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Can Electronic Voting Shape Election Outcomes in Developing Countries? Evidence from Peru*

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Abstract

This paper estimates the impact of the introduction of electronic voting technology on Municipal elections in Peru. Using a territorial regression discontinuity design, we estimate the impact on valid votes, and voter turnout. We find that, on average, electronic voting technology decreases blank votes by 1.8 percentage points and invalid votes by 4.4 percentage points. However, it did not have a significant effect on turnout rate. Difference-in-differences estimations and subsequent robustness checks confirm the validity of our results.

JEL Classification: D72, H50, P00.
Keywords: Electronic voting, political responsiveness, residual votes.

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1 Introduction

In 2011, the Peruvian Office of Electoral Processes and the Peruvian Elections Court (ONPE and JNE, for their names in Spanish) began to implement electronic voting (EV) booths, which would allow for simpler voting, ensure faster counting, and eliminate invalidated votes due to errors on the voting ballot. That year served as a pilot, as the new system was implemented only in one district.[1] Implementation progressed until the 2018 municipal elections, when the system was used by 1,729,028 voters in 39 districts. After that, the EV was removed from subsequent electoral processes.

In the 2018 municipal elections, out of 18,800,629 votes casted 1,066,848 were not counted (considered null or invalid); meaning that for about 7.83% of the population, participating in the municipal elections was an ineffective exercise, as their preferences were not recognized by election officials. The problem becomes more serious when considering that districts with lower educational levels are those with a lower percentage of valid votes out of the total votes cast.

This study explores how the introduction of EV technology impacted the Peruvian elections. Specifically, our goal is to identify the effect on the percentage of valid votes (measured as the reduction of blank and invalid votes) and voter turnout.

In their studies of the Brazilian voting system, Fujiwara (2015) and Schneider et al. (2020), find that EV promoted large electoral participation of mainly less educated citizens and low-income voters, which would favor political parties with support in poorer areas and could influence the government's budget priorities.

Using data from the ONPE at the polling center level and the Peruvian Ministry of Economy and Finance (MEF), we apply a territorial regression discontinuity design for the 2018 municipal elections with three buffers (1 km, 2 km, and 4 km) at the polling center level, considering as our treated group those who implemented electronic voting in the province of Lima (the capital) and Callao.

We find that the EV system reduced the percentage of blank and invalid votes by 1.8 and 4.4 percentage points, respectively, and did not make a significant impact on the turnout rate. Difference-in-Differences estimations and subsequent robustness checks confirm the validity and relevance of our results.

The paper proceeds as follows: The second section reviews our place in the existing literature. The third section discusses the process under which EV was established in Peru. The fourth section describes the databases used. The fifth section explains our empirical strategy. Our findings are

[1] The EV was implemented in the second ballot of the 2011 presidential elections in the district of Pacarán, located in the province of Cañete.

presented in the sixth section. The seventh section details a series of robustness checks. The eighth section addresses the limitations of our study. Finally, conclusions are presented in the ninth section.

2 Literature Review

The literature covers mostly the effect of EV systems in developed countries, lead by a focus on the United States. (see LeRoux et al. (2020), Yu (2019) and Goodman and Stokes (2020)). Comparatively few studies explored the EV adoption in developing countries, and fewer still for Latin Americans.[2] Regarding the later, research for Brazil showed that the introduction of EV significantly increases the number of valid votes through the reduction of null ones.[3] Specifically, Nicolau (2015), and Zucco Jr. and Nicolau (2016) found that EV technology produced a large decrease in the share of blank or null votes (relative to turnout). Fujiwara (2015) showed that the introduction of the EV system in Brazil significantly increased voter turnout among less educated, and reduced the voting errors that had previously harmed these groups, which altered the composition of the electoral results at the regional level. The increase in political participation prompted a redistribution of health resources towards municipalities with higher concentrations of less educated voters, leading to a rise in public health care expenditure. There was improved health care utilization, particularly in prenatal visits, and better health outcomes, such as higher birthweights among newborns of less educated mothers.

For developed countries, the literature finds contrasting results of the effect of EV. For instance, Allers and Kooreman (2009) find positive results for Netherlands. In particular, a positive but temporary effect of the implementation of the EV on the voter turnout, while also presenting a negative effect on the proportion of null votes.

For the United States, Tomz and Van Houweling (2003), evaluate the effect of this type of technology on social matters. They find that the introduction of electronic machines in election processes can virtually eliminate the black-white disparity in invalid ballots (null votes), improving the na-

[2] Darmawan (2021) reviews the studies that focus on electronic voting from 2005 to 2020. He finds a predominance of research in the United States. The research also finds very few analysis for Latin American countries.

[3] To be clear, Alles et al. (2023) state that although the system has not been implemented nation-wide in many Latin-American countries nor does it continue to this day for all, "*Electronic voting has been piloted or adopted in a limited number of local elections*". They mention the cases of Argentina, Ecuador, Guatemala, Paraguay, Peru, and Mexico. See also, Alvarez et al. (2009).

tion's ability to extend its representativeness. Other research finds complementary and somewhat contrasting results; such as the analysis of Card and Moretti (2007) for the U.S.A. Using information of the 2000 and 2004 presidential elections at the county level, they find that the technology had very little effect on the election outcomes, as the electronic voting is related with lower turnout rates. Similarly, Everett et al. (2008) find no difference between electoral outcomes for the U.S.A. using a computer-based voting systems and outcomes using traditional voting methods.

Regarding other developed economies, Van Den Besselaar et al. (2003) examine the effect of EV systems in France, England, Italy, and Finland. Their results do not support a significant increase of turnout due to the implementation of an EV system.[4] In contrast, a recent study by Petitpas et al. (2021) on electronic voting in Geneva, Switzerland, found that e-voting significantly increases voter turnout, with more pronounced impacts on abstainers and occasional voters compared to regular voters. The increase in participation was greater among adults than among young people, and within the group of abstainers, it was higher among men than among women. The authors suggest that the effects of electronic voting in less developed regions would be much greater than those found in Geneva.

This study complements the existing literature by analyzing, for the first time, the impact of EV technology on electoral outcomes in a general election in Peru, a small open Latin-American country. Additionally, the effect of EV technology on electoral outcomes are evaluated through a territorial comparison and regression discontinuity design. The analysis aims to assess if the implementation of EV improved the representativeness of Peruvian electoral results.

[4] They also argue that these types of technologies might have a negative effect when they aren't properly implemented (or well designed).

3 Peru's Background

The history of electronic voting in Peru dates to 1996. During a period known as the "Pilot Stage" (1996-1997), the National Office of Electoral Processes (ONPE by its acronym in Spanish) embarked on exploring this voting system and tested various technological solutions. This initial period focused on evaluating the technical feasibility and public acceptance of the system. Between 1998 and 2002, ONPE expanded its focus towards conducting national elections and the widespread dissemination of electronic voting system. Key events during this phase include the First International Convention on Electoral Processes in 1999 and a demonstration at a major Shopping Center in 2002, during the Regional and Municipal Elections (ERM). These dissemination activities were essential to raise awareness among the public and political actors about the advantages and challenges of electronic voting.

During the years 2003-2004, Peru experienced a pivotal phase marked by significant efforts toward to adopt and stabilize the electronic voting system. ONPE developed its own system, designed to operate on a network of workstations, incorporating innovations such as voter identification stations managed by polling station members and voting options via mouse and touch screens. The system demonstrated robust performance.[5]

During the period 2005-2012, electronic voting showed significant development both in technological aspects and practical implementation. In 2005, ONPE began a systematic process of automating suffrage, which included creating an electronic electoral roll and automated vote counting. This process aimed to improve the efficiency, accuracy, and transparency of the electoral process. During these years, tests and continuous adjustments were made to ensure the system's technical viability.[6]

The year 2010 marked a milestone with the approval of Chief Resolution N° 211-2010-J/ONPE, which established the regulations for electronic voting. These regulations detailed the norms for VEP, ensuring the integrity and secrecy of the vote. The implementation of these systems in in-

[5] During this phase, 49 electronic voting activities were conducted, including fourteen binding elections and thirty-two non-binding elections, in addition to three evaluation meetings. Within these activities, nine experiences were carried out with political parties such as Partido Popular Cristiano, Acción Popular, Partido Democrático Somos Perú, and Partido Aprista Peruano.

[6] In 2006, ONPE focused on developing specific technological solutions for in-person electronic voting (VEP) and non-in-person electronic voting (VENP). The VEP focused on automation within voting locations, using electronic ballot boxes and voter identification systems. Meanwhile, the VENP allowed voters to cast their votes from any location with internet access, facilitating the participation of Peruvians abroad and in remote areas.

ternal elections of civil organizations and in electoral simulations allowed ONPE to refine its electronic voting technology and procedures.

In 2011, a pivotal trial took place in Pacarán during the second round of the presidential elections. Ten electronic voting tables were deployed, and 1,175 voters participated. This election showed the effectiveness, reliability, and transparency of electronic voting in a real context. The process succeeded thanks to its fast vote counting, accurate vote capture, and absence of technical errors. Throughout the period, ONPE maintained a focus on training and dissemination, organizing workshops and informational campaigns to familiarize citizens and political actors with the new systems. [7]

From 2013 onwards, Peru saw significant advancements and broader implementation of electronic voting systems. This period marked the transition from pilot projects to more extensive applications in actual electoral processes. In 2013, the new municipal elections marked the initial implementation of VEP in one district. The following year, 2014, saw VEP used in the Regional and Municipal Elections, also in one district. In 2015, VEP was implemented again in a single district during the Municipal Elections. The year 2016 marked a significant expansion, with VEP being deployed in 19 districts for the General Elections. In 2017, VEP was utilized in 15 districts during the Municipal Elections, showcasing its increasing adoption.

The expansion continued in 2018 with VEP being used in 39 districts for the Regional and Municipal Elections, as well as the Referendum. In 2020, VEP was once again deployed in 39 districts during the extraordinary congressional elections. Despite these advancements, VEP was used for the last time in the 2020 congressional elections. According to Ricardo Saavedra, the primary reason for discontinuing the use of VEP in subsequent electoral processes was the lack of necessary audits for the system. This aligns with the statements made by ONPE's chief, Piero Corvetto. [8]

Throughout this period, ONPE has continually improved the technological framework of electronic voting systems. Significant advancements include the development of robust, user-friendly interfaces designed to simplify the voting process, enhanced security measures to protect voter data, and comprehensive backend systems for efficient vote tallying and result reporting. From 2023, ONPE began developing a new digital vote proposal aimed at non-presential voting. Ac-

[7] The establishment of the "Observatory of E-Voting in Latin America" in 2011 marked another significant milestone, offering a platform for sharing experiences and expertise on electronic voting across the region.

[8] On the other hand, VENP has never been implemented in binding national elections.It has only been used to provide technical assistance to political organizations and public and private institutions.

cording to Gite personnel interviewed, the main difference in this new system is the use of the electronic DNI (DNIe) and its respective key as credentials to improve security and ensure voter identity. Additionally, this new version can accommodate a larger number of voters. Another significant change is the architecture type: while the current VENP operates on a local architecture, the digital vote proposal uses cloud architecture.

Despite the notable advancements and successful implementations of electronic voting systems, Peru faces significant challenges due to pervasive distrust in institutions and logistical issues. This skepticism stems from past political controversies, necessitating rigorous audits and transparent processes to build public confidence. Additionally, the country's diverse geography and uneven technological infrastructure complicate the deployment of electronic voting, particularly in rural areas lacking necessary technology and internet connectivity. The implementation process is further complicated by the need for extensive training for both election officials and voters.

4 Data

Our main data sets come from the National Office of Electoral Processes and National Jury of Elections (ONPE & JNE). The ONPE is responsible for organizing and conducting electoral processes, while the JNE informs candidates and oversees the judicial confirmation of official election results. From official ONPE documents we construct a list of districts where the electronic vote was implemented, and from both we obtain information on each municipal election regarding the names of all parties registered, information on the candidates (including political positions held in the past), the number of votes each candidate received, votes cast as blanks, votes deemed invalid, and the total number of feasible voters.

Our focus is on the 2018 municipal elections, as it offers the largest number of districts using Electronic Voting. Similarly, we restrict our analysis to the regions of Lima and Callao, as they hold a significant majority of treated districts for that election and present larger number of suitable comparison districts.[9] Our smallest geographic unit of analysis is the polling center, but we aggregate information at the district level.

We use demographic information for each district, such as the elderly proportion of the electorate (people above 70 years old), as well as the youth proportion (the population below 29 years old), along with other characteristics, such as the percentage of women. Other control variables were extracted from the United Nations Development Programme (UNDP), related to each district's Human Development Index, which includes the mean years of schooling, population with 18 or more years old who completed high school, life expectancy at birth, and gross family income per capita. Also, from Li et al. (2020) we obtain a harmonized raster file of the average night-time light intensity for 2018 (see Appendix 10.1).

[9] See Table 1 for the number of districts treated in each election.

5 Empirical Strategy

Our identification strategy is based on the exogenous implementation of Electronic Voting in certain Peruvian districts, and the comparison with similar but unselected areas. We use a territorial regression discontinuity to estimate the effects of EV on electoral outcomes for the 2018 municipal elections.

5.1 First Stage: Electoral Outcomes

Given that the assignment of the electronic vote is deterministic and discontinuous in the boundary of the treated districts, we follow Dell (2010) and use a regression discontinuity approach. Furthermore, given that the districts' boundaries diverge from the commonly used Regression Discontinuity Design applications, we apply a territorial RDD. Specifically, the legal boundary of the treated districts forms a territorial discontinuity, that will be expressed in the following form:

$$\begin{aligned} D_i &= 1 \;\; if \;\; \text{Polling Center} < b \\ D_i &= 0 \;\; if \;\; \text{Polling Center} > b \end{aligned} \tag{1}$$

where the treatment is assigned according to the position of each polling centers i in relation to the boundary b of the treated districts with EV. Also, looking at how the treated districts are distributed, we consider the boundary of a subsample of treated districts to have a more precise estimation (see Figure 2).[10] We estimate the following equation:

$$O_{idb} = \alpha + \gamma EV_i + \chi_d' \beta + \epsilon_{id} \tag{2}$$

Where O_{idb} is a set of electoral outcomes for the polling center i located in the district d that is within the boundary b . EV_i is an indicator equal to 1 if the polling center is located in a district that implemented the electronic vote, and equal to 0 otherwise. χ_d' is a district level covariates vector, and ϵ_{id} is the model error, clustered at the district level.

[10] The treated zone is composed by the following treated districts: San Isidro, Magdalena, San Borja, Lince, Santiago de Surco, Pueblo Libre, Barranco, Miraflores, Surquillo, La Molina, Santa Anita, and San Luis.

The identification of our RD model is based on two key assumptions. The first one is that at the boundary of the treated districts, the relevant factors (other than the treatment) should exhibit a smooth variation. That is, we assume that individuals located immediately outside of the treated district can serve as a valid comparison group for those located inside it (see Figure 3). To have a more precise estimation and to ensure that we are comparing observations in close geographic proximity, we will consider three different buffers for the boundary b (see Figure 4). Secondly, we assume that no selective sorting around the treatment threshold. That is, we assume away that individuals decided where to locate based on whether a district was going to experience an Electronic Voting system. To be clear, in Peru, months prior to an elections individuals can choose a polling station based on their proximity, but the polling station must be located within the district they legally reside.

6 Results

6.1 First Stage: Electoral Outcomes

Regression Discontinuity

We present the estimates of the effects of our territorial regression discontinuity model (Equation 2) in Table 5. We estimate the model for each of the three buffers (1 km, 2 km, and 4 km). Columns (1) to (3) show that the EV system has a negative effect on the turnout rate variable, however, it does not show a statistical significance when the regression is estimated with controls. The effect remains constant for the three buffers.

For the effect on blank votes, columns (4) to (6) show that the implementation of the EV system reduced them, on average, by 2.9 percentage points (pp) compared to the non-treated polling centers; despite being on a smaller scale than the Brazilian case [(Fujiwara, 2015), and (Zucco Jr. and Nicolau, 2016)], this effect is statistically significant at the 1% level, aligning with the previous findings. When we incorporate control variables into the regression in Panel B, the results are still significant but reduced to an average of 1.8 pp.

Columns (7) to (9) show that the EV technology reduced the share of residual votes by an average of 5.0 pp; this result is statistically significant. In panel B, where we incorporate control variables, these results hold, but are reduced to 4.4 pp. These effects also go in line with Fujiwara (2015), who found that the implementation of electronic voting in Brazil reduced the share of residual votes, and also with Allers and Kooreman (2009), who found a negative effect of the EV on the number of residual votes in The Netherlands, since this type of error is virtually impossible to make with this technology.

Given these results, we can infer that this technology promoted a more accessible and user-friendly voting process, allowing voters to express their preferences more effectively, which made the decrease in blank votes possible. Also, they imply that the system likely provided clear instructions, minimizing potential errors, and increasing the overall validity of cast votes.

Finally, we apply the RDD specification to a set of electoral outcomes that could drive more directly to a larger representativeness of the citizens. First, we assess if the winning parties increased their share of valid votes; secondly, if in those districts with EV technology the difference between the winner and second parties decreased; and finally, if there was a decrease in the invalidated polling stations. In the case of the latter, the participation of the "political party official" (*Personero*) has a lot of influence.

The "political party official" is the citizen who watches over and represents the interests of a certain political organization or an authority, in the development of an electoral process[11]. They can request the invalidation of certain votes or the whole polling station if they consider that the vote counting is not correct, or has signs of manipulation. However, this could also be a tactic of certain "political party officials" to manipulate the results of the polling station and look after the interests of the party; the implementation of EV could help reduce this possibility.

Table 4 shows the results for the three transmission mechanisms. From columns (1) to (3) we can evidence that the introduction of EV technology did not impact the share of valid votes for the winning parties. Columns (4) to (6) also provide evidence that there was no effect on the difference between the winner and second-place parties. Nevertheless, columns (7) to (9) report that the EV technology reduced the number of invalidated polling stations by an average of 2.68 and it is significant at the 1% level for the three buffers.

[11] Source: https://portal.jne.gob.pe/portal_documentos/files/informacioninstitucional/escuelaelectoral/Martes%20Electorales%20-%20Exposiciones/ee2010/mar_31ago10.pdf

7 Robustness Check

In this section, we present a series of robustness checks that have been developed to challenge and validate the main results of this study. The findings will give us a better insight into the validity of the relationship between the EV system and electoral outcomes.

Our main concern is that the estimated coefficients could be biased by a heterogeneous distribution of the disproportionate distribution of the population between the control and treatment groups. Given that municipal elections occur every four years, we estimate the regression discontinuity design using the 2010, 2014 and 2022 municipal elections. Regarding the elections of 2010, electronic voting was not implemented yet. In the case of the elections of 2014, EV was implemented in only seven districts, five of which were in Lima. This will give us appropriate placebo tests to assess the validity of our results in the absence of the EV technology.

7.1 RD: Elections 2010 - 2014

Table 7 shows the electoral outcomes of the 2010, 2014 and 2018 municipal elections, comparing the treated and control groups in the absence of EV, with those who were indeed affected by its implementation. Columns (1) to (3) show that there has not been a statistically significant effect on the turnout for the three buffers when the regression is estimated with controls, just as presented in Table 5. Columns (4) to (6) report that, unlike Table 5, the effect on blank votes is not significant when we use controls, and the size of the coefficients is relatively smaller. Finally, from columns (7) to (9) we see evidence that, for the 4 km buffer of the 2010 elections, there is a negative and significant effect on the share of residual votes of 1.69 pp, when we use controls. However, unlike the previous results, there is no effect for the 1 and 2 km buffers, and again the size of the coefficients is considerably smaller.

Therefore, we could infer that the treated districts did not present a relevant reduction in the percentage of residual and blank votes in the absence of EV, which can shed light on the relevance of the policy.

Table 6 shows the 2022 municipal elections, as it was the first election conducted without the use of EV technology following its implementation. It is conducted separately from the other years due to its recency; as it is the latest election, there are fewer control variables accessible compared to the previous years (share of women, youth, elders, and nightlight intensity). Columns (1) to (3) show that, after including controls, only the 2 km buffer presents a significant effect (1.13 pp). Columns (4) to (6) show that the effect on blank votes is as expected, negative and significant at the 1% level for all buffers, howing that the implementation of EV technology changed the trend in blank vote outcomes when compared to districts with closer geographical proximity. Lastly, in columns (7) to (9) we see again that, for all buffers, there is a negative and significant effect on the share of residual votes. However, the size of the coefficients is modestly smaller than those presented in Table 5, which could be interpreted as if the policy may have contributed to a decrease in the proportion of residual votes within the treated districts, because of the spillover effects from the 2018's elections.

7.2 DiD estimation: Elections from 2010-2022

In order to enhance the reliability of our findings, we conducted several difference-in-differences (DiD) models. While the regression discontinuity design (RDD) allows for causal inference by exploiting the treatment assignment threshold, the DiD approach helps control for potential confounding factors and time-varying effects. This is achieved by comparing changes over time in both the treatment and control groups. Therefore, using this method strengthens the credibility of our results and addresses concerns about the validity of the RDD[12].

As shown in Table 9, columns (1) to (3) indicate that, consistent with Table 5, the EV system has a negative effect on the turnout rate variable. However, this effect is not statistically significant. Columns (4) to (6) show that the effect on blank votes is as expected —negative and significant for all buffers— indicating that the implementation of the EV technology did in fact have an effect on the outcomes for the blank votes. Lastly, in columns (7) to (9), we observe a negative and significant effect on the share of residual votes across all buffers. However, the size of the coefficients is moderately smaller than those presented in Table 5, but maintaining the sign and significance level.

Finally, Table 8 presents the results of the DiD estimation using the 2010 and 2022 municipal elections as a placebo test to evaluate the validity of our treatment effect. Corroborating our initial outcomes, the DiD analysis for these years shows that our variable of interest, $Time \times EV$, yields insignificant results for every buffer. This aligns with our expectations, supporting the validity of the estimated treatment effect observed in the actual treatment group. It suggests that the esti-

[12] In Appendix 10.2 we plot the common trend of our outcome variables and estimate a pre-treatment balance test

mated effect for the treated districts is unlikely to be driven by random events or other unrelated factors, but rather by the implementation of the electronic voting system.

8 Limitations

One of the main limitations of this paper is the presence of unobserved factors. Even though the territorial discontinuity design provides a strong framework for causal inference, unobserved factors may also explain the relationship between electronic voting technology and electoral outcomes. These factors, even when controlling for covariates, could result in omitted variable bias.

While this type of model provides a framework for causal inference, it still assumes that the assignment to treatment groups is based mainly on the location relative to the boundary. However, endogeneity concerns may arise if factors beyond location influence treatment assignment, potentially biasing the estimated effects.

Technical aspects may also affect our results. For instance, inadequate training, infrastructure limitations, or cybersecurity vulnerabilities could impact the effectiveness of the electronic voting technology, thus affecting the potential electoral outcomes.

Additionally, our study is based on a specific period of time, which may limit the evaluation of the long-term effects of electronic voting technology on Peruvian electoral outcomes. A more comprehensive analysis, spanning additional years, would allow us to capture potential changes, adaptations, and learning effects over time, leading to more accurate estimates

9 Conclusions

This paper analyzes the effects of the implementation of EV technology on Peru's electoral outcomes, applying a territorial regression discontinuity design with three buffers of 1 km, 2 km, and 4 km, using administrative data at the pooling center level. We found that the system reduced, on average, the percentage of blank and residual votes by 1.8 and 4.4 percentage points, respectively, aligned with previous research. Furthermore, it did not impact the turnout rate. These outcomes suggest that EV technology facilitates an accessible voting process, allowing voters to express their true preferences effectively, ensuring a successful and sustainable electoral outcome.

Nevertheless, we must acknowledge the limitations of this study, as we may be facing some unobserved factors and endogeneity concerns, which may be influencing the relationship between EV technology and the potential electoral outcomes. Other technical implications, such as cybersecurity vulnerabilities, technical training, infrastructure limitations, and implementation challenges, could also potentially affect the effectiveness of the EV system.

Ultimately, this study provides sufficient evidence to support the benefits of electronic voting technology in reducing potential errors and enhancing voter representation in electoral outcomes. As it represents a secure and reliable alternative, this system contributes to the validity and integrity of elections, especially in areas where voters are more susceptible to electoral fraud.

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Figure 1 – Timeline of Implementation of the Electronic Vote in Peru

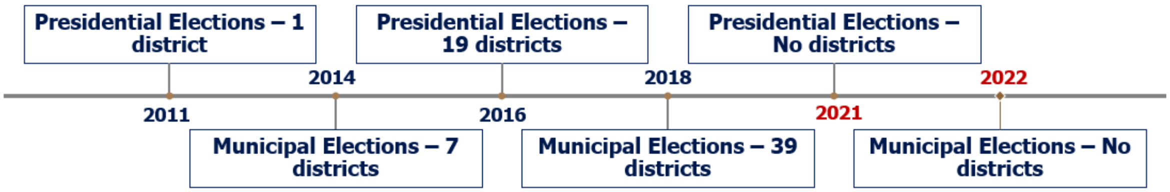


Figure 2 – Districts of Lima, Peru

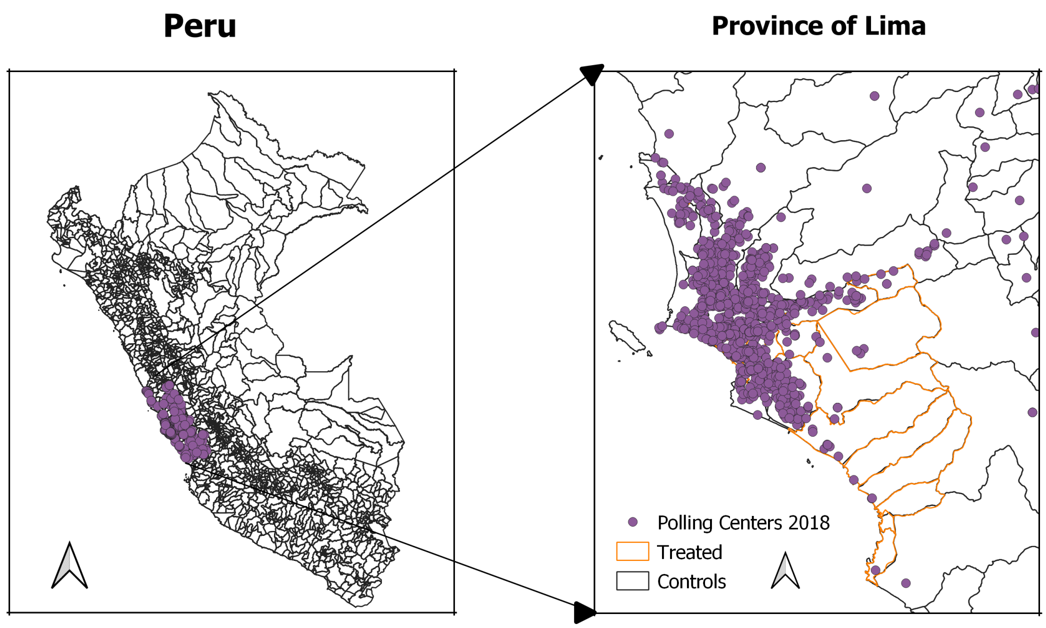


Figure 3 – Subsample of treated districts of Lima, Peru

Province of Lima, Treated Zone, 2018

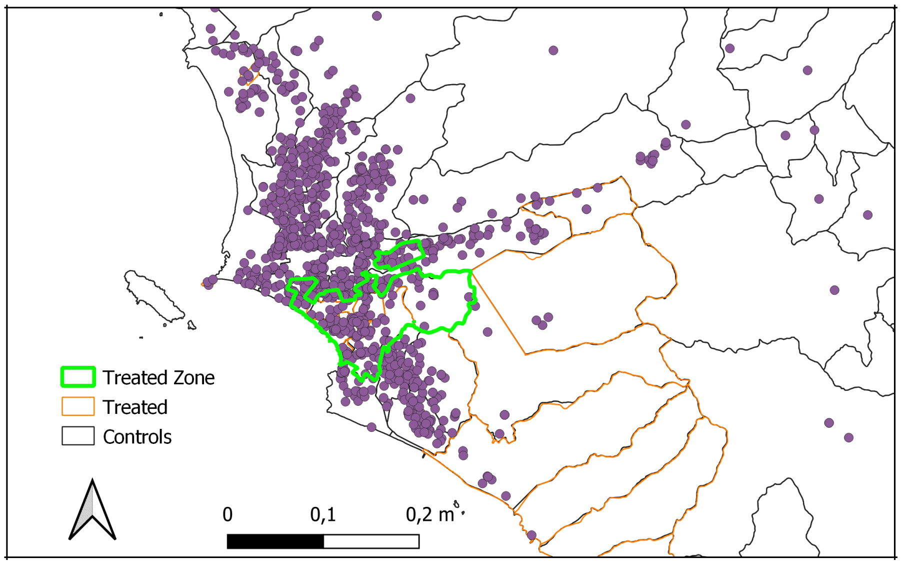


Figure 4 – Buffers for the subsample of treated districts of Lima, Peru

Buffers from the Treated Zone, 2018

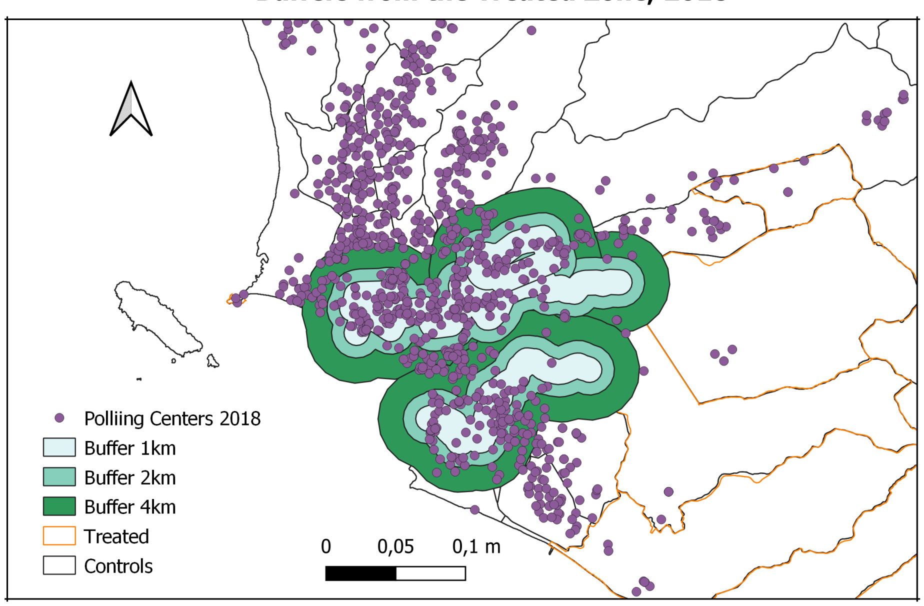


Table 1 – Districts with Electronic Voting System

	Year	Districts	Polling centers	Polling tables
Presidential Elections	2011	1	1	9
	2016	19	130	2194
Municipal Elections	2014	7	11	154
	2018	39	268	5860

Table 2 – Simulation - Assuming complete implementation of the EV system - 2018

Votes	Lima	Peru
Blanks	80,294	225,361
Residual	195,190	547,712
Total	275,484	773,073

We calculate a reduction of 1.8 pp for blank votes, and 4.4 pp for residual votes, aligned with our main model's results.

Table 3 – Sources of data

Sources	Observation level	Variables
National Office of Electoral Processes (ONPE)	Polling centers	Location of the polling centers
		Votes of every political parties
		Valid votes
		Blank votes
		Residual votes
		Number of voters
		Absenteeism
National Jury of Elections (JNE)	Districts	Year of the electoral process
		Number of voters
		Percentage of male
		Percentage of female
		Percentage of youth
		Percentage of elderly
Harmonized nighttime light intensity raster file	Districts	Proxy of the GDP
United Nations Development Programme (UNDP)	Districts	Mean years of schooling
		Population with 18 or more years old who completed high school
		Life expectancy at birth
		Gross family income per capita
Ministry of Economy and Finance	Districts	Local government budget

Own elaboration.

Table 4 – Transmission mechanisms for budgetary implications

	% Winner party			% Diff. Winner and second parties			Invalidated polling stations		
	1 km	2 km	4 km	1 km	2 km	4 km	1 km	2 km	4 km
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
EV	0.0246	0.0133	0.00879	0.0126	0.00241	0.000919	-3.002***	-2.662***	-2.390***
	(0.0257)	(0.0232)	(0.0206)	(0.0218)	(0.0182)	(0.0150)	(0.514)	(0.315)	(0.250)
Constant	0.478	0.571	1.157*	-0.00382	0.179	0.523	48.39*	38.68*	27.06**
	(0.959)	(0.973)	(0.623)	(0.895)	(0.857)	(0.555)	(25.99)	(21.75)	(11.02)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	213	335	491	213	335	491	213	335	491
R^2	0.323	0.273	0.252	0.274	0.154	0.138	0.267	0.254	0.242

Clustered standard errors at the district level in parentheses.

Controls incorporated at the district level are: proportion o youth, elders, and women, per capita income and educational level.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5 – Regression Discontinuity: 2018 Municipal Elections Results

	% Turnout			% Blank votes			% Residual votes		
	1 km	2 km	4 km	1 km	2 km	4 km	1 km	2 km	4 km
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Without controls									
EV	-0.0105	-0.0216*	-0.0283**	-0.0272***	-0.0292***	-0.0293***	-0.0483***	-0.0528***	-0.0501***
	(0.0117)	(0.0117)	(0.0104)	(0.00454)	(0.00427)	(0.00509)	(0.00690)	(0.00571)	(0.00531)
Constant	0.828***	0.830***	0.832***	0.0500***	0.0522***	0.0546***	0.0984***	0.103***	0.102***
	(0.00617)	(0.00689)	(0.00558)	(0.00448)	(0.00419)	(0.00428)	(0.00675)	(0.00547)	(0.00440)
Panel B: With controls									
EV	-0.0123	-0.0112	-0.000732	-0.0145***	-0.0183***	-0.0217***	-0.0421***	-0.0448***	-0.0463***
	(0.00835)	(0.00772)	(0.00538)	(0.00374)	(0.00447)	(0.00501)	(0.0108)	(0.00771)	(0.00578)
Constant	1.139***	0.876***	1.110***	-0.290**	-0.162	0.214	0.497*	0.458	0.535**
	(0.117)	(0.161)	(0.246)	(0.110)	(0.118)	(0.198)	(0.284)	(0.281)	(0.238)
Observations	213	335	491	213	335	491	213	335	491
R^2	0.207	0.280	0.254	0.788	0.753	0.608	0.465	0.455	0.451

Clustered standard errors at the district level in parentheses.

Controls incorporated at the district level are: proportion o youth, elders, and women, per capita income and educational level.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6 – Regression Discontinuity: 2022 Municipal Elections Results

	% Turnout			% Blank votes			% Residual votes		
	1 km	2 km	4 km	1 km	2 km	4 km	1 km	2 km	4 km
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Without controls									
EV	-0.0116	-0.0179*	-0.0209**	-0.0122***	-0.0129***	-0.0137***	-0.0223***	-0.0219***	-0.0224***
	(0.0113)	(0.0104)	(0.00879)	(0.00319)	(0.00299)	(0.00246)	(0.00422)	(0.00288)	(0.00265)
Constant	0.791***	0.792***	0.794***	0.0395***	0.0397***	0.0399***	0.0798***	0.0786***	0.0789***
	(0.00610)	(0.00530)	(0.00380)	(0.00295)	(0.00273)	(0.00221)	(0.00343)	(0.00215)	(0.00212)
Panel B: With controls									
EV	-0.0122	-0.0113*	-0.000961	-0.00952***	-0.00992***	-0.0109***	-0.0163***	-0.0161***	-0.0173***
	(0.00779)	(0.00622)	(0.00698)	(0.00254)	(0.00249)	(0.00243)	(0.00442)	(0.00249)	(0.00357)
Constant	1.189***	1.090***	0.842***	0.172**	0.235**	0.307***	0.0406	0.182	0.235**
	(0.397)	(0.187)	(0.203)	(0.0682)	(0.0912)	(0.0739)	(0.151)	(0.118)	(0.0922)
Observations	392	637	1008	392	637	1008	392	637	1008
R^2	0.0425	0.0561	0.0422	0.376	0.360	0.400	0.158	0.161	0.158

Clustered standard errors at the district level in parentheses.

Other controls incorporated at the district level are: proportion o youth, elders and women.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7 – Regression Discontinuity: Municipal elections results

	% Turnout			% Blank votes			% Residual votes		
	1 km	2 km	4 km	1 km	2 km	4 km	1 km	2 km	4 km
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: RD 2018									
EV	-0.0123	-0.0112	-0.000732	-0.0145***	-0.0183***	-0.0217***	-0.0421***	-0.0448***	-0.0463***
	(0.00835)	(0.00772)	(0.00538)	(0.00374)	(0.00447)	(0.00501)	(0.0108)	(0.00771)	(0.00578)
Panel B: RD 2014									
EV	-0.00123	-0.00725	-0.00432	0.00516	0.00655	0.00416	0.00143	-0.00488	-0.00721
	(0.00570)	(0.00480)	(0.00545)	(0.00404)	(0.00385)	(0.00336)	(0.00256)	(0.00397)	(0.00495)
Panel C: RD 2010									
EV	-0.00764*	-0.00738*	0.00120	0.00173	0.00180	-0.00357	-0.00530	-0.0000709	-0.0169**
	(0.00410)	(0.00403)	(0.00621)	(0.00473)	(0.00550)	(0.00490)	(0.00698)	(0.00612)	(0.00686)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Clustered by district standard errors in parentheses

Other controls incorporated at the district level are: proportion o youth, elders and women, per capita income and educational level.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8 – Municipal elections results: DiD 2010-2022

	% Turnout			% Blank votes			% Residual votes		
	1 km	2 km	4 km	1 km	2 km	4 km	1 km	2 km	4 km
$Time \times EV$	-0.000597	0.00105	0.00363	-0.00204	-0.00341	-0.00297	-0.00691	-0.00366	0.00744
	(0.00823)	(0.00584)	(0.00588)	(0.00887)	(0.00799)	(0.00660)	(0.0108)	(0.00844)	(0.00673)
EV	-0.0131*	-0.00954*	-0.00863	-0.00279	-0.00368	-0.00456	-0.00734	-0.00838	-0.0190***
	(0.00744)	(0.00560)	(0.00656)	(0.00637)	(0.00610)	(0.00502)	(0.00892)	(0.00735)	(0.00686)
Time	-0.0733***	-0.0762***	-0.0738***	-0.0166*	-0.0147*	-0.0137**	0.00538	0.00124	-0.00482
	(0.00740)	(0.00516)	(0.00421)	(0.00828)	(0.00740)	(0.00605)	(0.00557)	(0.00441)	(0.00368)
Constant	-2.133**	-0.958*	-0.976*	0.128	-0.217	-0.406	0.477	0.288	0.0639
	(0.838)	(0.476)	(0.509)	(0.399)	(0.438)	(0.421)	(0.362)	(0.324)	(0.374)
Observations	538	865	1337	538	865	1337	538	865	1337
R^2	0.201	0.214	0.180	0.577	0.519	0.495	0.147	0.169	0.187

Clustered standard errors in parentheses

Other controls incorporated at the district level are: proportion o youth, elders and women, per capita income and educational level.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9 – Municipal elections results: DiD 2010-2018

	% Turnout			% Blank votes			% Residual votes		
	1 km	2 km	4 km	1 km	2 km	4 km	1 km	2 km	4 km
Time × EV	-0.00300	-0.00465	-0.00608	-0.0181**	-0.0205**	-0.0196**	-0.0341***	-0.0357***	-0.0222**
	(0.00529)	(0.00515)	(0.00447)	(0.00818)	(0.00770)	(0.00826)	(0.0106)	(0.00943)	(0.00854)
EV	-0.00927**	-0.00795	-0.00793	-0.00146	0.000282	-0.000934	-0.00859	-0.00563	-0.0166**
	(0.00445)	(0.00481)	(0.00488)	(0.00541)	(0.00547)	(0.00527)	(0.00875)	(0.00800)	(0.00807)
Time	-0.0342***	-0.0361***	-0.0330***	-0.00542	-0.00208	0.00159	0.0256***	0.0270***	0.0212***
	(0.00344)	(0.00305)	(0.00330)	(0.00726)	(0.00684)	(0.00651)	(0.00567)	(0.00535)	(0.00501)
Constant	-0.924	-1.046*	-1.127*	0.956*	0.858	0.726	0.152	0.327	0.617
	(0.556)	(0.572)	(0.593)	(0.542)	(0.617)	(0.714)	(0.714)	(0.716)	(0.909)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	359	563	827	359	563	827	359	563	827
R^2	0.365	0.406	0.387	0.669	0.615	0.536	0.341	0.348	0.348

Clustered standard errors in parentheses

Other controls incorporated at the district level are: proportion o youth, elders and women, per capita income and educational level.

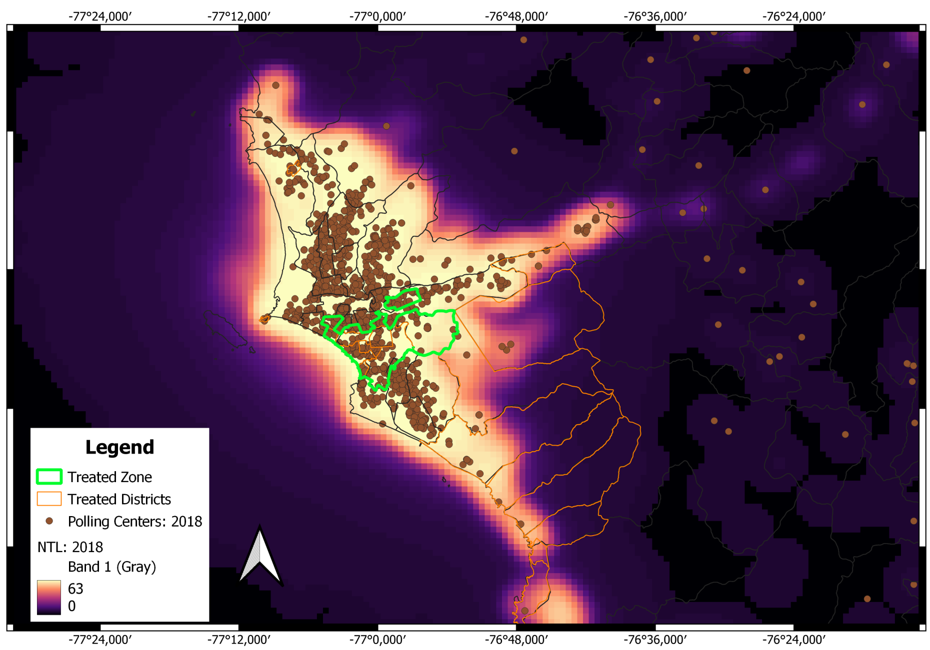
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

10 Appendix

10.1 Appendix: Nightlights

From Li et al. (2020), we will use a harmonized satellite image of the nighttime lights for the year 2018 to construct a proxy of the GDP of the districts. We use this variable as a control for our estimations. In Figure 4, the districts of the province of Lima are mostly covered by luminosity.

Figure 4: Nightlight intensity for the province of Lima, 2018



10.2 Balance check and graphs of the trends for control and treated groups for the three outcomes of table 5

Figure 5 shows that the turnout had a decreased parallel trend for both groups since 2010 municipal elections to the 2022 municipal elections. Moreover, figures 6 and 7 evidence that for the 2018 municipal elections, the trend for the blank and residual votes changed in the case of the treated group, compared to the control group, which had an increasing trend.

Figure 5 – Trends for the turnout outcome

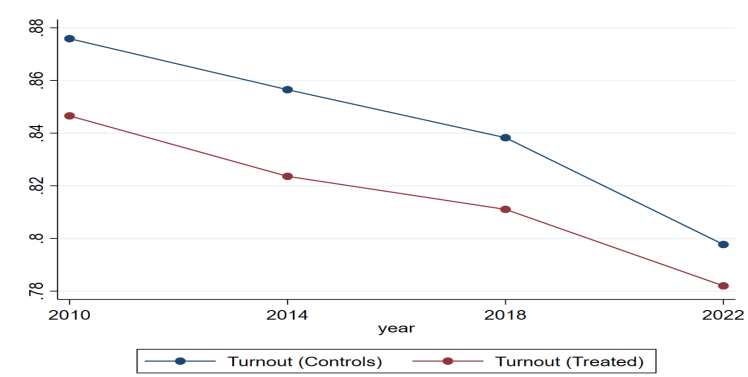


Figure 6 – Trends for the blank votes

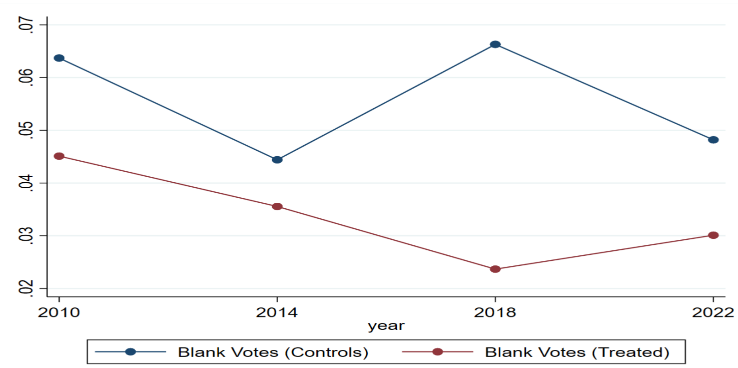


Figure 7 – Trends for the residual votes

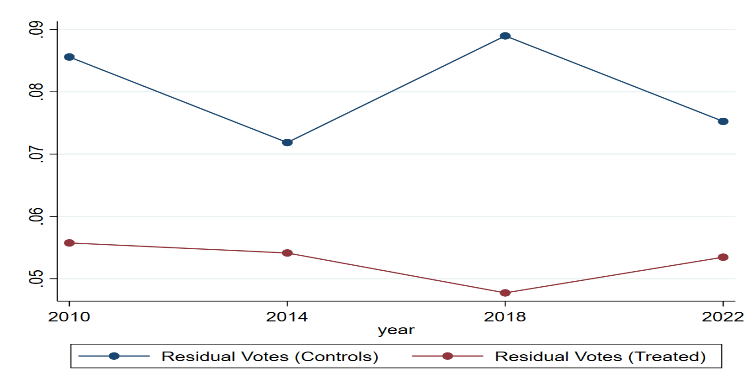


Table 10 – Balance Test: variables from 2010

	Treated	Controls	Difference	P_value
Life expectancy at birth	77.89	77.83	0.06	0.68
Population with 18 or more years old who completed high school	81.29	77.57	3.72	0.09
Mean years of schooling	12.02	11.10	0.92	0.02
Gross family income per capita	1053.05	894.12	158.92	0.02
Percentage of female	0.52	0.51	0.01	0.13
Percentage of youth	0.28	0.33	-0.05	0.01
Percentage of elderly	0.08	0.06	0.02	0.03

We compare control variables for treated and non treated districts in 2018 with their values of 2010. We found some pre-treatment differences, so we included all the control variables in our models.