of EVMs led to a significant decline in electoral fraud. In many constituencies under the paper ballot system, polling booths were captured, and ballot boxes were stuffed with fake ballots resulting in an unusually high voter turnout. Using state assembly election data, we show that the introduction of EVMs led to 3.5 percent decline in voter turnout. The decline was substantially larger in states prone to electoral fraud and where politicians faced serious criminal charges. These results can also be explained by voters negative preference toward voting machines, or formation of long lines in polling booths due to the upper limit on the maximum votes per minute. To address these issues, we analyze post-poll survey data collected by an independent agency. Interestingly, we find that the ability of vulnerable citizens (illiterates, females, scheduled castes, and tribes) to cast their vote improved significantly after the introduction of the EVMs. Furthermore, voters were less likely to report that they did not cast their vote due to fear of violence, vote capture or they were prevented from voting. Additionally, we also find that EVMs led to a virtual elimination of rejected or error-ridden votes.

Electoral goals often determine the distribution of discretionary grants and public goods. Arulampalam *et al.* (2009) find that swing states in India where the governing parties are aligned with the central government receive larger shares of federal grants. Electricity being necessary

[6]The first attempt to abate electoral fraud in India was the introduction of the indelible ink in the 1962 parliamentary election to prevent multiple voting. The ink, still in use, is smeared on the nail and cuticle of the index finger of the right hand after voters have exercised their franchise. It cannot be washed away or erased for at least a week, sometimes up to 15 days.

for industry, agriculture, and household consumption its supply in India had been politically driven (Brown and Mobarak, 2009). Public utility companies, often called State Electricity Boards, control the distribution of electricity. These institutions are susceptible to political capture as the managers are accountable to elected officials (Badiani and Jessoe, 2011). As fair elections provide the electorate a means to improve the responsiveness of the elected officials by making them more accountable (Callen and Long, 2015), we study the impact of EVMs on the provision of electricity. Using nighttime lights captured by satellites (luminosity) as a proxy for electricity provision we find that use of voting machines significantly increased the provision of electricity. The improvements were particularly striking for the fourth year since elections, that is, just before the upcoming elections.

Maintaining law and order is a fundamental responsibility of the state. In a democracy, where political representatives are elected by the people, it is expected that these political representatives ensure the security of the citizens by maintaining law and order. However, in a rigged electoral system, politicians fail to provide security to common people because they depend on criminal elements in the electoral process. Politicians, therefore, end up supporting and protecting criminals instead of being able to prevent them. Given that introduction of EVMs in elections was motivated by electoral fraud, we find it critical to extend our analysis to the effect EVMs might have on law and order within a constituency. We assembled district level data on crimes from the National Crime Records Bureau. Our analysis suggests a very strong link between the introduction of EVMs and decline in crime. In particular, we find a significant decline in crime related to murder and rape. Furthermore, it is noteworthy that this effect is stronger in states where large proportion of legislators have criminal records.

Transparent elections with fewer rejected votes may change the distribution of actual voters and politicians in office, simultaneously. A transparent election may induce the incumbent politician to align with the preferences of the median voter (Meltzer and Richard, 1981). While the citizen candidate models would predict similar outcomes through the election of politicians who are closer to the median voter (Besley and Coate, 1997; Osborne and Slivinski, 1996). We cannot explore these channels separately. Instead, we focus on electoral competitiveness. We test this indirectly by examining the effects of electronic voting on vote share and chances of re-election for the incumbent party. We find that the introduction of EVMs leads to a significant decline the vote share of the incumbent parties, and these effects were more pronounced in the

states prone to electoral violence. Overall there was no impact of the voting machines on re-election, but it decreased by 23 percentage points in the states with high re-poll orders issued by the Election Commission. These results suggest that elections became more competitive and were less likely to be manipulated by parties in power, which in turn had an impact on promoting development by increased provision of electricity.

Our paper makes significant contributions to the growing literature on the effect of the voting process on electoral outcomes and policy. For example, Fujiwara (2015) finds that EVMs reduced error-ridden and invalid votes in elections in Brazil. Paper ballots in Brazil required voters to write down the name of their preferred candidate. This requirement to write automatically led to a disenfranchisement of less educated people from the electoral process. Following the introduction of electronic voting which no longer required voters to write, winning parties directed a substantial fraction of government spending towards healthcare expenditure. Baland and Robinson (2008) examine the effect of a new secret ballot in Chile in 1958 on voting behavior. They find that before the reforms, localities with more pervasive patron-client relationships tended to exhibit a much stronger support for the right-wing parties. After the reform, however, such difference disappeared. In contrast to these studies, Card and Moretti (2007) shows that there was no significant effect of electronic voting on election outcomes in closely contested 2004 US presidential elections.[7]

Our paper also makes significant contributions to an important discussion on democracy and growth. A recent paper by Acemoglu *et al.* (2014), using a dichotomous measure of democracy (primarily based on country reports from Freedom House and Polity IV) and controls for country fixed effects and rich dynamics of GDP, finds strong evidence that democracy has a significant positive impact on growth in the long run. This result is in sharp contrast to an earlier work by Barro (1997) who finds that "...democracy is not key to economic growth." Our paper complements the findings of Acemoglu *et al.* (2014), that in addition to the effects of democracy causing long-term growth on the extensive margin, strengthening of democratic institutions also delivers the same outcomes in the intensive margin. For example, if we were to use a dichotomous measure, using the Freedom House and the Polity IV reports then between 1998 and 2015 India would have maintained the same status of a "free" and a "democratic" country. The adoption

[7] Ferraz and Finan (2011) study the impact of the electoral process on economic outcomes in Brazil. They use random audit reports of the local governments to construct measures of political corruption and combine this data with term-limits of the incumbent mayors. They find that mayors serving their first term with re-election incentives are significantly less corrupt compared to those facing a term limit.

of EVMs (to reduce electoral fraud by "booth capturing") during this period should, therefore, be interpreted as strengthening of democratic institutions while preserving India's "free" and "democratic" status.

2 Background

2.1 Political Institutions in India

India is a federal parliamentary democratic republic with a dual polity system consisting of the Union Legislature at the national level and State Legislatures at the state level. The bicameral Union Legislature consists of the President of India, the Lower House (*Lok Sabha* or House of the People) representing the people of India, and the Upper House (*Rajya Sabha* or Council of States) representing the states of the Indian federation. Those elected or nominated to either house of the Parliament are referred to as Members of Parliament (or MPs). The states follow a similar structure where the Lower House is known as the Legislative Assembly (*Vidhan Sabha*), and the Upper House is called the Legislative Council (*Vidhan Parishad*). Those elected to the Legislative Assembly are referred to as Member of Legislative Assembly (or MLAs).

Both the union and the states are divided into single-representative constituencies. Candidates compete in elections characterized by a first-past-the-post system, to represent the electoral districts in the legislature. The candidate with a plurality in a given constituency wins the seat. The party or coalition of parties with the majority has the first opportunity to form a government. Elections are scheduled quinquennially; although some states may have out-of-turn elections, mostly due to shifting of political alignments.

In this paper, we focus primarily on the State Legislative Assembly election results as they exhibit more time-variation in the use of voting machines.

2.2 Electronic Voting Machines in India

The objective of using electronic voting machines in India was to strengthen the electoral processes and to reduce the costs of conducting elections. Voting machines were used for the first time, as an experiment, in 1998 in Paravur assembly bye-election in the state of Kerala. Following the initial success, the ECI procured 150,000 machines in 1990 to use them on a national

scale. However, the political parties were apprehensive about the security of the machines. A petition was filed questioning the statutory authority of the ECI to use EVMs. The Supreme Court ruled that voting machines could not be used without a necessary provision under the law.[8] After the necessary amendments to the Constitution in December 1998, these machines were used in 16 selected constituencies in the state elections in Delhi, Madhya Pradesh, and Rajasthan. [9] These constituencies were were selected on the basis of "their compact character and adequate infrastructure to manage the logistics for introducing EVMs". Availability of good road connectivity played a major role so that in the event of malfunctioning, these machines could be promptly replaced. The ECI publicized the usage of EVMs heavily to make sure the process of casting a vote using EVMs was well understood.

Voting machines used in India can record a maximum of 3,840 votes. Since the number of registered voters in a polling station does not exceed 1500, the capacity of the machines is sufficient. These machines can accommodate a maximum of 64 candidates. Election officers, covering ten polling stations on an average, carry spare machines and are responsible for replacing faulty ones. In the event of a breakdown, votes recorded until the machine went out of order remain safe in the memory of the control unit, and it is not necessary to start the poll from the beginning.[10] These machines run on an ordinary 6-volt alkaline battery, and therefore, can be used in areas without electricity connections. All EVMs are provided with an "end of poll" button which, once pressed, renders them unable to record votes.

The use of voting machines simplified the voting procedure and quickened the process of ascertaining results. It also reduced the cost of conducting elections as the ECI could avoid printing of millions of ballots. Improper and multiple stamps on paper ballots making voter's choice unclear inevitably lead to the dismissal of her vote. Since EVMs could record only one response, the possibility of rejected votes was virtually eliminated.

The Goa legislative assembly election in June 1999 was held entirely with voting machines. For the Parliamentary election held later in the same year, EVMs were used in 45 constituencies

[8]To allay the concerns articulated by leaders of political parties about the machines security the ECI commissioned a study by an expert committee in 1990. The committee unanimously certified the machines as tamper-proof. A second committee was appointed by the commission in 2006 to evaluate the third-generation machines. In their report, the second committee also reiterated the belief that the machines were "tamper-proof". However, some recent independent studies have raised several security issues with voting machines used in India (Wolchok *et al.*, 2010).

[9]The percentage of constituencies using EVMs in the states of Delhi, Madhya Pradesh, and Rajasthan were 9%, 2%, and 3%, respectively.

[10]The rate of failure of voting machines is less than 0.5 percent.

out of 543, spread over 17 states covering 60 million voters. Among all the state assembly constituencies scheduled to hold elections in 1999 simultaneously with the Parliamentary elections, only those that were within the confinement of the 45 parliamentary constituencies used voting machines. For the state elections in the following year, 2000, once again, only the constituencies that were within the confinement of the same 45 parliamentary constituencies used EVMs. In February 2000, the Commission ordered the use of EVMs in 45 out of 90 Assembly seats in the state of Haryana. Table A.1 in the Appendix reports the fraction of constituencies that used voting machines between 1990–2007. Figure 2 plots the timeline of the introduction of EVMs in state assembly constituencies in India.

To formally test the factors affecting early roll out in state assembly elections we estimate a linear probability model of use of voting machines and report the results in Table 2. Column (1) reports the coefficient of an indicator variable that takes the value one if the corresponding parliamentary constituency used voting machines in 1999 and zero otherwise. The estimated coefficient is positive at 0.18 [$p < 0.01$].[11] The significance and magnitude of the coefficient does not change substantially after controlling for constituency level characteristics in Column (2). In fact, the coefficients on state assembly constituency characteristics are indistinguishable from zero. This implies that the introduction of the electronic voting machines were perhaps independent of unobserved assembly characteristics (Altonji *et al.*, 2005). In Column (3) we present the estimates of the interactions between the indicator variable for use of EVMs in the 1999 *Loksabha* election and indicators for assembly election years. The estimated coefficients are strongly significant and positive for the years 1998–2000. The estimates suggest that for state elections held in 1998, 1999, and 2000, assembly constituencies in the 45 parliamentary constituencies that used voting machines in 1999, are more likely to use voting machines. The magnitudes of these coefficients are given by 24%, 95%, and 78%, respectively, and are significant at one percent. The magnitudes do not change significantly after controlling constituency characteristics in Column (4). These estimates strongly suggest that use of voting machines in 1999 *loksabha* elections and exogeneous quinquennial state election cycles explain early adoption for assembly elections and observable assembly characteristics did not affect use of voting machines.[12]

[11] Several state assembly constituencies are nested inside one parliamentary constituency.

[12] The R square values for all the regressions are very close to one, leaving little room for unobservables to explain early use of voting machines.

2.3 Prevention of Electoral Fraud using EVMs

A serious concern with the use of paper ballots in India was booth capturing, wherein party loyalists would capture a polling booth by force and stuff the ballot box.[13] The EVMs were designed to discourage such frauds by limiting the rate of vote casting to five per minute. This feature did not rule out booth capturing completely but increased the time required to cast false ballots, increasing the chances of the arrival of security forces. Second, with the voting machines, the presiding officer could press the "close" button disabling the device to avoid intruders taking control over the polling booth. Third, under paper ballots signature or thumb impression of a voter was recorded on the counterfoil of a ballot, which was not open to inspection except under the orders of a court. While under electronic voting signatures or thumb impressions are maintained in a register which is open to inspection by public or anyone willing to file a petition to challenge election outcomes on the ground of bogus voting. Lastly, paper ballots leave important discretionary decisions in the hands of officers who determine whether a vote was valid for a particular candidate.

The Election Commission claimed that votes recorded in the machines are tamper proof, and physical tampering of the devices is easily detectable. However, these claims were later contested by rigorous independent evaluations (Wolchok *et al.*, 2010).

3 Data

3.1 Election Data

The Election Commission of India (ECI) oversees, directs, and controls the Parliament and State Legislative Assembly elections. The results of these elections are published by the ECI in Statistical Reports of General Election to *Loksabha* (Parliament) and *Vidhansabha* (State Legislative Assembly). The format of these reports vary but overall they publish total number of electors and voters by gender; name, gender, party affiliation, and votes secured by each

[13] "Booth capturing is carried out by hired criminals in a very organized way. First, booths are chosen carefully to minimize confrontation with the police and where citizen resistance is likely to be minimal. Second, those booths are targeted which are isolated or guarded by a small police force. Since a single booth is unlikely to affect the overall results, most candidates plan to target as many booths as possible. ⋯ The candidates hire armed criminals, obtain vehicles and guns before the elections start, and spend considerable amount of money on these resources." (Verma, 2005)

contestant at the constituency level.[14] We use these data to construct voter turnout, rejected votes, and winning margin.[15] Some of these reports provide information on postal ballots and re-poll orders at constituency level. We use re-poll orders in 2004 Parliamentary elections to find heterogeneity in the main results.

We restrict our analysis to the state assembly elections held between 1976–2007 as constituency boundaries did not change during this period, even though new states came into existence.[16] A total of 195 state elections were held during this period covering all 30 states and union territories and 4,119 assembly constituencies.[17] We use data from 164 of these elections in our estimation sample.[18] The dates of introduction of the EVMs are collected from ECI orders and several newspaper archives.

3.2 Nighttime Lights

We use annual satellite nighttime light images for the period 1992-2007 and assembly constituency maps to construct a proxy measure of electricity provision. We obtain the satellite raster images from the National Aeronautics and Space Administration's (NASA) Defense Meteorological Satellite Programs Operational Linescan System (DMSP-OLS), a set of military weather satellites orbiting and recording high-resolution images of earth each night between 20:00 and 21:30 local time.[19] These images are available from 1992 onwards and are used to produce annual composites after dropping cloud cover, Aurora, solar glare (mainly near the

[14]This data is available at the ECI's website for every general election held since 1951.

[15]Voter turnout is the ratio of total votes and electors; rejected vote is the difference between total votes and valid votes; winning margin is the difference between the fraction of votes of the winning and runners-up candidate.

[16]As per the constitutional and legal provisions, the total number of legislative assembly seats in all states is to remain unaltered till the first census after 2026. Given the fixed number of constituencies and differential population growth across regions constituency boundaries are redrawn periodically by the Delimitation Commission to reduce the variation in constituency sizes. The representation from each state is not altered during this exercise. However, the number of reserved seats (by caste) in a state may change as per the most recent census. Till date the Delimitation Commission has been set up four times: 1952, 1963, 1973 and 2002. The recommendations of the third and fourth Delimitation Commission were implemented in the year 1976 and 2008, respectively. The first election after delimitation was held in the state of Karnataka in 2008.

[17]Pondicherry and Delhi are the only Union Territories that has its assembly election and is included in our analysis.

[18]The 31 state elections that are missing are: Arunachal Pradesh (1978), Delhi (1977, 1983), Goa (1977, 1989, 1907), Jammu & Kashmir (1977, 1983, 1987), Manipur (1980, 1990, 1907), Mizoram (1978, 1984, 1987, 1989), Nagaland (1987), Meghalaya (1978, 1983, 1988), Pondicherry (1977, 1980, 1985, 1991, 1906), Sikkim (1979, 1985, 1989, 1904), and Tripura (1983, 1988). These elections are not included in our analysis mainly because the format of the reports for these elections are different than others.

[19]The high-resolution images captured at an altitude of 830 km above the earth, record concentrations of outdoor lights, fires, and gas flares at a resolution of 0.56 km and a smoothed resolution of 2.7 km.

poles), and fleeting lights such as forest fires and other noise. We use this series of images after masking the raster data for the geographic boundary of India. These pictures are scaled onto a geo-referenced 30 arc-second grid (approximately one sq. km.). Each pixel is encoded with a measure of its annual average brightness on a 6-bit scale from 0 to 63. Using state assembly constituency boundary maps we extract an annual time series of constituency level luminosity data between 1992–2007. Figure 4 shows the nighttime lights images for the years 1992 (in Panel A) and 2007 (in Panel B) with the assembly boundaries.

Political science literature has used nighttime lights extensively as a measure of the provision of electricity. Min *et al.* (2013) show that night lights imagery can be used to approximate rural electrification in developing countries using DMSP-OLS and survey data from Mali and Senegal. Recent economic growth literature establishes a high degree of correlation between the traditional measure of growth and luminosity. Henderson *et al.* (2012) develop a statistical framework that uses lights growth to enhance existing income measures. Interpretation of night lights as growth requires some degree of interpolation. We mainly use night lights as a measure of the provision of electricity which is primarily a state subject matter in India.

3.3 Crime Data

Data on different types of crime under the Indian Penal Code in India is collated at the district level and published by the National Crime Records Bureau (NCRB) since 1973. Since law and order and the police force are under state jurisdiction in India, we use this data to explore the effect of EVMs on crime.[20] There are concerns that the NCRB crime records are severely underreported except for heinous crimes such as murder. We analyze the effects of EVMs on total crimes as defined by the Indian Penal Code (IPC), murder, and rape. Since assembly constituencies do not extend to more than one district, we merge the elections data with the crime data after collapsing the former at the district level. As a result, while analyzing the crime data, our main explanatory variable measures the fraction of constituencies in a district that used EVMs.

[20]The power of the states and the center in India under the federal structure is delineated by the Indian Constitution. State list consists of 61 items that are under the states.

3.4 Post Poll Surveys

We use post-poll surveys conducted by the Centre for the Study of Developing Societies (CSDS), an autonomous organization, to corroborate our analysis using Election Commission data. A research program for studies on comparative democracy at the CSDS regularly conducts large-scale scientific studies of political behavior, opinions, and attitudes of Indian electorate. Further, the center is considered a pioneer in large-scale pre-, post- and exit-poll surveys for parliament and state legislative assembly elections. The first such study was conducted in the state of Kerala in 1965 but was not continued during the 1970s and 1980s. The study resumed in 1995 with Bihar state assembly election and had covered most state elections since then.

We focus on post-poll survey data for state legislative assembly elections available during the period 2000-05.[21] Out of these elections, voting machines were used in 20 elections, 3 used both EVM and paper ballots, and 1 used only paper ballots. Post-poll surveys are conducted after the day of polling and before the declaration of results. We use the data on whether the eligible voter was able to vote, and whether she abstained from voting due to fear of violence at the polling station, vote capture, or the use of force. The surveys also collect demographic information such as age, gender, caste, and education. Some of the surveys also have questions on awareness of and opinion on EVMs.

4 Estimation Strategy

As discussed earlier, our data is restricted to state assembly elections between 1976–2007 covering 164 assembly elections and 4,119 constituencies. Assembly elections dates are pre-scheduled and are quinquennium. Each state has its electoral cycle. All assembly election after 2002 were held electronically, whereas elections before 1998 used paper ballots. Therefore, time variation in use of electronic voting emerges due to pre-determined state election schedule. However, for the elections between 1998 and 2002, as reported in Table A.1, there was cross-sectional variation in the use of voting technology within a state. Our empirical specification below utilizes intra- and inter- state time variations to estimate the effects of electronic voting machines on

[21] Assam, Bihar, Chattisgarh, Delhi, Haryana, Jammu & Kashmir, Jharkhand, Kerala, Madhya Pradesh, Meghalaya, Mizoram, Odisha, Punjab, Rajasthan, Tamilnadu, Uttarakhand, and West Bengal.

outcome variables.

$$Y_{apt} = \beta_0 + \beta_{EV} EV_{apt} + \tau_t + \alpha_{apt} + \pi_p t + \beta_{\mathbf{x}} \mathbf{x}'_{apt} + \epsilon_{apt} \tag{1}$$

where the indices a, p and t represent assembly constituency, parliamentary constituency, and election year, respectively. EV_{apt} is a binary variable taking the value one if assembly constituency a in parliamentary constituency p used electronic voting machines in year t. The coefficient β_{EV} measuring the average effect of electronic voting on outcomes such as voter turnout, rejected votes, winning margin; is the parameter of interest. Assembly fixed effects (α_{apt}) control for time-invariant unobserved characteristics of constituencies that might have affected the early use of voting machines and electoral frauds simultaneously. The year fixed effects (τ_t) control for national events that might have affected the use of voting machines and voter turnout and other electoral outcomes, such as national elections coinciding with state elections. Parliamentary constituency specific linear time trends ($\pi_p t$), capture the trends in parliamentary constituency characteristics that may affect electoral outcomes due to demographic changes and growth. The constituency and time varying characteristics ($\mathbf{x}'_{apt}$) include variables that might influence election outcomes, such as total number of electorates, candidates, and their gender composition.

Since state elections are not held at the same time, identification of the effects of electronic voting that use inter-state time variation relies on comparison of two state elections at different time periods. Such comparisons may introduce bias in our estimates as state elections in various time periods might not be comparable. Along similar lines, identification exploiting the intra-state time variation assumes constituencies that used voting machines in a given state election are not systematically different from their counterparts using paper ballots. Summary statistics of control variables reported in Table 1 shows statistically significant difference between the two types of constituencies. For example, on an average, there are 51,195 additional eligible voters for elections with voting machines compared to the elections held using paper ballots. The difference in an average number of voters is 31,550 between the two types of voting technology. Such differences may get absorbed by the parliamentary constituency specific time trends and election year fixed effects in our model. However, time-varying unobserved differences between elections held with machines and paper ballots may confound our estimates if they determine

the use of voting machines and election outcomes simultaneously. We address this issue by estimating the same model after restricting our estimation sample such that covariate balance is achieved between elections with voting machines and poster ballots. We discuss this is greater detail in Section 8.

5 Results

5.1 Effect on Total Voters and Voter Turnout

The effects of an electronic voting machine on the number of voters and voter turnout is theoretically ambiguous. Unlike paper ballots, Indian voting machines by default record only five votes per minute. As a result, corrupt politicians had to capture polling booths longer to cast false votes, increasing costs of fraud and the chances of detection. Therefore, in the absence of electronic voting total number voters and turnout could be higher on account of fraudulent votes. Second, voters may turn out in greater numbers in constituencies where machines were used as the Election Commission heavily publicized the machines. Finally, if electronic voting was not systematically different from paper ballot we should not expect any changes in the election outcomes. Voting procedures with electronic machines used in India emulated the paper ballot system. As shown in Figure 1 the interface of the devices was similar to a paper ballot. Under the new system, voters had to press the button against their favorite candidate as opposed to using a stamp on a ballot paper. We present the results of electronic voting on the number of voters and voter turnout in Table 3.

Panel A in Table 3 reports the effects of EVM on the natural log of total, male and female voters for the period 1976-2007 using the specification in equation 1. The coefficient of -0.035, significant at one percent level in Column 1 suggests that introduction of voting machines reduced the number of voters by 3.5 percent.[22] The effects are similar for male voters measuring a 4.2 percent decline. The drop in female voters reported in Column (3) is slightly lower at 2.6 percent. Note that, specifications in Panel A control for a log of total-, male- and female- electors or eligible voters, respectively. Therefore, the estimated decline in voters is not on account of a spurious correlation between the introduction of voting machines and a simultaneous decline

[22]Since the dependent variable is in logarithmic scale the coefficient estimate of -0.035 translates into $(exp^{-0.035} - 1)$ = -3.4 percent.

in registered voters. In Panel B, we report the coefficient on voter turnout, defined as the ratio of the total voters over electorates. As Column (1) indicates the overall effects of electronic voting estimated at -3.18 percentage points continues to be negative and statistically significant at one percent. Drop in male turnout was sharper compared to female turnout supporting the results in Panel B. These estimates suggest that electronic voting machines might have reduced bogus votes. Given the average winning margin for the period of 1976-97 (pre-EVM period) was 15.8 percentage, a drop in turnout by 3.18 percentage points could affect election outcomes substantially.

5.2 Alternative Explanations

One plausible confounding factor behind the results described in the previous section could be the formation of long lines at polling booths due to the five votes per minute rule discouraging voters to exercise their franchise. Voters might also be averse to use new technology explaining the estimated drop in voter turnout. We test these alternative explanations using the *Lokniti* post-poll surveys conducted by the Centre for the Study of Developing Societies (CSDS). Among many questions on political preferences, these cross-section surveys collected data on awareness and opinion about voting machines. About 96.4 percent of the respondents (eligible voters) preferred electronic voting machines over paper ballots. The survey also collected data on whether voters were able to cast their vote and reasons thereof. In this section, we report the effects of electronic voting on these two outcome variables.

In Table 4.A reports the effects of electronic voting on whether an eligible voter was able to cast her vote. The dependent variable takes the value one if she voted and zero otherwise. All specifications reported in the table control for election years and assembly constituency fixed effects, and demographic characteristics of the respondent (age and gender). As indicated in Column (1) the coefficient of *Electronic Voting* is 0.0038 and statistically indistinguishable from zero. This result suggests that introduction of the machines did not affect a voter's ability to cast her vote, eliminating concerns about the confounding factor of long lines or aversion to using new technology. In the rest of the columns, we interact *Electronic Voting* with indicators for several vulnerable groups of electors. The coefficient of the interaction between *Electronic Voting* and voters with below intermediate education, in Column (2) on ability to vote is 0.056 ($0.01 < p < 0.05$) suggesting that a less educated voter was 5.6 percentage points more likely to

be able to vote if elections were held using voting machines. Given the baseline average at 0.87 for voters with bellow intermediate education, the use of EVMs led to a 6.4 percent increase in the likelihood that a less educated voter will cast her vote. In the subsequent columns, we interact *Electronic Voting* with indicators for women, lower caste, senior citizen, and illiterate female voters, respectively. All reported coefficients on the interactions are positive and highly significant suggesting the introduction of electronic voting empowered the vulnerable groups by increasing their participation in elections. In contrast with the results described earlier that use of electronic voting led to a drop in voter turnout, these findings strengthen our conclusion that electronic voting reduced electoral fraud.

In Table 4.B, we explore the effects of electronic voting on the reasons behind voters' inability to vote. The dependent variable measuring vote capture takes the value one if a respondent did not vote due to fear of violence, someone else cast her vote or was prevented from voting and zero otherwise. As in the previous table all specifications control for election years and assembly constituency fixed effects, and demographic characteristics of the respondent. In Column (1) the estimated effect of *Electronic Voting* on vote capture is -0.0066 and it is estimated imprecisely, suggesting voting machines did not affect vote capture. However, the estimated coefficients on the interactions between *Electronic Voting* and indicators for the vulnerable groups of voters, reported in Columns (2)–(6) are negative and precisely estimated. For example, in Column (2), the estimated coefficient on the interaction between *Electronic Voting* and an indicator for less educated voters is -0.013 and it is significant at ten percent. Similarly, for female, lower caste, senior citizen, and less educated female voters the estimated coefficients are measures at -0.016 [$p < 0.01$], -0.012 [$0.01 < p < 0.05$], -0.0072 [$p > 0.1$], and -0.016 [$p < 0.01$], respectively. These results presented in Tables 4.A and 4.B taken together suggests that with electronic voting the likelihood of participation in election improved for the vulnerable voters and this was mainly due to a decline in electoral frauds.

5.3 Effect on Rejected Votes

Under the paper ballot system, voters applied a stamp against the election symbol of their preferred candidate to cast their vote. An unclear or multiple stamping may lead to rejection of the ballot. Unless a voter consciously chooses to waste her vote by marking the ballot in a confounding manner, rejected votes generate inefficiencies in the electoral system. Electronic

voting could prevent the total number of rejected votes substantially as voters had a single chance to push only one button indicating their preference. We analyze the effect of electronic voting on rejected votes for all state elections between 1976-2007 using the specification in equation 1.

Table 5 reports the effect of voting machines on rejected votes. All specifications control for election year fixed effects and parliamentary constituency specific linear time trends. The estimated coefficient on rejected votes, without any additional covariates, reported Column (1) suggests that elections with electronic voting had 2139 fewer rejected votes compared to paper ballot voting. The coefficient is significant at one percent level. Note that the estimated coefficient is almost equal to the baseline average (elections with paper ballots) of 1969 rejected votes. In Column (2) we additionally control for the total number of electors. The coefficient estimate is marginally less negative at -2130, but it continues to be significant at one percent. In the following two columns, (3) and (4), we additionally control for assembly constituency fixed effects and number of contestants in the previous election, respectively. The coefficient estimate changes marginally and continues to remain highly significant. These results suggest that voting machines almost eliminated all rejected votes leading to a 2.7 percent increase in the number of valid votes at the baseline. Being a multi-party system with narrow winning margins an increase in valid votes can potentially change election outcomes.[23]

6 Heterogeneity in the Effects of EVMs

In the previous section, we show that electronic voting in India has led to a decline in voter turnout while some of the disadvantaged voters reported that they were more likely to cast their vote. These results suggest that voting machines reduced electoral fraud. In this section, we present the differential effects of electronic voting for states where elections were more likely to be rigged.

6.1 Re-poll Orders

Since there is no objective measure(s) available to rank constituencies by their likelihood of frauds, we use re-poll orders issued by the Election Commission. The Election Commission

[23]Out of all elections held between 1976–97 (paper ballot elections) 9.2 percent of constituencies had a winning margin lower than 2.7 percent.

appoints observers in every constituency to monitor the elections to ensure free and fair voting. Based on negative reports submitted by these observers, the Commission may declare the results from a particular polling booth void and can issue orders for re-poll. The re-poll orders are consistently available only for the 2004 parliamentary elections. Table A.3 ranks all states in India by per constituency re-poll orders. We create a dummy (*Highest Re-poll States*) for the three states of India with highest average re-poll orders.[24]

As reported in Panel A of Table 6, the coefficients of the interaction between *Electronic Voting* and the *Highest Re-poll States* on the log of total voters, male and female voters are at -.073, -0.083, and -0.079, respectively. All of these estimates are significant at one percent level. The main effects of *Electronic Voting* continues to be negative but it's magnitude and significance decrease compared to the coefficients reported in Table 3. These results suggest that following the introduction of EVMs the drop in the number of voters and turnout in the three states with highest re-poll orders was almost double compared to the rest of the states.

In Column (1) of the bottom panel of Table 6 we report that the use of EVM reduced voter turnout by additional 2 percent in the four legislative assemblies with highest re-poll orders while the main effects continue to be negative and significant. We find adverse effects on male and female turnout measured at -3.9 and -1.9 percent, respectively. Except for female voter participation these estimates are significant at ten percent levels. The heterogeneity in the effects of voting machines strengthens our earlier conclusion that drop in voter turnout reflects reduced electoral malpractices.

6.2 Politicians with Criminal Background in Close Elections

The increase in the number of criminally accused politicians has created a heated debate in India. Approximately a quarter of members of *Lok Sabha* elected in 2004 and 2009 were facing or previously faced criminal charges Prakash *et al.* (2014). Aidt *et al.* (2011) documents that under electoral uncertainty, Indian political parties are more likely to field candidates with criminal background. Therefore, close elections are more likely to suffer from electoral fraud where politicians with criminal backgrounds are more likely to be elected. Political science literature often argues that elections with tiny winning margin are very similar and, therefore,

[24]These states, Andhra Pradesh, Bihar, and Jharkhand, are densely populated with 13.7 percent of the landmass and 18.3 percent of total population in India.

are comparable (Butler, 2009; Eggers and Hainmueller, 2009). To visualize the election outcomes for the close elections we plot voter turnout against the winning margin for the elections with and without EVMs in Figure 3. In Panel A, the sample is restricted to the states of Bihar, Jharkhand, Maharashtra, and Uttar Pradesh where a substantial fraction of elected representatives had a criminal background.[25] The figure reveals that the average voter turnout is significantly lower in constituencies that used EVMs compared to their counterparts using paper ballots. We do not find any significant difference in voter turnout in Panel B, where the sample is restricted to the states where members of the legislative assemblies were less likely to have a criminal background.[26]

We test this more rigorously in Table 7. All specifications reported in the table control for election year and state fixed effects, state specific time trends, gender of the winning candidate and the number of contestants in the previous election. Column (1) of Panel A reports the effects of the use of EVMs for constituencies with winning margin less than 3 percent. The estimates suggest that overall, male, and female turnout was significantly lower for the constituencies that used EVMs. The effects continue to remain significant with a quadratic specification in Column (2) measured at -4.9 ($p < 0.01$), -5.3 ($p < 0.01$), and -4.28 ($0.01 < p < 0.05$) for overall, male, and female turnout, respectively. The relative magnitudes of these estimates are very similar to those of the effects of EVMs for the entire sample reported in Table 3 earlier. Column (3) and (4) report the same estimates for constituencies with winning margin less than 6 percent and the effects of EVMs on voter turnout continues to persist. All reported estimates confirm that voter turnout in close elections was significantly lower if elections were held using EVMs.

Panel B reports the same estimates after restricting the data to the states of Bihar, Jharkhand, Maharashtra, and Uttar Pradesh where the fraction of elected representatives with serious criminal charges were the highest. The effects on overall, male, and female turnout are each almost three times larger compared to Panel A, and they are significant at one percent level when the sample is restricted to constituencies with less than 6 percent winning margin.

Panel C reports the same estimates for the states where fewer elected representatives have

[25]Table A.2 reports the state-wise percentage of members of state legislative assembly with criminal cases against them for the earliest possible election year. This data is not available for the period when voting machines were introduced.

[26]These states are Nagaland, Arunachal Pradesh, Mizoram, Goa, Manipur, Meghalaya, Tripura, Sikkim, Jammu & Kashmir, Assam, and Rajasthan. See Table A.2 for ranking of Indian states by the fraction of the members of the legislative assemblies with serious criminal charges.

serious criminal charges against them. The estimates suggest that the effects of EVMs in close elections for these states are in the same direction, but of much smaller magnitude.

Systematic differences in the closely contested constituencies using EVMs and paper ballots may confound our results. To rule out such possibilities we plot constituencies characteristics, derived from the 2001 Census data, against winning margin by use of EVMs.[27] Figure 6 plots the predicted values (residuals after taking out the state fixed effects) of a local linear smoother estimated separately for constituencies that used EVM and paper ballots. None of the plotted characteristics reveal any systematic differences between constituencies that use EVMs and paper ballots at close elections.

7 Public Goods and Electoral Competition

Results discussed in the previous sections suggest that the number of voters and voter turnout decreased with the introduction of electronic voting. The decline is relatively larger in the state assemblies where the Election Commission ordered more re-polls in the 2004 parliamentary election. These results, taken together, imply that the introduction of voting machines increased transparency in assembly elections.

Incumbent politicians often manipulate fiscal and macroeconomic policies to improve their chances of re-election.[28] A transparent election may induce the incumbent politician to align with the preferences of the median voter (Meltzer and Richard, 1981). Members of legislative assemblies have less discretionary power and access to state funds, but they routinely exploit state-controlled discoms to increase their chances of reelection. We test this indirectly by exploring the effects of electronic voting on the provision of electricity. Conversely, the citizen candidate models predict that the consequences of a transparent election will manifest through the election of politicians who are closer to the median voter (Besley and Coate, 1997; Osborne and Slivinski, 1996). We explore this channel by investigating the differential impact of electronic voting on vote shares and reelection of the incumbent.

[27] These characteristics include percent workers engaged in cultivation, urban population, literacy rate (total, male and female), schedule caste, schedule tribes and female population as per census 2001

[28] See Drazen (2001) and Alesina *et al.* (1997) for excellent reviews.

7.1 Provision of Electricity

State-level corporations are the largest producers of electricity in India (41%) and are responsible for transmission and distribution. Electricity is one of the key issues during state elections, and importantly, its provision is primarily under state control. Using transmission loss data for a major state in India, Min and Golden (2014) show that transmission losses peak just before the state assembly elections. Most importantly, politicians wield considerable power and exercise them to control and manipulate the provision of electricity to tilt election outcomes in their favor (Baskaran *et al.*, 2014). We use annual constituency-level luminosity data as a proxy for the supply and consumption of electricity, and the specification outlined in equation 1 to explore the effects of electronic voting on the supply of electricity. Due to data limitations, we restrict our analysis to the period between 1992–2007.

Table 8 reports the dynamic effects of electronic voting on luminosity. All specifications control for election year and assembly constituency fixed effects, state-specific time trends, the gender of the winning candidate and the number of contestants in the previous election. In Column (1) we report the impact of electronic voting on log luminosity after one year of an election. The coefficient on *Electronic Voting* at -0.088 suggests that luminosity drops by nine percent after one year since the election in constituencies with electronic voting machines. However, this estimate is not precise. In Column (2), for elections with voting machines, luminosity increases by 9.2 percent in the second year after the election compared to elections with paper ballots. Similarly, in Column (3) and (4) the reported coefficient suggests that provision of electricity increases by 12 ($0.01 < p < 0.05$) and 23 ($p < 0.01$) percent in the third and fourth year after elections if voting machines were used. The coefficients reported point out that provision of electricity in constituencies that used voting machines increases as the next election draws nearer and it is the highest for the year before the next election. [29] In Column (5) we report the effect of EVMs on annual average luminosity for each state election cycle. The statistically insignificant coefficient estimated at 0.089 indicates that, overall, constituencies enjoy a marginally higher supply of electricity if elections are held with voting machines as compared to paper ballots.

[29] Elections in India are held quinquennially. The number of observations in the columns drops gradually as some of the states had out-of-turn elections.

7.2 Vote Shares and Reelection

Weak institutions, lack of information, and political clientelism may lead to the capture of democracy by the political elite (Banerjee *et al.*, 2010). Transparent elections or revealing information to the voters may reduce such inefficiencies. For example, disclosure of the local government's corrupt practices reduced the incumbent's likelihood of reelection in Brazil's municipalities (Ferraz and Finan, 2008). As argued in the previous, sections voting machines in India strengthened the electoral process, making rigging difficult. Therefore, EVMs may affect political competitiveness reflected in the vote share of the incumbents and their reelection chances.

We present the effects of electronic voting on vote shares and incumbent party's reelection in Table 10.[30] All specifications reported in Table 10 control for the same set of regressors as in the previous tables. Panel A reports the effects for all state elections. Incumbent party's vote share reported in Column (1) decreases by 3.62 percentage points with the introduction of voting machines. The estimate is significant at the 5 percent level. On a baseline average of 34.97, this is an 10.35 percent decrease. The effect on the likelihood of reelection of the incumbent, reported in Column (2), is positive at 0.082. However, this estimate is marginally significant at 10 percent.

In Panel B, we present the differential effects of the voting technology in politically sensitive states. The coefficients on the interaction between the indicator for *Electronic Voting* and the *Highest Re-poll States* reported in the second row estimates the differences in the effects of electronic voting on the same outcome variables between the states with the highest number of re-poll orders versus the rest of the assemblies. As earlier, *Highest Re-poll States* takes the value one for the states of Andhra Pradesh, Bihar, Jharkhand, and Orissa. The Incumbent party's vote share in these states, reported in column (1), declined by an additional 5.54 percentage points with the introduction of voting machines with the estimate being significant at one percent level. In column (2), the likelihood of the incumbent party's reelection in the highest re-poll order states declined by 11 percentage points compared to the rest of the states. This

[30]Ideally we want to explore the consequences of the change in voting technology on the incumbent candidate's reelection. Tracking a candidate's performance over several years of election is difficult on several accounts. First, candidate names are not spelled consistently in the election reports over time. Second, parties often field dummy candidates with matching names with their rival candidates. Finally, politicians in India often change their party affiliation making the tracking exercise difficult. Therefore, instead of incumbent candidates we focus on the effects of the change in technology on the incumbent parties.

point estimate is significant at the five percent level and on the baseline average of 0.35, this represents a staggering 31 percent decline in the likelihood of retaining seats. These results indicate that the introduction of voting machines significantly affected the vote shares of both the incumbent and the winning parties, and the effects were more pronounced in the states where electoral fraud was most likely.

7.3 Effects on Crime

In the previous sections, we show that the introduction of electronic voting machines reduced voter turnout, and reelection chances for the incumbent politicians in the states where more re-poll orders were issued. These results suggest that voting machines might have reduced the influence of criminals politicians in elections (Verma, 2005), which may, in turn, affect crime. We use annual district level crime data and merge the election results after collapsing them at the district level to explore the dynamic effects of electronic voting on total crimes. In particular we analyze the effects on total crimes as defined by Indian Penal Code, murder, and rape. Due to limitations of the crime data, we restrict our analysis to the period between 1987–2007.

Table 9 reports the results on the natural log of the crime variables. We create a dummy *Criminal Legislatures* for the states where the fraction of the members of the legislative assembly with criminal background was the highest. [31] All specifications control for the election year and district fixed effects, fraction of gender of the winning candidate $(t-1)$ and the total number of contestants $(t-1)$ from all the assembly constituencies in a district. As we have aggregated the election data at the district level, *EVM* now represent fraction of constituencies that used electronic voting machine in a district. In Column (1) of panel A of Table 6, the coefficient of the interaction between *EVM* and the *Criminal Legislatures* suggests that the use of electronic voting machines reduced total crimes by 31 percent in states with high percentage of criminal MLAs as compared to other states after one year of election. Similarly, in Columns (2) through (4) of panel A, the estimated coefficient on the interaction suggests that total IPC crime reduced significantly by 17, 19, and 13 percent in the high criminal legislatures as compared to others states in the second, third, and fourth year after elections, respectively. In Column (5) of panel A, we report the effect of EVMs on total IPC crime for each election cycle. The coefficient

[31] Table A.2 shows that the states of Bihar, Jharkhand, Uttar Pradesh and Maharashtra had the highest fraction of MLAs with serious crime cases against them.

estimated in the interaction term indicate that overall total crimes reduced by 20 percent in the states of Bihar, Jharkhand, Uttar Pradesh and Maharashtra while the overall effects of the EVMs is slightly positive at 0.06, but it is imprecisely estimated.

In panel B and C, we report the effect of EVM on reported murder and rape, respectively. We find that the overall introduction of EVMs lead to a decline in total murders in the third (0.19, $0.01 < p < 0.05$) and fourth (0.18, $0.01 < p < 0.05$) year since an election and for the entire five-year election cycle (0.08, $0.05 < p < 0.1$). The coefficient estimates on the interaction between *EVM* and the *Criminal Legislatures* for the first year after an election is -.40 and it is significant at one percent. The effects decline for the subsequent years and continue to remain significant at one percent. The coefficient on the interaction for the total number of murders reported during the entire election cycle, reported in Column (5), suggests that the introduction of EVMs reduced total murders by 30 percent in the states of Bihar, Jharkhand, Uttar Pradesh and Maharashtra compared to the rest of the states. We find very similar results on the reported number of rapes in Panel C. The coefficient estimate for the interaction indicate that with the introduction of electronic voting machine reported rapes reduced significantly by 32 percent in the four states as compared to the rest. While, the overall effects of EVMs is indistinguishable from zero.

8 Robustness

The estimation strategy described earlier in equation 1 assumes that constituencies with electronic voting and paper ballots are comparable. However, the summary statistics of observables reported in Table 1 shows a significant difference between them. As long as these differences are time invariant, they will get absorbed by assembly constituency fixed effects. However, time-varying unobserved differences between elections held with machines and paper ballots that are not captured by parliamentary constituency-specific time trends may confound our estimates if they determine the use of voting machines and election outcomes simultaneously. We address this issue by estimating the same model (equation 1) after restricting our estimation sample on the common support of predicted use of electronic voting such that covariate balance is achieved between elections held with voting machines and poster ballots. To validate our results we also estimate the effects of voting machines in an instrumental variable framework exploiting the

timing of assembly elections and roll-out of the machines in parliamentary elections. As a placebo check, we examine whether the introduction of voting machines would have had any impact on the outcomes if we change the dates of its introduction arbitrarily. Finally, we check for other security factors, in particular, whether greater policing is confounding our results.

8.1 Covariate Balance

Time variation in the introduction of voting machines in assembly elections was mainly determined by the state election cycles and the use of voting machines in selected constituencies in the 1999 parliamentary election. Therefore, our estimation strategy relies on comparing election outcomes of the same constituencies over time and cross-sectional comparison of constituencies using voting machines and paper ballots. Note that ultimately voting machines were used in all state elections. One potential problem with this identification strategy is that constituencies using voting machines early on might not be a proper counterfactual for the ones where they were used later. The significant difference in the average characteristics by voting technology reported in Table 1 cannot rule out this potential problem. Constituency fixed effects in our model eliminate concerns about time-invariant differences, but time-varying unobservable differences may confound our results.

To address this issue, we implement the main specification after restricting the data to the common support of predicted use of voting machines for constituencies using paper ballots and electronic voting machines.[32] Columns (1) and (2) of Table A.4 report the average number of electors and voters by gender for constituencies using paper ballots and voting machines, respectively, for the restricted sample. Note that the differences in average characteristics for the restricted sample are smaller in magnitude compared to the entire data, reported in Table 1, and the differences are statistically indistinguishable from zero in most cases. The estimation results on voter turnout for the restricted sample is reported in Table A.5.

Column (1) in Table A.5 reports that the overall effect of electronic voting on voter turnout

[32]Use of electronic voting is predicted using a linear probability model. The control variables include an indicator for use of voting machines in 1999 parliamentary elections, the number of eligible voters, number of candidates, urban population, literacy rate and total population by gender, fraction of the SC-ST population, the percentage of the population engaged in agriculture, and a linear time trend. Constituency level demographic characteristics are constructed using Primary Census Abstract, 2001. The choice of the common support between [0.3, 0.55] is determined after visually inspecting the distributions of predicted probability for EVM and paper ballot constituencies (See Figure 5). The results reported in Table A.5 are robust to other choices of intervals of common support or non-linear models for predicting the use of voting machines and are available upon request.

is measured at -3.92 percentage points ($0.05 < p < 0.1$). Drop in female turnout (-4.46) was sharper compared to the drop in male turnout (-3.44). These results on the restricted sample strengthen our earlier results and allay concerns regarding systematic unobservable differences between constituencies using different voting technology. Besides, the estimated coefficients for the restricted sample are larger in magnitude (except for male voters) compared to the estimated effects of electronic voting on the entire sample reported in Table 3, suggesting unobservable confounding factors, if any, led to underestimation of the effects of electronic voting.

8.2 Instrumental Variable Estimates

Our estimation strategy exploits within- and between-state variation in the time of the introduction of voting machines. Between-state variations were determined by state election cycles making them plausibly exogenous. Characteristics of the constituencies might have determined cross-sectional variation in the use of voting machines within a state. If constituency fixed effects and parliamentary constituency specific time trends fail to absorb such factors, then our model yields biased estimates. To address such concerns, in this section, we validate the effects of EVMs using an instrumental variable framework.

To reduce the variations in electoral, demographic, and other factors over time we restrict our estimation sample to elections before and after 1999. For these elections, the introduction of voting machines was mainly determined by the location of assembly constituencies and the year of elections. As described earlier in Section 2.2 the ECI used EVMs in 45 out of 543 constituencies in the 1999 parliamentary (*Loksabha*) elections. For the assembly constituencies within these 45 parliamentary constituencies and the states where state assembly and *Loksabha* elections were held together in 1999, the likelihood of using voting machines was much higher. We exploit this fact and use the interaction between an indicator for the location of state assemblies within 45 parliamentary constituencies and an indicator for the year 1999 as an instrument for electronic voting. The IV approach involves estimating a two-stage model as follows:

$$\text{First stage: } EV_{apt} = \alpha_0 + \alpha_{IV}\left(I_{within\ 45\ PC} \times I_{year=1999}\right) + \tau_t + \alpha_p + \alpha_{\mathbf{x}}\mathbf{x}'_{apt} + \epsilon_{apt} \quad (2)$$

$$\text{Second stage: } Y_{ast} = \beta_0 + \beta_{EV}\widehat{EV_{apt}} + \tau_t + \alpha_p + \beta_{\mathbf{x}}\mathbf{x}'_{apt} + \nu_{apt} \tag{3}$$

The IV estimation strategy relies on the assumption that the indicator $I_{within\ 45\ PC}$ is independent of the outcome variables. According to the Election Commission documents these 45 constituencies were chosen mainly due to better infrastructure facilities as transporting voting machines would be easier. We assume that the parliamentary constituency fixed effects in our model absorbs such differences.

We report the two stage least squares (2SLS) estimation results in Table A.7. Panel A reports the first stage results. The coefficient on the interaction between $I_{within\ 45\ PC}$ and $I_{year=1999}$ is 0.86 and it is significant at one percent level. The magnitude of the coefficient and the Kleibergen-Paap F-stat reported at the bottom rules out concerns about relevance and weakness of the instrument. Panel B reports the Two-Stage Least Squares estimate on overall, male, and female turnout in columns (1), (2) and (3), respectively. All measures of turnout show that it decreases if EVMs are used in assembly elections. The effect is highest for female voter turnout at -3.02 percent. These results are very similar to our previous results, from the specification in equation 1. However, the 2SLS-IV estimates should be interpreted as Local Average Treatment Effects (LATE) as opposed to the Average Treatment Effect on the Treated (ATT) presented in Table 3.[33]

8.3 Placebo Year of Introduction of Voting Machines

In this section we describe a falsification test to confirm the results reported in Table 3 represent the effects of electronic voting machines. We estimate our main specification in equation 1 after randomly changing the voting technology for post-1998 elections by states. We assign each post-1998 elections either to paper ballots or electronic voting without changing the fractions of elections that use voting machines within each state after 1998. The estimated effects of shuffled electronic voting are reported in Table A.6. All estimated coefficients on electronic voting are very close to zero and are statistically insignificant.

[33] See Angrist and Pischke (2008) and Athey and Imbens (2006) for details.

8.4 Policing and Elections

Electoral reform towards transparent elections is a continuing process. Apart from the introduction of voting machines, other major measures undertaken by the Election Commission included model code of conduct, annulment of election results in the event of booth capturing (1988), use of photo identity cards to identify voters (1993), and disclosure of antecedents by candidates (2003).[34] Other recent security measures include verifiable paper trail, closed-circuit cameras, and identification of politically sensitive booths. To test whether other confounding factors, such as greater policing, might have coincided with the introduction of voting machines confounding our results we estimate our main empirical specification after controlling for the number of phases of election.[35] The results are reported in Table A.8.

As expected, the coefficients on the number of phases on the natural log of total voters, reported in Panel A, is -0.042 and the point estimate is significant at one percent level. This suggests that the marginal effect of an additional phase in election decreases the number of voters by 4.2 percentage points. Note that the inclusion of the number of phases as an additional control does not reduce the effects or significance of voting machines discussed earlier. On the contrary, the effects are slightly more negative than the estimates reported in Table 3. In Panel B we report the effects of voting machines on voter turnout after controlling for the number of phases for each assembly elections. The effects of voting machines are slightly more negative compared to the baseline results in Table 3 and continue to be significant at one percent level.

9 Conclusion

Free and fair elections are cornerstones of democracy. In the 1990s, the Election Commission of India (ECI) introduced electronic voting machines (EVMs) to address electoral frauds and simplify the electoral procedure. Using electoral data of the state assembly elections in India (largest democracy in the world) from 1976 to 2007, we study the effect of EVMs on electoral fraud, democracy, and development.

[34] The ECI circulated the first model codes before 1971 general elections, and it has been revised several times.

[35] The Election Commission does not have its staff for the administration of elections. Therefore, security personnel is requisitioned from the provincial and central government for policing. To prevent local political rivalries from influencing these officials, they are deputed away from their region of work. Moreover, since $\cdots$ state elections are conducted in several phases to maximize the use security forces depending on the size of a state.

First, we looked at the impact of EVMs on electoral fraud. Electoral fraud is very difficult to detect. However, it is well documented in India that prior to the EVMs, in many constituencies, under the paper ballot system, polling booths were captured, and ballot boxes were stuffed with fake ballots which resulted in an unusually high voter turnout. Our estimates show that voter turnout and rejected votes declines significantly with the use of EVMs in Indian assembly elections. Moreover, independently collected post-poll survey data shows that the introduction of EVMs led to greater participation in electoral process by the marginalized and vulnerable voters such as women, scheduled caste, and tribe. They are also likely to report lesser instances of rigging or intimidation. We also find evidence that the decline in voter turnout with the use of EVMs was more pronounced in those states where elected legislative members had more serious criminal charges against them and where the Election Commission was more likely to issue re-poll orders. These results along with the post-poll survey data result, strongly suggests, that introduction of EVMs reduced electoral fraud. We also find strong evidence that introduction of EVMs made the electoral process more competitive - it led to a decline in the winning margin and the vote share of the winning candidate.

Electoral goals often determine the distribution of discretionary grants and public goods. Fair and competitive elections provide the electorate a means to improve the responsiveness of the elected officials by making them more accountable. Therefore, we study the impact of EVMs on the provision of electricity at the level of the constituency. We find that the constituencies using voting machines have better provision of electricity than their counterparts using paper ballots. The provision of electricity improves over time, and the effect is strongest for the year just before the subsequent election. Since the introduction of the machines may have changed both the composition of the voters and the characteristics of the elected politicians, it is challenging to identify the exact mechanisms.

Maintaining law and order is a fundamental responsibility of the state. In a rigged electoral system, politicians fail to provide security to common people because they depend on criminal elements in the electoral process. Politicians, therefore, end up supporting and protecting criminals instead of being able to prevent them. Given that introduction of EVMs in elections was motivated by electoral fraud, we find it critical to extend our analysis to the effect EVMs might have on law and order within a constituency. Our analysis suggests a very strong link between the introduction of EVMs and decline in crime. In particular, we find a significant

decline in crime related to murder and rape. Furthermore, it is noteworthy that this effect is stronger in states where a large proportion of legislators have serious criminal charges against them.

This paper makes a significant contribution to the literature on democracy and development. In particular, it shows that strengthening of democratic institutions does lead to better representation of the marginalized and vulnerable sections of the society by giving them a voice, and it also leads to development.

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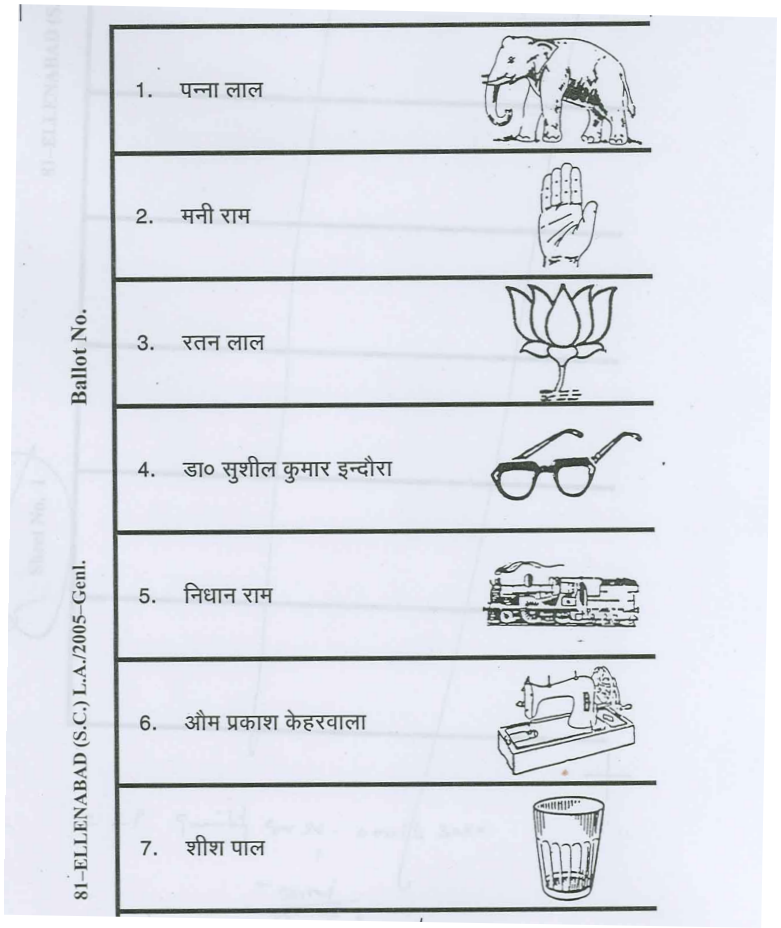
FIGURE 1: Paper Ballots and Electronic Voting Machines used in India.



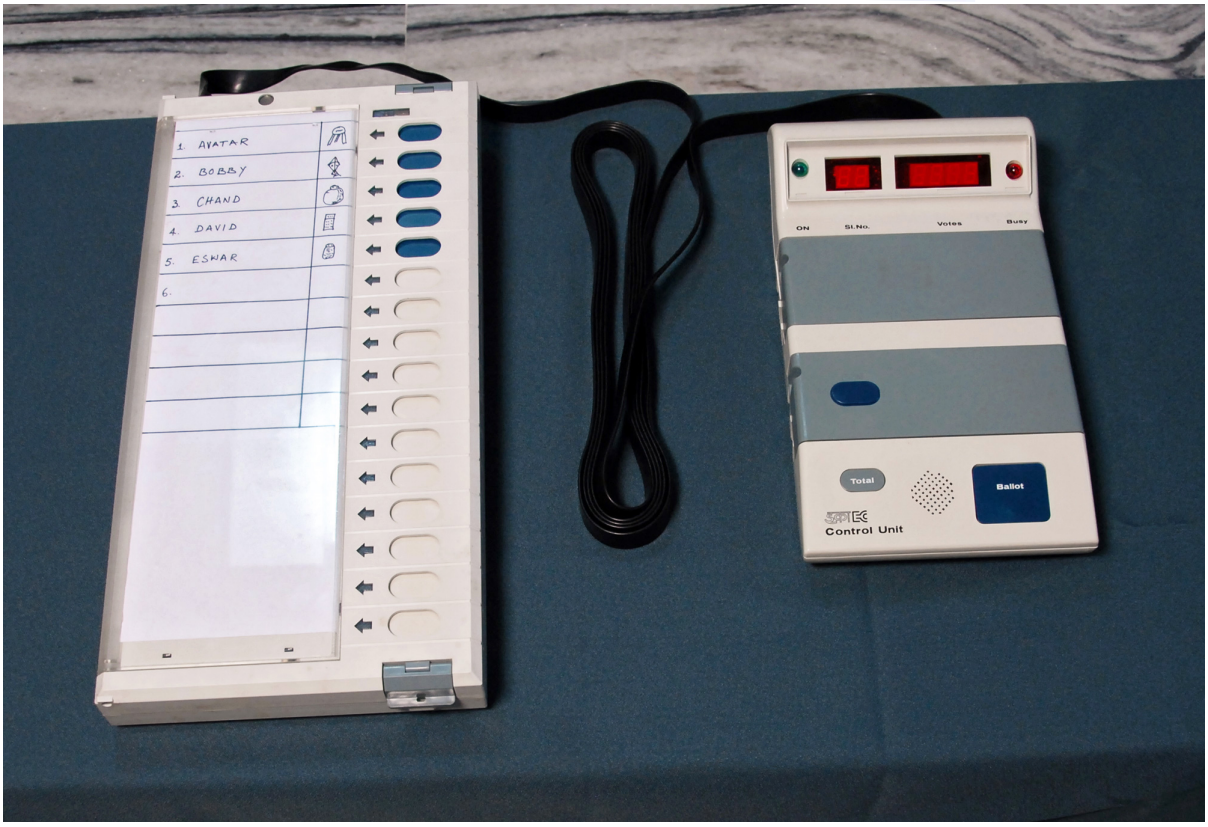
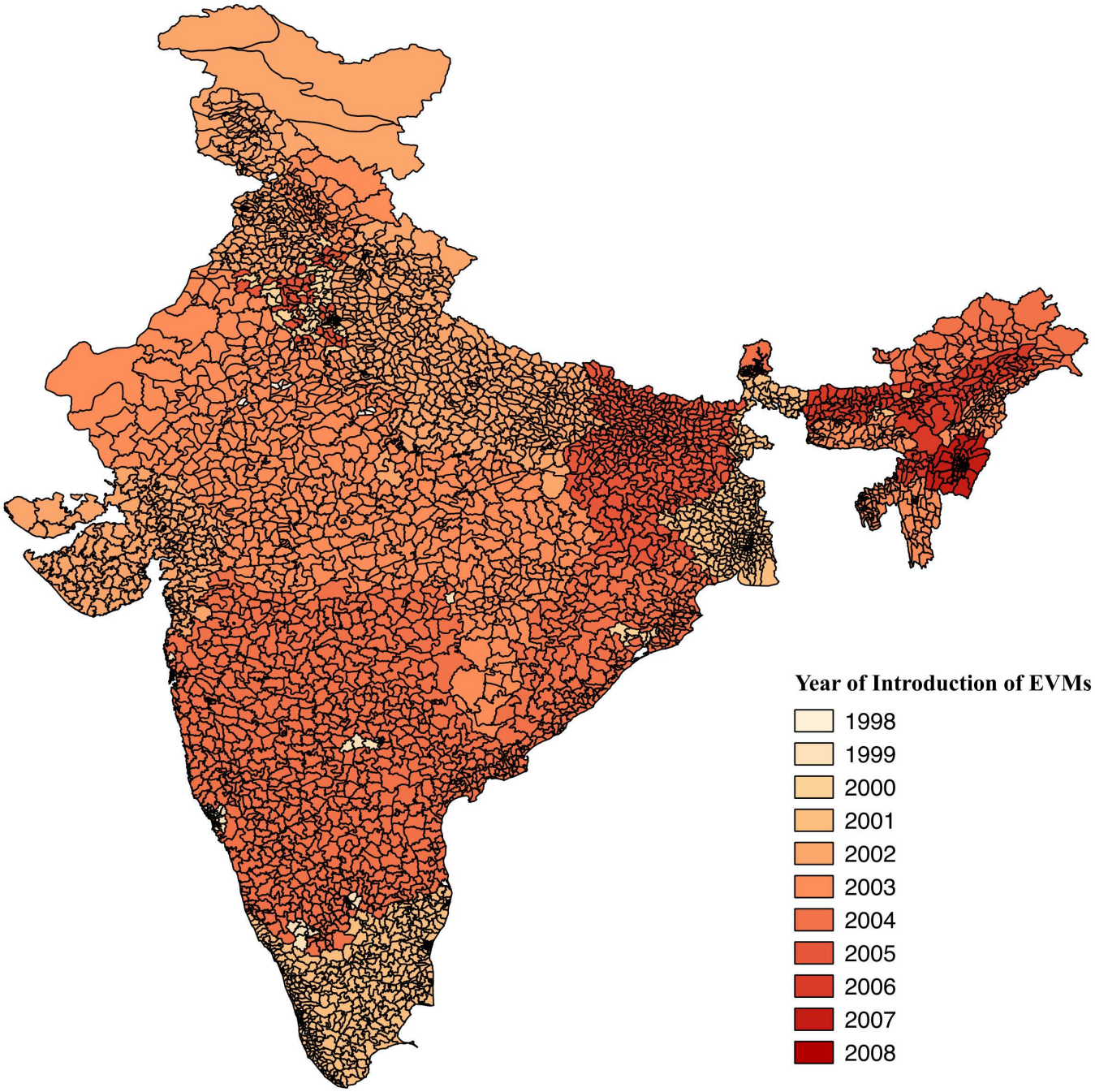


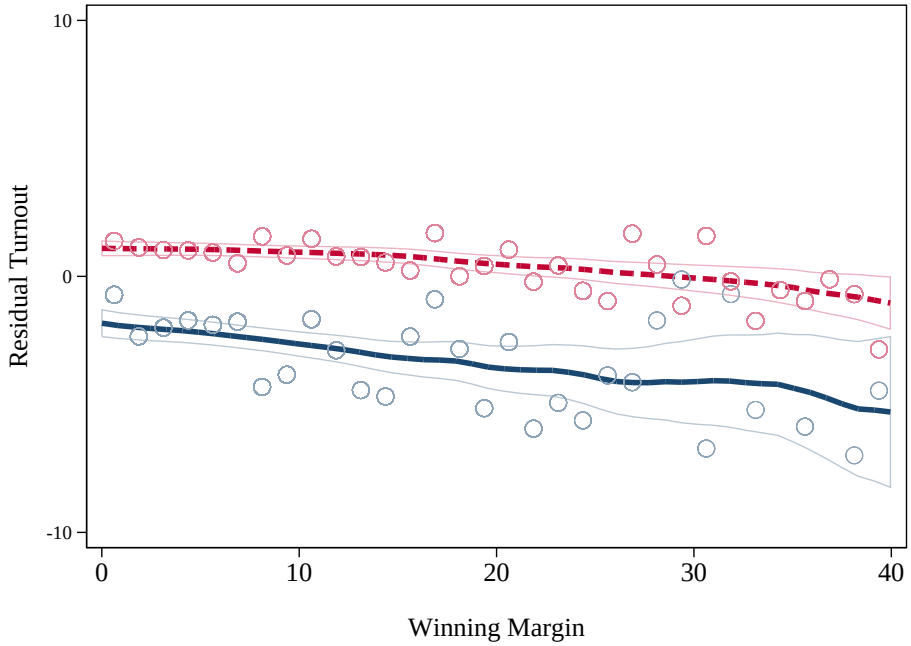
FIGURE 2: Time-line of Introduction of Electronic Voting Machines in State Assembly Constituencies in India.



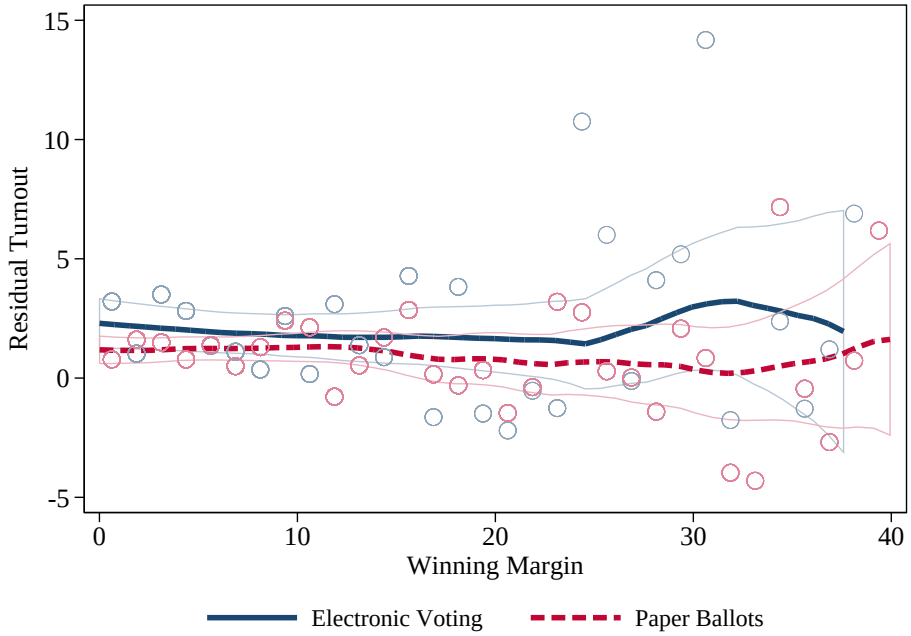
Notes: The years of the introduction of electronic voting machines are obtained from the election commission's orders.

FIGURE 3: Turnout and Winning Margin by States: Local Polynomial Fit.

PANEL A: States with More Criminal Cases against Elected Members



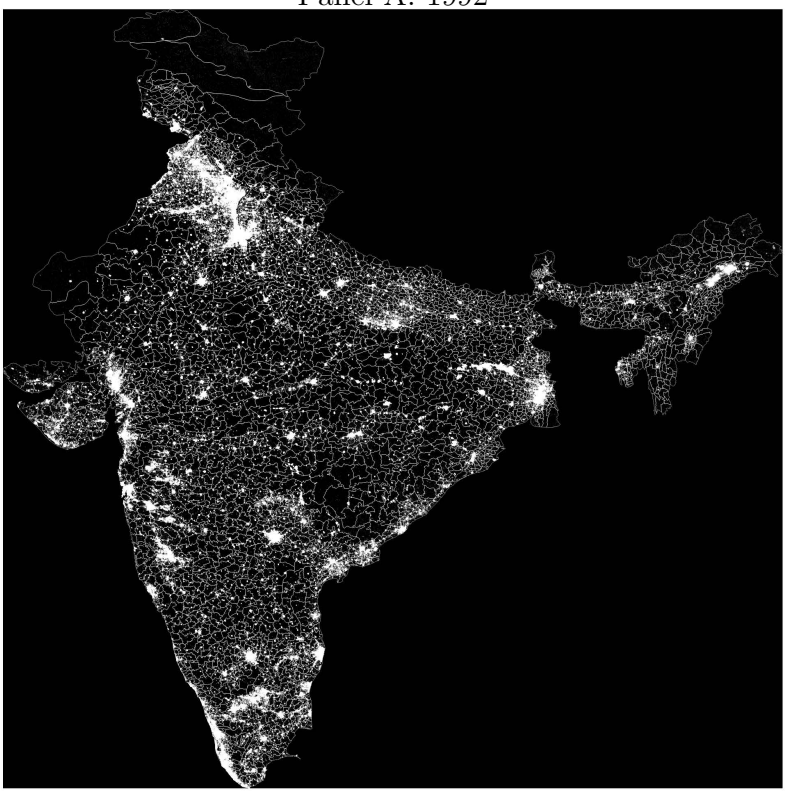
PANEL B: States with Fewer Criminal Cases against Elected Members



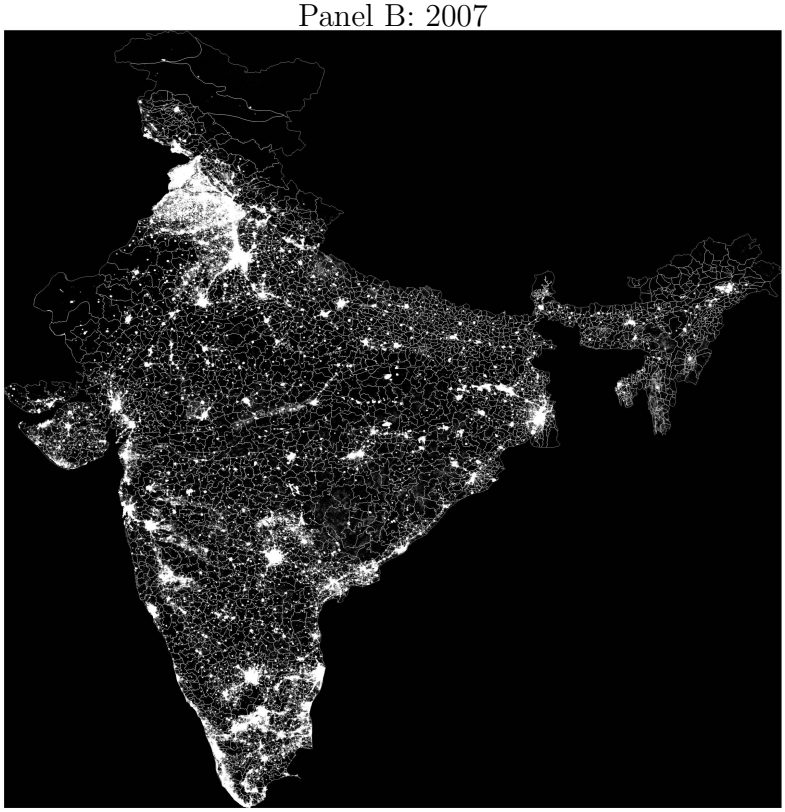
Notes: Data include results from state assembly elections between 1976–2007 published by the Election Commission. In PANEL A the data is restricted to the states of Bihar, Jharkhand, Maharashtra, and Uttar Pradesh where the highest fraction of the members of the legislative assembly had serious criminal cases against them. In PANEL B the data is restricted to the states of Nagaland, Arunachal Pradesh, Mizoram, Goa, Manipur, Meghalaya, Tripura, Sikkim, Jammu & Kashmir, and Assam where the lowest fraction of the members of the legislative assembly had serious criminal cases against them. The y-axis plots the residual turn-out after taking out assembly constituency fixed effects.

FIGURE 4: Nighttime Lights in India with Assembly Constituency Boundary.

Panel A: 1992

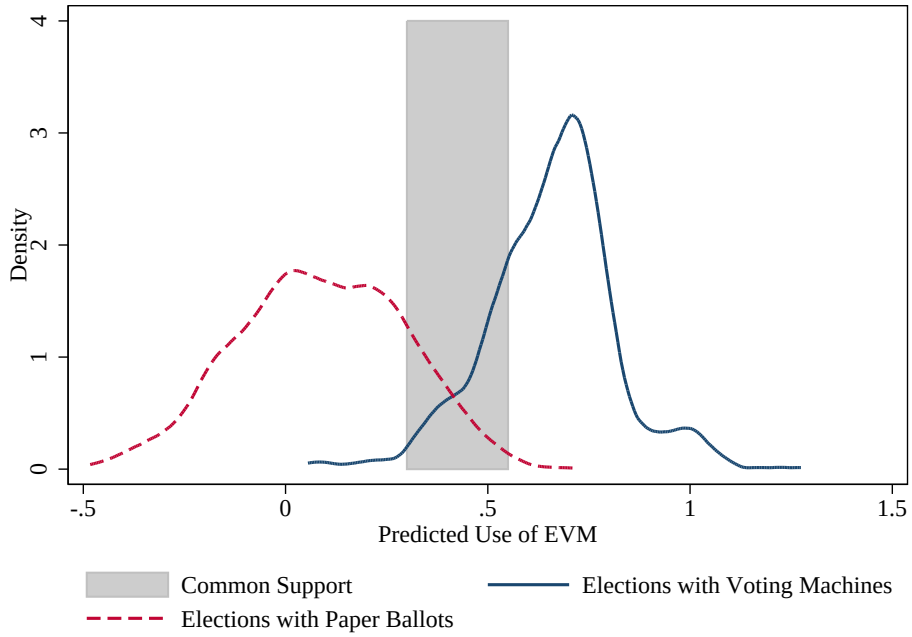


Panel B: 2007



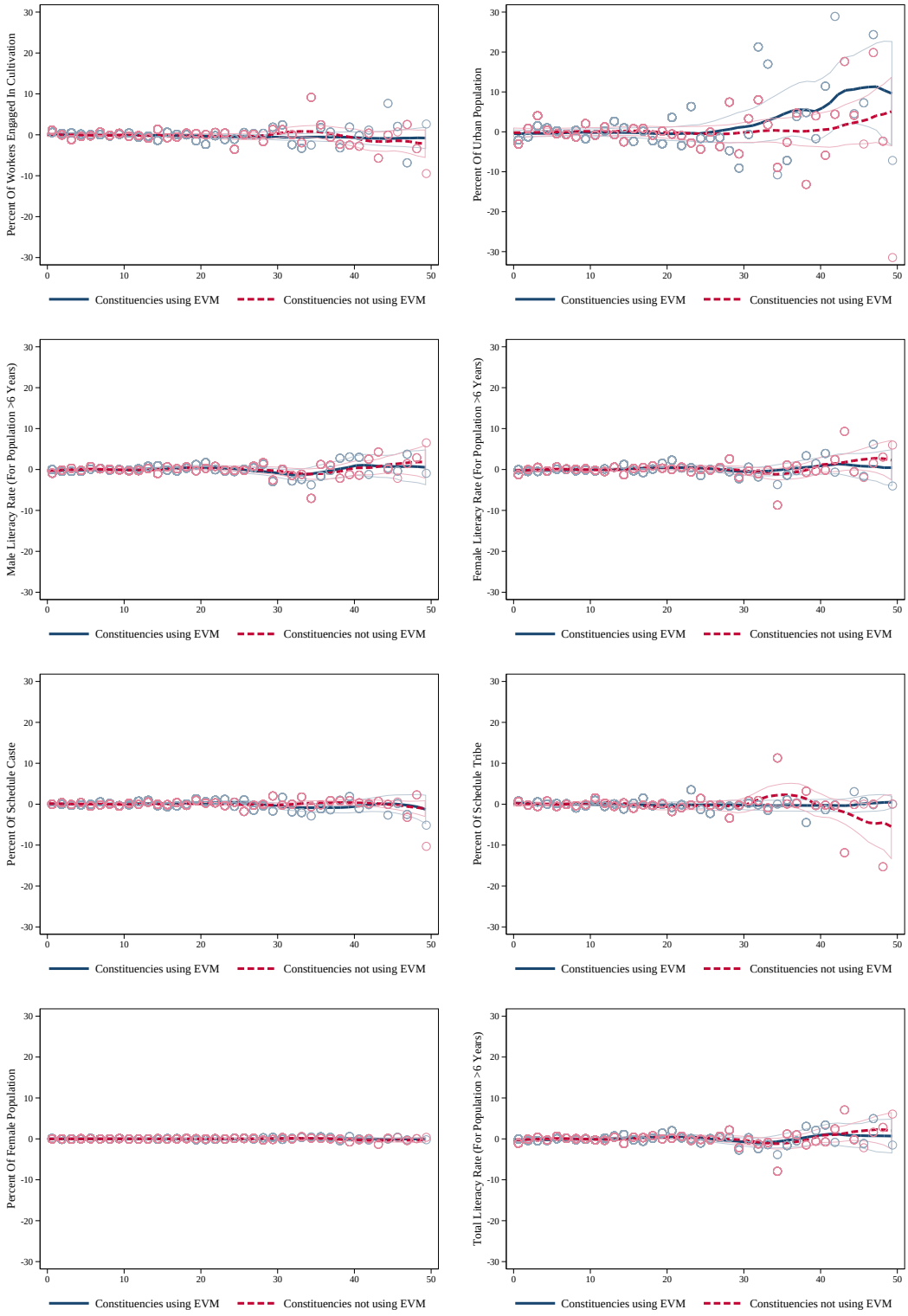
Notes: Satellite raster images are obtained from the National Aeronautics and Space Administration's (NASA) Defense Meteorological Satellite Programs Operational Linescan System (DMSP-OLS). 1992 is the first year, and 2007 is the last year of our data.

FIGURE 5: Predicted use of Electronic Voting Machines by Voting Technology and Common Support Region.



Notes: The graph plots predicted the probability of use of voting machines from a Linear Probability Model using time trend, baseline assembly characteristics including the fraction of the urban population, percentage of workers engaged in cultivation, literacy rates by gender, fraction of the population belonging to scheduled caste and tribes as controls. The shaded rectangle between the predicted probability of [0.3, 0.55] reflects the common support region.

FIGURE 6: Continuity Checks for Exogenous Variables



Notes: Data include results from state assembly elections between 1976–2007 from all states in India. Furthermore, we use the data on demography and other socio-economic indicators from Census 2001 published by Office of Registrar General, Government of India. The panel refers to the following covariates - literacy rate (total, male & female), percent workers engaged in cultivation, urban population, schedule caste, schedule tribes and female population as per census 2001. The figure shows the predicted values of a local linear smoother estimated separately for, constituencies that used EVM and postal ballots. The running variable is winning margin of the candidate.

Table 1: Summary Statistics.

	Paper Ballot Voting	Electronic Voting	Difference
Electors	125101.8	183635.6	58533.802***
	[53498.2]	[81583.63]	
Male Electors	65435.66	95923.36	30487.700***
	[30616.66]	[45033.48]	
Female Electors	59665.62	87712.25	28046.626***
	[24217.53]	[37031.67]	
Voters	77363.45	113474.3	36110.828***
	[33574.75]	[41101.45]	
Male Voters	43047.9	61270.23	18222.337***
	[18680.27]	[22895.47]	
Female Voters	34314.93	52085.86	17770.929***
	[15880.95]	[19059.71]	
Turnout	62.9	64.8	1.895
	[13.95]	[12.95]	
Male Turnout	67.09	66.99	-0.094
	[13.34]	[12.63]	
Female Turnout	58.53	62.26	3.723*
	[18.59]	[13.85]	
Winning Margin	15.4	11.29	-4.117***
	[13.42]	[10.35]	
Vote Share of the Winning Candidate	48.01	45.39	-2.618**
	[11.06]	[9.95]	
Rejected Votes	1969.5	55.18	-1914.312***
	[1593.92]	[172.52]	
Gender of the Winning Candidate (t-1)	.96	.94	-0.028***
	[.19]	[.24]	
Total Candidates (t-1)	8.66	9	0.342
	[7.42]	[14.96]	
No. of Phases	1.26	2.19	0.934**
	[.49]	[1.58]	

Notes: Data include results from state assembly elections between 1976-2007.

TABLE 2: Determinants of Introduction of Electronic Voting Machines.

	(1)	(2)	(3)	(4)
Dependent variable:	Use of Electronic Voting Machines			
EVMs used in *loksabha* in 1999	0.175***	0.165***	-0.043***	-0.043***
	(0.03)	(0.04)	(0.01)	(0.01)
Fraction of Urban pop.		0.005		0.008
		(0.01)		(0.01)
Male literacy rate		0.000		0.000*
		(0.00)		(0.00)
Female literacy rate		0.000		-0.000*
		(0.00)		(0.00)
Fraction of pop. engaged in Cultivation		-0.000*		-0.000**
		(0.00)		(0.00)
EVMs used in *loksabha* in 1999 × 1998			0.284***	0.325***
			(0.07)	(0.06)
EVMs used in *loksabha* in 1999 × 1999			0.941***	0.961***
			(0.05)	(0.04)
EVMs used in *loksabha* in 1999 × 2000			0.774***	0.765***
			(0.09)	(0.08)
EVMs used in *loksabha* in 1999 × 2001			0.126***	0.130***
			(0.03)	(0.03)
EVMs used in *loksabha* in 1999 × 2002			0.070**	0.057**
			(0.03)	(0.02)
EVMs used in *loksabha* in 1999 × 2003			0.041***	0.041***
			(0.01)	(0.01)
EVMs used in *loksabha* in 1999 × 2004			0.041***	0.039***
			(0.01)	(0.01)
R Squared	0.914	0.917	0.939	0.934
No. of Observations	8168	6525	8168	6525

Notes: Data include results from state assembly elections between 1995–2004. All columns control for the election year and state fixed effects. Assembly characteristic is constructed using the village-level Primary Census Abstract 2001. Errors are robust and clustered at the state level. ***, **, and, * indicate statistical significance at the 1, 5, and, 10 percent levels respectively.

TABLE 3: Effect of Electronic Voting Machines on Voters and Turnout by Gender.

	(1)	(2)	(3)
Panel A: Effect of EVM on log Voters			
Dependent Variable	Voters	Male Voters	Female Voters
Baseline Average	77363	43048	34315
Electronic Voting	−0.035***	−0.042***	−0.0100
	(0.01)	(0.01)	(0.01)
R Squared	0.945	0.948	0.933
No. of Observations	25848	25848	25846
Panel B: Effect of EVM on Voter Turnout			
Dependent Variable	Turnout	Male Turnout	Female Turnout
Baseline Average	62.9	67.09	58.53
Electronic Voting	−3.18***	−4.34***	−2.10***
	(0.74)	(0.87)	(0.75)
R Squared	0.869	0.789	0.767
No. of Observations	25848	25848	25848

Notes: Data include results from state assembly elections between 1976-2007. All columns control for the election year and assembly constituency fixed effects, the gender of the winning candidate $(t-1)$, the number of contestants $(t-1)$, and parliamentary constituency specific time trends. Each specification in Panel A additionally controls for the log of the total, male, and female electors, respectively. Turnout is defined as the percentage of voters over total eligible electors. Errors are robust and clustered at parliamentary constituency-election year level. ***, **, and, * indicate statistical significance at the 1, 5, and, 10 percent levels respectively.

TABLE 4.A: Effects of Electronic Voting Machines on Ability to Vote

	(1)	(2)	(3)	(4)	(5)	(6)
Baseline Average	.88	.87	.84	.86	.79	.83
Electronic Voting	0.0038	-0.043*	-0.018	-0.021*	-0.0017	-0.021
	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)
Electronic Voting × Below Intermediate		0.056**				
		(0.02)				
Electronic Voting × Female			0.049			
			(0.03)			
Electronic Voting × Lower Caste				0.042***		
				(0.01)		
Electronic Voting × Senior Citizen					0.063	
					(0.04)	
Electronic Voting × Below Intermediate - Female						0.061*
						(0.03)
R Squared	0.027	0.028	0.028	0.028	0.029	0.029
No. of Observations	36273	36273	36273	36273	36380	36273

Notes: Data include results from post-poll surveys conducted by *Lokniti*-CSDS in 17 states during the period 2000-06. All columns control for the gender and age of the respondent, the election year and assembly constituency fixed effects. *Lower caste* takes the value one if the respondent belongs to schedule caste, schedule tribes, or other backward castes. *Below Intermediate* takes the value one if the respondent has not completed primary education. *Senior citizen* takes the value one if the respondent's age is more than 60 years. Errors are robust and clustered at the level of assembly constituency. ***, **, and, * indicate statistical significance at the 1, 5, and, 10 percent levels respectively.

TABLE 4.B: Effects of Electronic Voting Machines on Vote Capture

	(1)	(2)	(3)	(4)	(5)	(6)
Baseline Average	.02	.02	.03	.03	.03	.03
Electronic Voting	-0.0066	0.0049	0.00040	0.0012	-0.0061	-0.00010
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Electronic Voting × Below Intermediate		-0.013*				
		(0.01)				
Electronic Voting × Female			-0.016***			
			(0.01)			
Electronic Voting × Lower Caste				-0.012**		
				(0.01)		
Electronic Voting × Senior Citizen					-0.0072	
					(0.01)	
Electronic Voting × Below Intermediate - Female						-0.016***
						(0.01)
R Squared	0.096	0.096	0.097	0.097	0.096	0.097
No. of Observations	36214	36214	36214	36214	36321	36214

Notes: Data include results from post-poll surveys conducted by *Lokniti*-CSDS in 17 states during the period 2000-06. All columns control for the gender and age of the respondent, the election year and assembly constituency fixed effects. *Lower caste* takes the value one if the respondent belongs to schedule caste, schedule tribes, or other backward castes. *Below Intermediate* takes the value one if the respondent has not completed primary education. *Senior citizen* takes the value one if the respondent's age is more than 60 years. Errors are robust and clustered at the level of assembly constituency. ***, **, and, * indicate statistical significance at the 1, 5, and, 10 percent levels respectively.

TABLE 5: Effect of Electronic Voting Machines on Rejected Votes.

	(1)	(2)	(3)	(4)
Dependent Variable	Rejected Votes			
Baseline Average	1969	1969	1969	1969
Electronic Voting	−2138.9***	−2130.1***	−2048.0***	−2051.4***
	(261.65)	(260.76)	(250.47)	(250.75)
Election Year FE	✓	✓	✓	✓
Total Electors		✓	✓	✓
Assembly Constituency FE			✓	✓
Number of Candidates(t-1)				✓
R Squared	0.858	0.859	0.759	0.764
No. of Observations	26572	26572	26572	25832

Notes: Data include results from state assembly elections between 1976-2007. All columns control for election year fixed effect and parliamentary constituency specific time trend. Errors are robust and clustered at parliamentary constituency-election year level. ***, **, and, * indicate statistical significance at the 1, 5, and, 10 percent levels respectively.

TABLE 6: Heterogeneity in the Effects of EVMs by Re-poll Orders.

	(1)	(2)	(3)
Panel A: Effect of EVM on log Voters			
Dependent Variable	Voters	Male Voters	Female Voters
Baseline Average	77363	43048	34315
Electronic Voting	−0.020*	−0.026**	0.0052
	(0.01)	(0.01)	(0.01)
Electronic Voting × High Re-poll States	−0.073***	−0.083***	−0.079***
	(0.02)	(0.02)	(0.02)
R Squared	0.945	0.948	0.933
No. of Observations	25848	25848	25846
Panel B: Effect of EVM on Voter Turnout			
Dependent Variable	Turnout	Male Turnout	Female Turnout
Baseline Average	62.9	67.09	58.53
Electronic Voting	−2.78***	−3.85***	−1.87**
	(0.69)	(0.81)	(0.75)
Electronic Voting × High Re-poll States	−2.13*	−2.61*	−1.20
	(1.13)	(1.37)	(0.97)
R Squared	0.869	0.789	0.767
No. of Observations	25848	25848	25848

Notes: Data include results from state assembly elections between 1976-2007. All columns control for election year and assembly constituency fixed effects, gender of the winning candidate $(t-1)$, the number of contestants $(t-1)$, and parliamentary constituency specific time trends. Each specification in Panel A additionally controls for the log of the total, male, and female electors, respectively. Turnout is defined as the percentage of voters over total eligible electors. *High Re-poll States* takes the value one for the states of Andhra Pradesh, Bihar, Jharkhand, and Orissa. Errors are robust and clustered at parliamentary constituency-election year level. ***, **, and, * indicate statistical significance at the 1, 5, and, 10 percent levels respectively.

TABLE 7: Effect of Electronic Voting Machines on Turnout in Close Elections.

↓ Dependent Variable	Avg. under Paper Ballot [Std. Dev.]	Effects of Electronic Voting (1)	(2)	(3)	(4)
PANEL A: All India					
Turnout	62.9	−4.89***	−4.9***	−6.66***	−6.04***
	[13.95]	(1.73)	(1.86)	(1.28)	(1.38)
Male Turnout	67.09	−5.67***	−5.3***	−7.57***	−6.88***
	[13.34]	(1.8)	(1.92)	(1.33)	(1.43)
Female Turnout	58.53	−3.92**	−4.28**	−5.51***	−4.94***
	[18.59]	(1.8)	(1.96)	(1.35)	(1.47)
Observation		4055	4055	7812	7812
PANEL B: States with Serious Criminal Charges against Elected Members					
Turnout	56.35	−11.78*	−10.64	−16.77***	−16***
	[11.75]	(6.98)	(7.24)	(4.15)	(4.28)
Male Turnout	62.08	−13.74*	−12.65*	−18.64***	−17.63***
	[13.98]	(7.39)	(7.65)	(4.45)	(4.56)
Female Turnout	50.04	−10.02	−8.73	−15.1***	−14.41***
	[13.97]	(6.74)	(7.05)	(3.96)	(4.15)
Observation		1337	1337	2589	2589
PANEL C: States with Fewer Criminal Charges against Elected Members					
Turnout	65.74	−2.76*	−3.19*	−4.22***	−3.71***
	[13.87]	(1.65)	(1.74)	(1.19)	(1.31)
Male Turnout	69.26	−2.89*	−2.75	−4.34***	−3.75***
	[12.45]	(1.65)	(1.73)	(1.13)	(1.26)
Female Turnout	62.21	−2.46	−3.48*	−3.96***	−3.57**
	[19.13]	(1.81)	(1.94)	(1.39)	(1.52)
Observation		2718	2718	5223	5223
Winning margin <		3	3	6	6
Specification		Linear	Quadratic	Linear	Quadratic

Notes: Data include results from state assembly elections between 1976-2007. All specifications control for the election year and state fixed effects, state-specific time trends, the gender of the winning candidate $(t-1)$, and the number of contestants $(t-1)$. In Column (1) and (3) the model is linear in winning margin. Whereas in columns (2) and (4), the model is quadratic. In Panel B, the sample is restricted to the states of Bihar, Jharkhand, Maharashtra and Uttar Pradesh. In Panel C, the sample is restricted to rest of the states of India. Errors are robust and clustered at the parliamentary constituency-election year level. ***, **, and, * indicate statistical significance at the 1, 5, and, 10 percent levels respectively.

TABLE 8: Effect of Electronic Voting Machines on Luminosity

	(1)	(2)	(3)	(4)	(5)
Lead length Baseline Average	1 period	2 periods	3 periods	4 periods	Average
Electronic Voting	-0.088 (0.07)	0.092 (0.06)	0.12** (0.06)	0.23*** (0.06)	0.089 (0.06)
R Squared	0.970	0.967	0.969	0.969	0.975
No. of Observations	11645	11556	10965	9955	11646

Notes: Data include results from state assembly elections between 1992-2007. The baseline averages report average luminosity (in levels) for the elections with paper ballots. All specification control for the election year and constituency fixed effects, the gender of the winning candidate $(t-1)$, the number of contestants $(t-1)$, and state-specific linear trends. Errors are robust and clustered at parliamentary constituency-election year level. ***, **, and, * indicate statistical significance at the 1, 5, and, 10 percent levels respectively.

TABLE 9: Dynamic Effects of Electronic Voting Machines on Crime

Lead length	1 period (1)	2 periods (2)	3 periods (3)	4 periods (4)	Average (5)
Panel A: Total IPC crime (Log)					
Baseline Average	3244	3320	3270	3286	3275
EVM	0.13**	0.097**	0.036	-0.034	0.059
	(0.05)	(0.04)	(0.05)	(0.06)	(0.04)
EVM × Criminal Legislatures	-0.31***	-0.17***	-0.19***	-0.13***	-0.20***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
R Squared	0.967	0.976	0.969	0.973	0.981
No. of Observations	2141	2140	2127	2125	2141
Panel B: Murder (Log)					
Baseline Average	77	78	78	76	77
EVM	0.017	0.013	-0.19**	-0.18**	-0.083*
	(0.08)	(0.08)	(0.08)	(0.08)	(0.05)
EVM × Criminal Legislatures	-0.40***	-0.30***	-0.29***	-0.21***	-0.30***
	(0.06)	(0.05)	(0.05)	(0.05)	(0.04)
R Squared	0.936	0.936	0.937	0.941	0.968
No. of Observations	2133	2129	2117	2118	2140
Panel D: Rape (Log)					
Baseline Average	27	28	28	29	28
EVM	0.056	-0.085	0.053	0.00061	-0.020
	(0.09)	(0.11)	(0.09)	(0.11)	(0.09)
EVM × Criminal Legislatures	-0.27***	-0.19**	-0.48***	-0.29***	-0.32***
	(0.08)	(0.08)	(0.08)	(0.07)	(0.06)
R Squared	0.882	0.876	0.870	0.888	0.940
No. of Observations	2086	2091	2072	2079	2131

Notes: Data include results from state assembly elections between 1991-2007 from all states in India published by the Election Commission of India. District level crime data is obtained from the National Crime Records Bureau. The baseline averages show average crime reported (in levels) for the elections with paper ballots. All specification control for the election year and district FEs; the gender of the winning candidate $(t-1)$ and the number of contestants $(t-1)$. *Criminal Legislatures* takes the value one for the state of Maharashtra, Uttar Pradesh, Bihar and Jharkhand. Errors are robust and clustered at the state level. ***, **, and, * indicate statistical significance at the 1, 5, and, 10 percent levels respectively.

Table 10: Effects of EVMs on Incumbent Party's Vote Share and Reelection.

	(1)	(2)
Dependent variable	Vote share	Reelection
Baseline Average	34.97	.35
Panel A		
Electronic Voting	-3.62**	0.082*
	(1.53)	(0.04)
R Squared	0.554	0.405
No. of Observations	21357	25848
Panel B		
Electronic Voting	-2.58	0.10**
	(1.67)	(0.04)
Electronic Voting × Highest Re-poll States	-5.54***	-0.11**
	(1.92)	(0.05)
R Squared	0.554	0.405
No. of Observations	21357	25848

Notes: Data include results from state assembly elections between 1976-2007. All columns control for election year and assembly constituency fixed effects, the gender of the winning candidate $(t-1)$, the number of contestants $(t-1)$, and parliamentary constituency specific time trends. Each specification in Panel A additionally controls for the log of the total, male, and female electors, respectively. Turnout is defined as the percentage of voters over total eligible electors. *Highest Re-poll States* takes the value one for the states of Andhra Pradesh, Bihar, Jharkhand, and Orissa. Errors are robust and clustered at parliamentary constituency-election year level. ***, **, and, * indicate statistical significance at the 1, 5, and, 10 percent level respectively.

Appendix

TABLE A.1: Fraction of Constituencies using Electronic Voting Machines over Time.

State	Year 1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
Andhra Pradesh					0					0.05					1				0.35
Arunachal Pradesh	0					0				0					1				0.25
Assam		0					0					0.03					1		0.26
Bihar	0					0					0					1			0.33
Chhattisgarh														1					1
Delhi				0					0.09					1					0.36
Goa					0					1			1					1	0.75
Gujarat	0					0			0				1					1	0.40
Haryana		0					0				0.50					1			0.38
Himachal Pradesh	0			0					0					1				1	0.40
Jammu & Kashmir							0						1						0.50
Jharkhand																1			1
Karnataka					0					0.11					1				0.37
Kerala		0					0					1					1		0.50
Madhya Pradesh	0			0					0.02					1					0.20
Maharashtra	0					0				0.13					1				0.28
Manipur	0					0					0		0.10					1	0.22
Meghalaya				0					0					1					0.33
Mizoram				0					0					1					0.33
Nagaland				0					0					1					0.33
Orissa	0					0					0.05				1				0.26
Pondicherry	0	0					0					1					1		0.40
Punjab			0					0					1					1	0.50
Rajasthan	0			0					0.03					1					0.26
Sikkim					0					0					1				0.33
Tamil Nadu		0					0					1					1		0.50
Tripura				0					0					1					0.33
Uttar Pradesh		0		0			0						1					1	0.39
Uttarakhand													1					1	1
West Bengal		0					0					1					1		0.50
Total	0	0	0	0	0	0	0	0	0.02	0.12	0.08	0.85	0.94	1	1	1	1	1	0.37

Sources: The dates of introduction of the electronic voting machines are compiled from the Election Commission orders and several newspaper archives. The states of Chhattisgarh, Jharkhand, and Uttarakhand came into existence in the year 2000.

TABLE A.2: State-wise Percentage of Members of Legislative Assembly with Criminal Cases.

States	Constituencies	MLAs	Criminal Cases		Serious Criminal Cases		Election
		Analysed	No.	Frac.	No.	Frac.	Year
Nagaland	60	56	0	0.00	0	0.00	2008
Arunachal Pradesh	60	60	2	3.33	0	0.00	2004
Mizoram	40	38	4	10.53	0	0.00	2008
Goa	40	40	9	22.50	0	0.00	2007
Manipur	60	60	1	1.67	1	1.67	2007
Meghalaya	60	60	1	1.67	1	1.67	2008
Tripura	60	57	3	5.26	1	1.75	2008
Sikkim	32	32	1	3.13	1	3.13	2009
Jammu & Kashmir	87	60	6	10.00	2	3.33	2008
Assam	189	126	7	5.56	5	3.97	2006
Rajasthan	200	197	31	15.74	8	4.06	2008
Punjab	117	117	20	17.09	5	4.27	2007
Karnataka	225	218	44	20.18	18	8.26	2008
Delhi	70	68	29	42.65	6	8.82	2008
Chattisgarh	90	85	11	12.94	8	9.41	2008
Andhra Pradesh	293	284	74	26.06	27	9.51	2009
Uttarakhand	70	70	17	24.29	7	10.00	2007
West Bengal	307	283	45	15.90	30	10.60	2006
Tamil Nadu	237	234	77	32.91	25	10.68	2006
Himachal Pradesh	68	68	26	38.24	8	11.76	2007
Gujarat	182	182	47	25.82	22	12.09	2007
Kerala	140	139	68	48.92	17	12.23	2006
Madhya Pradesh	230	219	58	26.48	27	12.33	2008
Haryana	90	90	28	31.11	13	14.44	2005
Orissa	147	145	58	40.00	24	16.55	2004
Pondicherry	30	30	6	20.00	5	16.67	2006
Uttar Pradesh	402	402	142	35.32	75	18.66	2007
Maharashtra	288	288	132	45.83	54	18.75	2004
Jharkhand	81	72	31	43.06	18	25.00	2005
Bihar	260	233	117	50.21	68	29.18	2005

Source: Association for Democratic Reforms and National Election Watch.

TABLE A.3: Re-poll Orders per Parliamentary Constituency by State in 2004 Parliamentary Election.

State	No. of Assembly Constituencies	Re-poll Orders	% Re-poll Orders
Uttaranchal	6807	0	0
Chandigarh	409	0	0
Kerala	20333	0	0
Dadra & Nagar Haveli	128	0	0
Himachal Pradesh	6232	0	0
Assam	17646	0	0
Lakshadweep	40	0	0
Pondicherry	557	0	0
Andaman & Nicobar Island	329	0	0
Sikkim	349	0	0
National Capital Territor	9039	0	0
Goa	1003	0	0
Manipur	2003	0	0
Arunachal Pradesh	1756	0	0
Meghalaya	1582	0	0
Maharashtra	62476	0	0
Daman & Diu	84	0	0
Mizoram	798	0	0
Tripura	2372	0	0
Nagaland	1586	0	0
Gujarat	36830	2	0.00543
Jammu & Kashmir	7215	2	0.0277
Punjab	15649	6	0.0383
Tamil Nadu	45731	27	0.0590
Uttar Pradesh	102434	83	0.0810
West Bengal	48775	40	0.0820
Haryana	12574	11	0.0875
Madhya Pradesh	42285	38	0.0899
Rajasthan	35822	38	0.106
Karnataka	39795	49	0.123
Chhattisgarh	15670	22	0.140
Orissa	26250	41	0.156
Andhra Pradesh	56168	119	0.212
Jharkhand	17062	108	0.633
Bihar	49684	2589	5.211

Source: Election Commission of India.

TABLE A.4: Summary Statistics for Restricted Sample.

	Paper Ballot Voting	Electronic Voting	Difference
Electors	152224.3	171400.6	19176.242
	[66333.13]	[65405.97]	
Male Electors	79455.12	87896.32	8441.199
	[36593.1]	[35054.16]	
Female Electors	72768.08	83504.25	10736.171
	[30254.67]	[31083.73]	
Gender of the Winning Candidate (t-1)	.95	.94	-0.014
	[.21]	[.24]	
Total Candidates (t-1)	13.27	13.65	0.378
	[10.99]	[36.51]	
No. of Phases	1.59	1.17	-0.421**
	[.7]	[.48]	

Notes: Data include results from state assembly elections between 1976-2007 from 30 states in India.

TABLE A.5: Effect of Electronic Voting Machines on Voter Turnout on the Common Support.

	(1)	(2)	(3)
Dependent Variable	Turnout	Male Turnout	Female Turnout
Baseline Average	69	72	66
Electronic Voting	−3.92*	−3.44*	−4.46**
	(1.99)	(2.07)	(1.95)
R Squared	0.502	0.452	0.487
No. of Observations	568	568	568

Notes: Data include results from state assembly elections between 1976-2007. All columns control for the election year and assembly constituency fixed effects; the gender of the winning candidate $(t-1)$, the number of contestants $(t-1)$ and parliamentary constituency specific time trends. Each specification in Panel A also controls for log of total, male and female electors respectively. Errors are robust and clustered at the assembly constituency level. ***, **, and, * indicate statistical significance at the 1, 5, and, 10 percent levels respectively.

TABLE A.6: Effect of Electronic Voting Machines on Voter Turnout.

	(1)	(2)	(3)
Dependent Variable	Turnout	Male Turnout	Female Turnout
Baseline Average	63	67	59
Electronic Voting (Shuffled)	−0.012	−0.17	0.13
	(0.21)	(0.22)	(0.23)
R Squared	0.869	0.788	0.767
No. of Observations	25848	25848	25848

Notes: Data include results from state assembly elections between 1976-2007. All columns control for election year and assembly constituency fixed effects; the gender of the winning candidate $(t-1)$, the number of contestants $(t-1)$ and parliamentary constituency specific time trends. Each specification in Panel A also controls for the log of total, male and female electors respectively. Errors are robust and clustered at the assembly constituency level. ***, **, and, * indicate statistical significance at the 1, 5, and, 10 percent levels respectively.

TABLE A.7: IV Estimates of Effect of Electronic Voting Machines on Voter Turnout.

	(1)	(2)	(3)
Dependent Variable	Turnout	Male Turnout	Female Turnout
Baseline Average	68.18	71.62	64.48
PANEL A: First Stage			
Within 45 PC × Year = 1999	0.86***	0.86***	0.86***
	(0.07)	(0.07)	(0.07)
No. of Observations	7513	7513	7513
Kleibergen-Paap F-stat	132.851	132.851	132.851
PANEL B: Second Stage			
Electronic Voting	-2.57*	-2.53	-3.02**
	(1.37)	(1.68)	(1.36)
R Squared	0.008	0.010	0.006
No. of Observations	7513	7513	7513

Notes: Data include results from state assembly elections between 1976-2007. All columns control for the election year and assembly constituency fixed effects; the gender of the winning candidate $(t-1)$, the number of contestants $(t-1)$ and parliamentary constituency specific time trends. Each specification in Panel A also controls for the log of total, male and female electors respectively. Errors are robust and clustered at the assembly constituency level. ***, **, and, * indicate statistical significance at the 1, 5, and, 10 percent level respectively.

TABLE A.8: Effect of Electronic Voting Machines on Voters and Turnout by Gender.

	(1)	(2)	(3)
Panel A: Effect of EVM on log Voters			
Dependent Variable	Voters	Male Voters	Female Voters
Baseline Average	77363	43048	34315
Electronic Voting	−0.042***	−0.050***	−0.018
	(0.01)	(0.01)	(0.01)
No. of Phases	−0.042***	−0.043***	−0.043***
	(0.00)	(0.00)	(0.00)
R Squared	0.946	0.949	0.934
No. of Observations	25848	25848	25846
Panel B: Effect of EVM on Voter Turnout			
Dependent Variable	Turnout	Male Turnout	Female Turnout
Baseline Average	62.9	67.09	58.53
Electronic Voting	−3.62***	−4.83***	−2.48***
	(0.76)	(0.87)	(0.78)
No. of Phases	−2.08***	−2.32***	−1.78***
	(0.17)	(0.18)	(0.20)
R Squared	0.874	0.795	0.769
No. of Observations	25848	25848	25848

Notes: Data include results from state assembly elections between 1976-2007. All columns control for election year and assembly constituency fixed effects, the gender of the winning candidate $(t-1)$, the number of contestants $(t-1)$, and parliamentary constituency specific time trends. Each specification in Panel A additionally controls for the log of the total, male, and female electors, respectively. Turnout is defined as the percentage of voters over total eligible electors. Errors are robust and clustered at parliamentary constituency-election year level. ***, **, and, * indicate statistical significance at the 1, 5, and, 10 percent level respectively.