RODRIGO SCHNEIDER
Skidmore College, Saratoga Springs, New York, USA

Free or Fair Elections? The Introduction of Electronic Voting in Brazil

ABSTRACT This paper studies the phased-in introduction of electronic voting in Brazil to disentangle the effects of free and fair elections on politicians' responsiveness to voters' demands. The new technology improved voters' access, particularly for less educated ones, to legislative elections, and it undercut the election fraud that had previously occurred with paper ballots during the vote count (that is, votes were added to tabulation sheets after voting had ended). At the same time, the new technology increased the relative appeal of voter fraud via ballot stuffing (that is, when voters illegally vote more than once). I find that municipalities using electronic rather than paper ballots experienced larger increases in the number of registered voters, suggesting an increase in ballot stuffing. I also find that enfranchisement biased toward low-income voters does not necessarily lead to an increase in public spending. Results suggest that election fairness is a complementary condition to guarantee electoral accountability.

JEL Codes: H41, H51, H75, D72

Keywords: Electronic voting, enfranchisement, electoral fraud, social spending

In a democratic system, free and fair elections are the mechanism for guaranteeing that politicians will be responsive to citizens and less likely to pursue policies for their own self-interest (Acemoglu, Robinson, and Torvik, 2013). Democracy per se is thus not sufficient to ensure that governments will consider their citizens' preferences (Callen and Long, 2015). Meltzer and Richard (1981), who focus on enfranchisement—that is, free elections—show that politicians will only consider the preferences of voters who participate in elections. An alternative explanation for politicians ignoring their citizens' preferences is the presence of electoral fraud, or unfair elections, whereby

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politicians are not held accountable and can divert resources for their own benefit (Debnath, Kapoor, and Ravi, 2017).

I examine electoral accountability in Brazil, where electronic voting affected both access to and the fairness of elections. On the one hand, electronic voting enfranchised voters, especially less skilled ones, in legislative elections (Fujiwara, 2015). To cater to these voters, elected members of Congress increased expenditures in municipalities with electronic voting, by proposing amendments to the annual national budget favoring these places (Schneider, Athias, and Bugarin, 2020). This result should be expected because low-income voters demand more public expenditure, from which they benefit, although they pay a smaller share of the tax revenue used to finance it (Meltzer and Richard, 1981). On the other hand, the new voting system eliminated the possibility of vote-count fraud after the voting was completed (that is, the addition of votes to tabulation sheets) (Hidalgo, 2012), which increased the relative attractiveness of other types of election fraud, such as ballot stuffing (Hidalgo and Nichter, 2016). Empirical evidence suggests that the elimination of fraud complements enfranchisement by providing accountability: places where electronic voting enfranchised poor voters, but where there was suggestive evidence of electoral fraud, experienced a relatively smaller (or null) change in public expenditures in areas such as health and employment.

I take advantage of the phased introduction of electronic voting in Brazil to disentangle the effects of enfranchisement and electoral fraud on public spending. The advantage of examining the Brazilian case is that only four states used electronic voting exclusively across their territory in 1998. In Brazil, congressional candidates are elected to represent their states, which are large multimember districts. Under electronic voting, there would be no possibility of fraud during the vote count for congressional candidates belonging to these four states. Therefore, election fraud via ballot stuffing (that is, when voters illegally vote more than once) would be relatively more attractive in these districts. I construct a geographic regression discontinuity design (RDD) in which the distance to the border of these four states is the running variable, while the change in the number of registered voters is the dependent variable. Insofar as the most common form of ballot stuffing is for voters to illegally obtain more than one voter identification card and cast more than one ballot, municipalities belonging to the states that implemented electronic voting should have a relatively inflated number of registered voters.

The Brazilian case offers an opportunity to disentangle the effects of free and fair elections because electronic voting homogeneously enfranchised

less educated voters and generated variations in voter registration, which can be related to electoral fraud. Using the proposed geographic regression discontinuity framework, I find a voter enfranchisement similar to the level reported in the literature using a different sample and a population RDD (Hidalgo, 2012; Fujiwara, 2015); this suggests that electronic voting homogeneously caused enfranchisement in Brazil. However, the increase in voter registration was not homogeneous across the country. Evidence consistent with the presence of ballot stuffing is observed only in the sample analyzing the geographic RDD. I find that municipalities belonging to the four states that exclusively used electronic voting had relatively inflated numbers of registered voters. Nonetheless, the same is not observed in the sample using the population RDD previously explored in the literature. In addition, I find heterogeneous effects of electronic voting on the number of registered voters within the geographic regression discontinuity sample. This allows me to keep the enfranchisement of less educated voters constant while changing the level of inflated electorate. Exploring this heterogeneity, I find that members of Congress are more responsive to the enfranchisement of less educated voters in places where there was no increase in voter registration.

The most natural explanation for the increase in voter registration is that citizens responded positively to the new technology by registering to vote. If this is the case, then the results showing that there was relatively smaller social spending in places that used electronic voting and had higher levels of voter registration could be reconciled with a broader literature showing that enfranchisement does not necessarily lead to redistributive politics for reasons such as malapportionment (Ardanaz and Scartascini, 2013) and lack of pro-poor candidates (Machado, 2012).[1] However, in the specific case of electronic voting in Brazil, empirical results suggest that Meltzer and Richard's (1981) prediction is valid, to the extent that poor voters' enfranchisement increased taxation, intergovernmental transfers, and public expenditure (Fujiwara, 2015; Schneider, Athias, and Bugarin, 2019, 2020). Moreover, although I cannot establish that positive changes in voter registration constitute evidence of electoral fraud, I show evidence that is consistent with this interpretation. First, I report anecdotal evidence of ballot stuffing in districts where vote-count fraud was no longer feasible (that is, in states using the new technology exclusively). Second, I show empirical evidence that electronic voting caused an increase in voter registration only in these districts. Third, I find

1. Another possibility for why policymakers disregard voters' preferences is the subordination of local politicians to central government's interests (Kresch and Schneider, 2020).

empirical evidence that municipalities that were more likely to be involved in electoral fraud before the introduction of electronic voting were also more likely to have an inflated electorate in the 1998 elections. Finally, I show that places with fewer voters per congressional seat, where ballot stuffing is relatively more attractive because each vote carries a larger weight in the political process, are also more likely to show a larger increase in their electorate.

This work relates to the literature investigating the consequences of enfranchisement on fiscal policies and electoral outcomes. Husted and Kenny (1997) argue that eliminating voting requirements such as literacy tests and poll taxes increased voting participation in the United States, especially among the poor, and that government spending increased in response. Similar results are found in other contexts as a consequence of nationwide enfranchisement (Acemoglu and Robinson, 2000; Aidt and Jensen, 2009).[2] Gingerich (2013) shows that the introduction of the secret ballot in Brazil in the 1960s decreased de facto participation among poor voters, which benefited left-wing parties. The author argues that the poor and illiterate were dominated by clientelism and would cast their vote under the influence of local leaders representing the right-wing parties. Since the secret ballot did not allow those voters to arrive with a printed ballot to slip into the urn, they would have to actually write the name of their candidate, which most could not do successfully. Thus the disenfranchisement of the poor and uneducated disproportionately benefited left-wing parties. In contrast, the present work investigates an electoral policy that de facto enfranchised poor voters in Brazil and explores the consequences for electoral outcomes and fiscal policies.

The second strand of related literature analyzes electronic voting systems, which have been adopted by many democracies since the 1990s (Katz and others, 2011) and are under consideration in several others (Alvarez and Hall, 2010). Although the adoption of the new technology is expected to improve elections, it is not clear whether electronic voting can improve political accountability—and if it fails to do so, then politicians may be less responsive to voters' demands (Lehoucq, 2003). Therefore, if electronic voting attempts to enhance political accountability, it should eliminate the possibility of electoral fraud and be politically neutral. Nonetheless, many authors show that voting technologies can have important consequences for electoral outcomes, such as

2. For more examples of the positive effect of enfranchisement on public spending, see Mueller and Stratmann (2003), Lindert (2004), and Bugarin and Portugal (2015).

favoring certain political parties (Ansolabehere and Stewart, 2005; Card and Moretti, 2007; Garner and Spolaore, 2005; Katz and others, 2011; Schneider and Senters, 2018; Shue and Luttmer, 2009; Stewart, 2011).[3] Moreover, electronic systems include potential systemic glitches and a lack of transparency in the recording, counting, and tabulation of votes (Birch, Cockshott, and Renaud, 2014).[4] Thus the use of electronic voting can be problematic for achieving electoral fairness.

The homogeneous enfranchisement of lower-income voters caused by electronic voting in Brazil is expected to increase taxes and redistribution. This prediction is derived from Meltzer and Richard (1981), who show that when the income of the median (decisive) voter falls below the average income, there is an increase in taxes and redistribution. Three papers show empirical evidence corroborating this result. Fujiwara (2015) shows that Brazilian states with a larger share of voters using electronic voting experienced larger public spending on health care and improvements in health outcomes, such as prenatal care. Schneider, Athias, and Bugarin (2020) show that Brazilian municipalities using electronic voting were disproportionately favored by amendments to the annual public budget, resulting in larger expenditure in their territories. Finally, Schneider, Athias, and Bugarin (2019) find that municipalities using electronic voting had an increase in tax revenue and public spending in the areas of education, public employment, and health.

I add to these works by also considering that electronic voting, by eliminating the possibility of vote-count fraud, increased the attractiveness of alternative electoral malfeasance (Hidalgo and Nichter, 2016). Therefore, I take into account the possibility that the enfranchisement of low-income voters may be mitigated by electoral fraud that allows politicians to ignore the low-income voters' higher demand for public provision. This prediction is consistent with the theoretical model of Acemoglu and Robinson (2008), who show that voters' preferences can be ignored in a democracy when elites have relatively more de facto political power through lobbying and bribery. Fergusson and others (2020) show empirical evidence corroborating this prediction in Colombia, where political elites used violence to retaliate against electoral victories of previously excluded left-wing parties.

3. The impact of electronic voting on electoral outcomes could actually be considered a correction of the preexisting bias as the new technology may enfranchise voters, as in the Brazilian case.

4. For an example of how electronic voting can reduce fraud, see Callen and Long (2015), who analyze voting technology in Afghanistan.

Electronic Voting and Free and Fair Elections in Brazil

Electronic voting technology was introduced in Brazil to eliminate fraud during the vote count (Hidalgo, 2012). In 1996, all municipalities with more than 200,000 eligible voters used the new technology. In 1998, the use of the technology expanded to include all municipalities with more than 40,500 eligible voters. In addition, four states used electronic voting exclusively for all their municipalities regardless of the number of eligible voters (namely, Alagoas, Amapá, Roraima, and Rio de Janeiro). Starting with the 2000 election, all Brazilian voters vote electronically.

The new system enfranchised voters and increased participation in legislative elections. Before electronic voting, many Brazilians experienced difficulties casting valid votes due to low literacy skills; votes were invalidated when candidates' names (or numbers) were not clearly written. Prior to the introduction of electronic voting, knowing how to read and write, and understanding the complicated ballot instructions, were crucial for voters to cast their votes correctly and validly. With the introduction of the new system, voters had only to indicate the number of their preferred candidate (or party, in the legislative elections). After they entered the candidate's (or party's) number, a photo of the candidate or party would appear on the screen for confirmation. The ratio of the number of valid votes to turnout for federal representatives increased from 54 percent in 1994, when all municipalities used paper ballots, to 90 percent in 2002, when all municipalities used voting machines. Fujiwara (2015) shows empirical evidence that the introduction of voting machines in Brazil amplified the ratio of valid votes to turnout for representatives, especially benefiting illiterate voters, who were no longer required to write in the candidates' names.

Nonetheless, the introduction of voting technology in Brazil also increased the attractiveness of other types of voting fraud (Hidalgo and Nichter, 2016). As mentioned, while electronic voting eliminated the possibility of vote-count fraud, such as adding votes to tabulation sheets after actual voting had ended, it generated incentives for alternative methods of electoral malfeasance, such as ballot stuffing. In what follows, I explain the Brazilian electoral context, which motivated the introduction of electronic voting to eliminate vote-count fraud.

Electronic Voting and the Possibility of Electoral Fraud in Brazil

The 1994 legislative elections in the state of Rio de Janeiro were manipulated and consequently annulled, with allegations of widespread fraud during the

vote count.[5] The state of Rio de Janeiro thus had to re-run its proportional elections in conjunction with the 1994 federal elections. In the first round of elections, fraud was found, for instance, in 80 percent of the ballot boxes in the twenty-fifth electoral zone of this state. Fraud was detected when ballot boxes were illegally unsealed. Evidence of fraud was also discovered during the recount, when the total vote count for a candidate from a specific ballot box exceeded the total number of ballots containing votes for the candidate inside the box.[6] Finally, electoral fraud was also identified when voters illegally cast more than one ballot.[7]

The electoral fraud in the state of Rio de Janeiro motivated the introduction of electronic voting in Brazil. In 1994, the electoral judge of Rio de Janeiro and current Supreme Court justice Luiz Fux recommended electronic voting as the only solution to avoid electoral fraud in the future.[8] In 1998, Brazil used the new voting system for the first time in a federal election, and Rio de Janeiro was one of the four states selected to fully implement the system statewide because of its past involvement in electoral fraud.[9]

Although electronic voting eliminated the possibility of vote-count fraud, it did not rule out the possibility of other types of electoral fraud. Specifically, ballot stuffing (that is, having people vote more than once) became relatively more attractive for those who were willing to manipulate electoral outcomes. One way to have a single voter illegally vote more than once is to give him or her more than one voter identification (ID) card. Although voters need to be registered and have their voter ID cards verified prior to voting, they were not required to show a photo ID either on registration or at the election. Therefore, voters could vote more than once if they had multiple voter ID cards, obtained using fake social security cards to register to vote.[10] People could

5. "TSE detectou fraudes e interveio na apuração no Rio," *Folha de São Paulo*, October 16, 1994.

6. One case illustrates this type of fraud: Marcia Cibilis Viana, one of the candidates running for Brazilian Congress in 1994 in the state of Rio de Janeiro, had twenty-one votes counted from one specific ballot box, whereas the recount of the votes inside this ballot box found only one ballot cast for her ("Zona oeste tem a apuração mais atrasada," *Jornal do Brasil*, October 12, 1994).

7. For instance, one ballot box contained forty-five votes in the same handwriting, cast for the congressional candidate Paulo de Almeida ("TSE detectou fraudes e interveio na apuração no Rio," *Folha de São Paulo*, October 16, 1994).

8. "Santa Cruz, um ninho de fraudes," *Jornal do Brasil*, October 12, 1994.

9. "Eleitorado cresce quase 2 vezes o esperado," *Folha de São Paulo*, July 28, 1998.

10. The most extreme case of this illegal action was found in 2017 in the state of Goiás, where the same voter had fifty-two voter ID cards. Elisa Clavery, "Biometria detecta 25 mil títulos de eleitor duplicados," *Estado de São Paulo*, October 9, 2017. Available online at politica.estadao.com.br/noticias/geral,biometria-detecta-25-mil-titulos-de-eleitor-duplicados,70002035075.

also obtain extra voter ID cards by not cancelling the cards of voters who had passed away or moved to another municipality. The surplus voter ID cards from these latter two sources, if not canceled, could then be illegally sold. In 1998, authorities believed that the most likely electoral fraud taking place in Brazil was voting in the place of someone who had died.[11]

There is ample evidence that extra voter ID cards were being sold in the first year of electronic voting. In 1998, police officers in Roraima, one of the states using electronic voting, found and arrested a man who had 622 voter ID cards.[12] He was reported to police after attempting to sell these cards for 50,000 Brazilian reais (close to $42,000 in 1998 U.S. dollars) to one of the candidates in the state.[13] In the state of Alagoas—which was also implementing electronic voting—10,000 voter ID cards were stolen from the first electoral zone of the state capital, Maceió, and one person was later arrested with 498 of these cards in his possession. To avoid fraud, therefore, the electoral authorities determined that Alagoas would be the only state in the 1998 federal elections to require voters to present photo ID at the polling station (voter ID cards contain no photos). This requirement did not eliminate fraud, however: two days prior to the election, police officers in Alagoas seized 340 fake worker ID cards, one of the options that voters could use to identify themselves at the polls.[14] Finally, the suspiciously high increase in the number of voters in each state also points to this type of electoral fraud. In 1998, the state of Tocantins audited its electoral rolls and canceled 45,000 voter ID cards belonging to voters who had more than one card in their name and who did not show up when requested to explain the irregularity. The number of registered voters in the state of Tocantins thus decreased 6.7 percent between 1996 and 1998. Nonetheless, state electoral authorities are not required to audit their electoral rolls, and the excess voter ID cards could potentially be used to manipulate elections. In fact, the number of registered voters grew significantly in many states between 1996 and 1998. The two largest increases

11. "'Fantasma' é a fraude mais provável," *Folha de São Paulo*, September 26, 1998.

12. "PF apreende títulos de eleitor em RR," *Estado de São Paulo*, October 19, 1998.

13. On the day of the 1998 federal election, police in Roraima identified dozens of voters who had duplicated their voter ID cards, and one voter was arrested with twelve fake IDs in his possession. There were allegations of 10,000 fake voter ID cards circulating in the state ("Reforço de tropas garante dia tranqüilo em Roraima," *Estado de São Paulo*, October 26, 1998).

14. "PF pega carteiras em branco em al," *Folha de São Paulo*, October 3, 1998.

in the electorate in the period were in Roraima and Amapá, with 21.43 and 22.67 percent, respectively.[15]

Data Description and Methodology

I collected electoral and socioeconomic data to analyze whether places using electronic voting had a suspicious increase in the size of their electorate. I focus on the federal elections of 1994, 1998 and 2002, which elected state and federal representatives, as well as senators, governors, and the president. I examine the possibility of electoral fraud by studying the increase in the number of eligible voters at the municipal level. I collected this information, as well as other relevant electoral variables, from the Superior Electoral Court (TSE). The socioeconomic data used in the analysis are from Ipeadata, the database maintained by the Institute of Applied Economic Research.[16]

I then construct a geographic regression discontinuity design (RDD), where distance to the border of states that exclusively used the new voting technology is the forcing variable.[17] For this analysis, I restrict the sample to municipalities surrounding the geographic boundaries of the four states in question. Formally, I construct the following regression:

$$\text{(1)} \qquad \mathrm{EC}_{mt} = \alpha + \gamma D_m + \beta\left(r_m - c\right) + \epsilon_{mt},$$

subject to $(c - h) \geq r_m \leq (c + h)$,

where EC_{mt} is the percentage change in the number of registered voters in municipality m from election $t - 1$ to election t, c represents the cutoff (borders of states using only electronic voting), r_m indicates the distance to

15. "Três estados apresentam redução," *Folha de São Paulo,* July 28, 1998. Roraima was also the most extreme case where the number of voters exceeded the population eligible to vote in 1998, with 13 percent more actual voters than eligible voters ("Eleitorado supera população em 13 estados," *Folha de São Paulo,* August 12, 1998).

16. The English version of the Superior Electoral Court website can be accessed at english.tse.jus.br. The English version of the Ipeadata website can be accessed at www.ipeadata.gov.br/Default.aspx.

17. For a detailed description of geographic regression discontinuity design, see Keele and Titiunik (2015).

the cutoff (in kilometers), D_m is a dummy variable indicating that the state border was crossed, and h represents the selected bandwidth (in kilometers). The main independent variable, γ, captures the electronic voting effect, β measures closeness to the cutoff, and ϵ_{mt} contains the error term for each observation.[18]

My hypothesis is that states using only electronic voting will have an inflated number of voters, suggesting an attempt at ballot stuffing. States that fully implemented electronic voting statewide are a good treatment group in this case because, in Brazil, each state acts as a multimember district. Therefore, congressional candidates belonging to these districts who were willing to commit electoral fraud did not have the option of manipulating ballot boxes (that is, vote-count fraud). In states where some municipalities used electronic voting and the rest used paper ballots, such candidates could concentrate their efforts on vote-count fraud in municipalities using paper ballots.

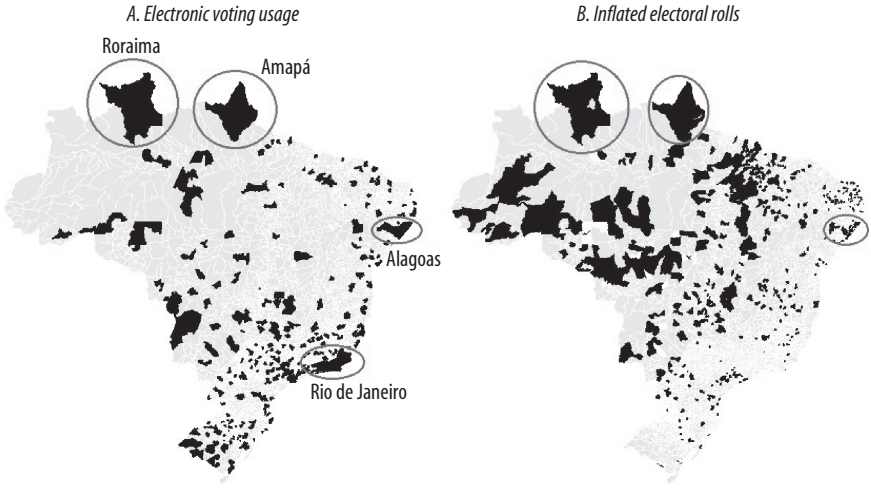
Therefore, a population RDD, as previously used by Fujiwara (2015) and Schneider, Athias, and Bugarin (2020), is not ideal. Their studies eliminated the four states using only electronic voting from the sample. Their analysis thus contains districts (states) that elect their congressional representatives using both electronic and paper ballots. If vote-count fraud is easier or cheaper than ballot stuffing, which is likely to be the case since the new technology was enacted to eliminate the frequent use of the former, then politicians would be less likely to attempt ballot stuffing in municipalities with electronic voting when they have the possibility of vote-count fraud in municipalities that used paper ballots. This paper uses population regression discontinuity only to test the robustness of the main results.

Results

The main assumption required to validate my estimations from equation 1 is that municipalities close to the geographic boundaries of the states that exclusively used electronic voting have similar characteristics. The choice of the four states with full implementation was not random. Amapá and Roraima (two remote states in the Amazon) were selected to test electoral authorities' ability to use the voting machines in isolated areas, while Rio de Janeiro and

18. I also allow for a change in slope after the cutoff has been surpassed, that is, $D_m * (r_m - c)$, when using the rdrobust package.

FIGURE 1. Electronic Voting in Brazil



Notes: In panel A, the black areas are municipalities that used electronic voting in 1998. The four states that exclusively used electronic voting are circled. In panel B, the black areas indicate the 10 percent of Brazilian municipalities that had the largest increase in the number of registered voters between 1996 and 1998.

Alagoas were selected because of their history of electoral fraud.[19] Including the states of Rio de Janeiro and Alagoas in the econometric analysis could therefore overestimate coefficients in light of their past involvement with electoral fraud.

This concern can be allayed, however, by mapping the districts with a suspicious increase in their voter rolls. Figure 1 shows all municipalities using electronic voting in 1998 (panel A) and the 10 percent of municipalities that had the largest increase in the number of registered voters between 1996 and 1998 (panel B). As the figure shows, Roraima and Amapá (circled) are the two states that had the most suspicious increase in their number of registered voters. In contrast, Rio de Janeiro did not see a suspicious increase in the number of registered voters, which has three possible explanations. First, Rio de Janeiro was being closely watched by electoral authorities, insofar as the 1994 vote-count scandal in the state was the reason electronic voting was adopted in 1998.[20] Second, Rio de Janeiro was not involved in any of the

19. "Eleitorado cresce quase 2 vezes o esperado," *Folha de São Paulo*, July 28, 1998.

20. "Santa Cruz, um ninho de fraudes," *Jornal do Brasil*, October 12, 1994; "Eleitorado cresce quase 2 vezes o esperado," *Folha de São Paulo*, July 28, 1998.

ID-related electoral scandals reported by the main Brazilian media outlets in 1998. Third, because of malapportionment, Rio de Janeiro has a large number of voters per seat, which mitigates the incentives for this kind of fraud (see below).

Next, to provide further evidence that states that solely used electronic voting have similar characteristics and are therefore comparable, I estimate equation 1 to show placebo changes in registered voters. I find that in 1994 (when all municipalities used paper ballots) and in 2002 (when all municipalities voted electronically), the percentage change in the number of registered voters is continuous around the cutoff. The only discontinuity close to the cutoff is observed in 1998, when only the treated group used electronic voting. Figure 2 presents the results. As the figure shows, electronic voting caused the number of registered voters between 1996 and 1998 to increase by 5.2 percent, while in the remaining years, the change in voter roll is continuous around the cutoff.

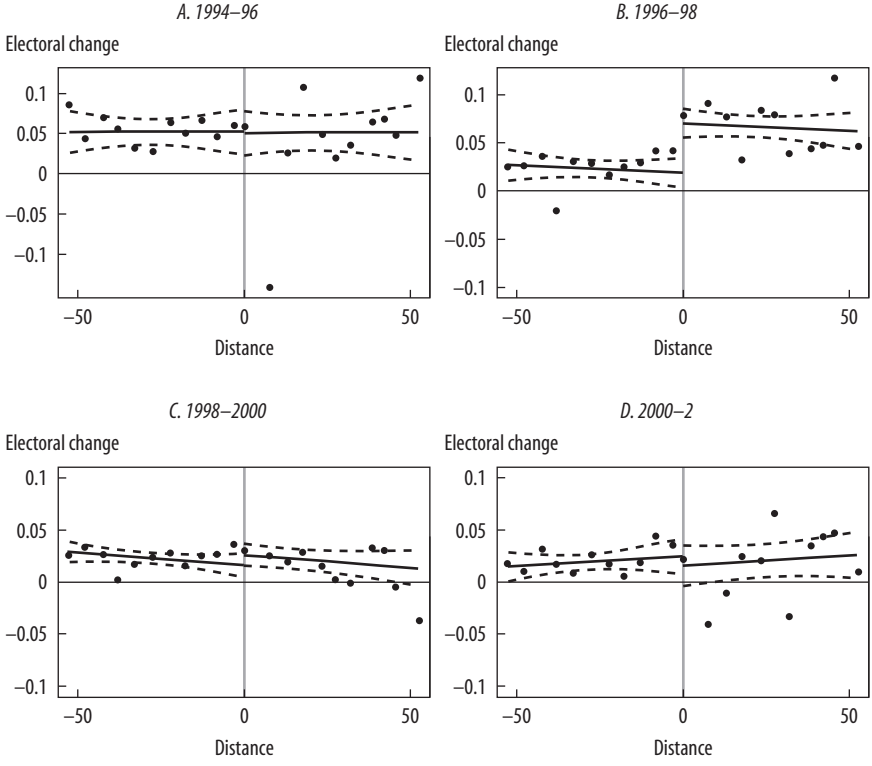
I then extend the analysis to check the validity of the comparability assumption to socioeconomic characteristics. I test whether rural population, change in population, Human Development Index, GDP per capita, and illiteracy rate are all continuous across the four state borders. As shown in table 1, the socioeconomic variables analyzed are continuous around state borders, validating the comparability assumption. These variables are also continuous around the threshold used for the population RDD, which is consistent with Fujiwara (2015).[21] Nonetheless, as I show below, the change in the number of registered voters is observed only in the geographic RDD.

Table 2 shows the effect of electronic voting usage on electoral outcomes. Using the geographic RDD, I find that electronic voting increased the number of registered voters (as shown in figure 2), votes cast, and the ratio of valid votes to turnout for federal representatives.[22] The increase in votes cast (that is, valid votes) and in the valid-votes-to-turnout ratio is expected because electronic voting made it easier for voters to cast a ballot. However, the observed positive change in registered voters was not expected a priori.

21. As mentioned, twenty-two Brazilian states implemented the new technology in municipalities with more than 40,500 eligible voters but used paper ballots in smaller municipalities. I take advantage of this cutoff point and construct a population RDD that excludes the four states using electronic voting exclusively and considers the same independent variables as the geographic RDD.

22. As mentioned earlier, under the paper ballot system, many votes were invalidated when candidates' names (or numbers) were not written legibly.

FIGURE 2. Placebo Estimations of the Electronic Voting Effect



Notes: The figure shows four time-varying functions using a 52.529-kilometer bandwidth selected by the robust bias-corrected confidence intervals proposed by Calonico, Cattaneo, and Titiunik (2014) and a vertical ine representing the cutoff point. The solid line is fitted separately on each side of the threshold, and the dashed lines represents the 95 percent confidence interval. The scatter plots show five-kilometer bins averages. Panels A, C, and D show placebo estimations using the change in the number of registered voters between 1994–96, 1998–2000, and 2000–02, respectively. Panel B shows the change in the number of registered voters between 1996–98 and captures the true electronic voting effect. *Electoral change* is graphed on the y-axis, *Distance* is graphed on the *x*-axis.

When I use the number of eligible voters as the running variable (that is, the population RDD), the results suggest that electronic voting usage per se is not causing an increase in registered voters. This finding mitigates concerns with alternative explanations for the results reported here. For instance, if electoral officials visit municipalities that are implementing the new technology more frequently in order to ensure that the system is ready to use, their presence could incentivize local authorities to do their job more effectively in terms of registering voters. This does not appear to be the case. Furthermore, the

TABLE 1. Effect of Electronic Voting Usage on Socioeconomic Variables

Dependent variable	*Geographic RDD (1)*	*Population RDD (2)*
Illiteracy rate (in percent)	2.925	−3.655
	(2.906)	(3.308)
HDI (in decimals)	−0.004	0.021
	(0.017)	(0.022)
GDP per capita (in 2000 Brazilian reais)	6.967	28.374
	(16.022)	(32.81)
$(\text{Population}_t - \text{population}_{t-1})/\text{Population}_{t-1}$	0.025	6.663
	(3.539)	(5.168)
$\text{Rural population}_t/\text{Total population}_t$	0.013	−0.048
	(0.043)	(0.055)
No. observations	342	156

Notes: The socioeconomic variables are from the 2000 Brazilian Census. The geographic RDD uses an optimal bandwidth of 52.529 kilometers; the population RDD, 7,064 eligible voters. Robust standard errors clustered at the municipal level are reported in parentheses. HDI, the UNDP's Human Development Index.

TABLE 2. Effect of Electronic Voting Usage on Electoral Outcomes

Dependent variable	*Geographic RDD (1)*	*Population RDD (2)*
$(\text{Registered voters}_t - \text{Registered voters}_{t-1})/\text{Registered voters}_{t-1}$	0.052***	0.028
	(0.014)	(0.019)
$\text{Valid votes for federal representatives}_t/\text{No. people voting}_t$	0.239***	0.202***
	(0.012)	(0.027)
$(\text{Votes cast}_t - \text{Votes cast}_{t-1})/\text{Votes cast}_{t-1}$	0.282***	0.259***
	(0.061)	(0.089)
$\text{Registered voters}_t/\text{No. people voting}_t$	−0.018	0.005
	(0.015)	(0.024)
No. observations	342	156

***$p < 0.01$.

Notes: The geographic RDD uses an optimal bandwidth of 52.529 kilometers; the population RDD, 7,064 eligible voters. Robust standard errors clustered at the municipal level are reported in parentheses.

increase in votes cast and in the valid-votes-to-turnout ratio is similar under both measures, confirming that electronic voting facilitated voting.[23]

The results presented in this subsection suggest that electronic voting increased the number of registered voters. Nonetheless, this result works exclusively for the investigation analyzing the states that fully implemented

23. The result on the votes-to-turnout ratio presented in table 2 is similar to previous findings using the population RDD, where the number of eligible voters is the running variable (Fujiwara, 2015; Hidalgo, 2012).

the new technology. I propose two explanations for this finding, both of which are related to the cost-effectiveness of fraud. First, insofar as vote-count fraud was common in Brazil, which motivated the adoption of electronic voting, it may be that vote-count fraud is superior to ballot stuffing. If this is the case, politicians in states that had both types of voting system (that is, paper and electronic) who were willing to commit fraud would concentrate their efforts in municipalities using the old paper ballot system. One way to test this hypothesis is by examining the valid-votes-to-turnout ratio, because a suspiciously high number of valid votes in Brazil served as evidence of fraud and triggered vote recounts by electoral authorities (Hidalgo, 2012). However, the problem is that electronic voting *caused* an increase in the valid-votes-to-turnout ratio by facilitating casting a ballot, which prevents me from using the new technology as an exogenous shock to study valid votes as a proxy for fraud.[24]

Second, politicians who were willing to stuff ballots should have a larger incentive to do so in districts where voters have more weight, that is, where the number of voters per congressional seat is relatively small. As Brazil has high levels of malapportionment (Snyder and Samuels, 2001), some states (districts) have a much lower ratio of voters to congressional seats. Among the eleven states considered in the geographic RDD sample analyzed, the top four states with the lowest electorate-to-seats ratio include three of the four states using only electronic voting (Alagoas, Amapá, and Roraima).[25] Therefore, the increase in registered voters observed exclusively in the geographic RDD could be explained by the fact that most of the states that fully implemented the new technology across their territory were also districts where voters have a greater weight, making ballot stuffing relatively more attractive.[26]

In the next subsection, I test whether the finding of an increase in registered voters is robust to alternative model specifications and whether population migration within Brazil can explain the result. I also test whether places that had a larger valid-votes-to-turnout ratio prior to electronic voting (as a proxy for fraud in the baseline) also had a larger increase in registered voters.

24. If vote-count fraud is more cost-effective and politicians who were willing to commit this fraud concentrated their efforts in municipalities using paper ballots, then the impact of electronic voting on valid votes reported in the literature is underestimated.

25. Amapá and Roraima have the lowest electorate-to-seats ratio in Brazil. Thus voters in these states have a much larger weight.

26. Helf and Hahn (1992) and Ziblatt (2009), for instance, discuss the connection between malapportionment and fraud.

TABLE 3. Alternative Model Specifications

	Optimal bandwidth				
Explanatory variable	*Uniform kernel (1)*	*Triangular kernel (2)*	*Triangular kernel and quadratic fit (3)*	*Half bandwidth (4)*	*Double bandwidth (5)*
Electronic voting usage	0.044***	0.050***	0.046***	0.050***	0.048***
	(0.011)	(0.009)	(0.011)	(0.017)	(0.010)
No. observations	432	588	692	185	584

***$p < 0.01$.

Notes: The dependent variable in all specifications is the change in registered voters between 1996 and 1998, measured in decimals. Columns 1–3 show results using the rdrobust package choosing a uniform kernel, triangular kernel, and triangular kernel with a second-order polynomial to fit the running variable. Column 4 shows results using half the bandwidth size chosen by the rdrobust package; column 5, double the bandwidth. Robust standard errors are reported in parentheses.

Finally, I test whether malapportionment can explain the results by checking whether districts/states that have a below-median electorate-to-seats ratio had a larger increase in registered voters.

Robustness Checks and Alternative Hypothesis

I start by checking whether the results showing an increase in the number of registered voters caused by the introduction of electronic voting are robust to different model specifications. I implement a bias-corrected nonparametric regression discontinuity estimation with robust confidence intervals using optimal bandwidth, as proposed by Calonico, Cattaneo, and Titiunik (2014). I modify the specification by using a uniform kernel, a triangular kernel, and a triangular kernel with the running variable varying quadratically. Table 3 reports my findings and shows a consistent and positive impact of electronic voting—across different model specifications—on the number of registered voters (varying between 4.3 and 5.0 percent). Results are also not sensitive to choosing different bandwidths.

An alternative explanation for the results presented here is that a disproportionately large number of voters migrated to states that used only electronic voting. Using municipal-level electoral data on the inflow and outflow of voters (that is, voters who moved to a place and reregistered there versus voters who moved away and canceled their registration), I construct a variable that subtracts the outflow in 1997–98 from the inflow and then divides by the total number of voters in 1998. I find that municipalities belonging to the four states with only electronic voting had a net inflow of voters between 1997 and 1998. However, the increase is not large enough to explain the main

TABLE 4. Effect of Electronic Voting on Number of Registered Voters, by Valid-Votes-to-Turnout Ratio

Decile of the valid-vote ratio	*Electronic voting usage (1)*	*Robust standard error*	*No. obs. to left and right of cutoff*
First	0.03	(0.04)	12;21
Second	0.02	(0.02)	18;14
Third	0.01	(0.04)	23;10
Fourth	0.05	(0.04)	13;19
Fifth	0.01	(0.04)	21;11
Sixth	0.01	(0.02)	18;15
Seventh	0.02	(0.05)	14;18
Eighth	0.03	(0.02)	16;17
Ninth	0.02	(0.05)	15;17
Tenth	0.08***	(0.02)	18;14

***$p < 0.01$.

Notes: The dependent variable is the change in registered voters between 1996 and 1998 for all specifications, measured in decimals. The geographic RDD sample is divided into tenths according to the size of the valid-votes-to-turnout ratio in the 1994 legislative elections, as a proxy for prior indication of electoral fraud. All estimations use the 52.529 kilometers optimal bandwidth. Robust standard errors are in parentheses.

results. Specifically, the net inflow of voters increased the electoral roll by just 0.4 percent. Not only is the coefficient less precisely estimated than those in table 3 but the magnitude is too small to be driving the results.

Next, I analyze whether prior evidence of electoral fraud can explain the observed increase in the electorate. If the increase in the number of registered voters is evidence of electoral fraud, then places where fraud was more likely to happen prior to the introduction of electronic voting should be driving the results. Politicians who previously manipulated electoral outcomes via vote-count fraud should be more willing to use ballot stuffing once electronic voting eliminated the former option. In several states, an abnormally high valid-votes-to-turnout ratio for congressional elections served as prima facie evidence of fraud and consequently triggered recounts (Araujo, 1998). This would be the case because, prior to electronic voting, voters had to know how to read and write in order to cast a ballot. This was a limiting factor in a developing country such as Brazil, where about one-third of the electorate was illiterate (Hidalgo, 2012).

Using this information, I divide the geographic RDD sample into tenths according to the size of the valid-votes-to-turnout ratio in the 1994 legislative elections (when all municipalities used the paper ballot system). If a larger ratio is evidence of fraud, then the number of registered voters should increase more in municipalities belonging to the top deciles. Table 4 shows evidence that this is the case: the previous results reported in this paper

TABLE 5. Descriptive Statistics: Share of Illiterates, Valid Votes, and Malapportionment

Variable	*Alagoas (1)*	*Amapá (2)*	*Rio de Janeiro (3)*	*Roraima (4)*
Share belonging to 10th decile	5.6%	37.5%	3.7%	57.14%
Share of illiterates (rank among 11 states)	1	7	11	6
Share of illiterates (national rank among 27 states)	1	16	27	14
Voters per congressional seat	460,075	87,579	637,276	62,379
Voters' influence (rank among 11 states)	4	2	9	1
Voters' influence (national rank among 27 states)	7	2	22	1

Note: The first row shows the share of municipalities in each state belonging to the tenth decile of the distribution of the valid-votes-to-turnout ratio in the 1994 legislative elections. The share of illiterate voters and voters per congressional seat are calculated using the 1991 decennial census and the 1998 legislative elections, respectively. Voters' influence increases when there are fewer voters per seat. The table reports the rank of each state within both the eleven states considered in the geographic RDD analysis and the twenty-seven Brazilian states.

showing an increase in the number of registered voters are driven by the tenth decile.

The results presented thus far suggest that the number of registered voters increased in states using only electronic voting. This result, however, is driven by municipalities that have evidence of prior electoral fraud—that is, places that had a high valid-votes-to-turnout ratio under the paper ballot system, which would trigger a vote recount (Araujo, 1998). An alternative explanation for the positive relationship between the valid-votes-to-turnout ratio and the increase in registered voters is that places with a larger share of valid votes are more developed and have more educated citizens. Therefore, these citizens would be more willing to register to vote once electronic voting was introduced because it hampered vote-count fraud and strengthened the Brazilian democracy.

Table 5 shows evidence against this hypothesis. Rio de Janeiro has the smallest share of illiterate voters among the four states using only electronic voting and one of the smallest shares in Brazil. At the same time, Rio de Janeiro has the smallest share of municipalities in the top decile of the valid-votes-to-turnout ratio. Therefore, a higher level of education does not explain the high share of valid votes, reinforcing the hypothesis that vote-count fraud is likely to be the cause of the high ratios (Hidalgo, 2012; Araujo, 1998).

Table 5 reveals that among the states that used only electronic voting, Amapá and Roraima have the largest percentage of municipalities in the top decile of the valid-votes-to-turnout ratio. At the same time, these two states have the fewest voters per congressional seat in the country. As mentioned, Brazil has high levels of malapportionment (Snyder and Samuels, 2001),

TABLE 6. Malapportionment and the Change in Voter Registration

Explanatory variable	*Full sample (1)*	*Above median (2)*	*Below median (3)*
Share belonging to electronic voting in 1998	0.050***	–0.004	0.070***
	(0.009)	(0.014)	(0.015)
No. observations to left and right of cutoff	380;208	72;62	158;120
No. observations	588	134	312

***$p < 0.01$.

Note: The dependent variable is the change in registered voters between 1996 and1998 in all specifications, measured in decimals. All regressions use the rdrobust package with triangular kernel. In columns 2 and 3, the sample is divided into states above and below the median number of voters per congressional seat. In column 2, the treatment and control groups are composed of municipalities in Rio de Janeiro and in Minas Gerais and São Paulo, respectively. In column 3, treatment and control groups are composed of municipalities in Alagoas, Amapá, and Roraima; and in Bahia, Pará, Pernambuco, and Sergipe, respectively. Robust standard errors are reported in parentheses.

so the influence of each voter varies among states/districts and is especially strong in Amapá and Roraima (the two top-ranked states for voters' influence). Thus, one may hypothesize that politicians who were willing to buy votes would focus on places where voters have greater influence or weight.

To test whether ballot stuffing efforts were concentrated in places where voters have greater influence, I split the geographic RDD sample into states that have a below-median and those that have an above-median number of voters per congressional seat. The below-median sample contains states where voters have a relatively larger weight. Table 6 presents the results. The positive change in registered voters between 1996 and 1998 was driven by states/districts where voters have a relatively greater weight. This corroborates the hypothesis that politicians who were willing to commit fraud through ballot stuffing would concentrate their efforts in places where voters had a relatively larger weight.

The estimations in tables 2, 3, and 6 indicate that in states using only electronic voting, the number of registered voters increased 4.3 to 5.2 percent on average. Can this increase be explained solely by electoral fraud? If so, is the magnitude reasonable? The average electorate size was 15,577 voters in 1996, considering the municipalities belonging to the geographic RDD analysis reported in table 2. Therefore, if ballot stuffing is driving the results, an average of 810 voters per municipality were illegally registered to vote. This is not far from the number of fake IDs found in the reports of fraud described earlier in the paper. For instance, a voter in Roraima had 622 voter ID cards in his possession.[27] Although one cannot conclude that ballot stuffing

27. "PF apreende títulos de eleitor em RR," *Estado de São Paulo*, October 19, 1998.

is driving the results, the magnitude of the findings can be reconciled with the evidence of fraud reported by the main media outlets in the 1998 federal election coverage.

Public Finance and Fraud

In this section, I analyze the impact of electronic voting on public finance, following Schneider, Athias, and Bugarin (2019). More specifically, I examine whether municipalities using electronic voting spent more on public employment, health, and education. Using a population RDD, Schneider, Athias, and Bugarin (2020) show that Brazilian legislators sent a larger amount of discretionary intergovernmental transfers to municipalities that used electronic voting. Complementing this work, Schneider, Athias, and Bugarin (2019) show that municipalities using electronic voting spent more money on public employment and also had greater public expenditure in the areas of health and education. In what follows, I test whether these findings hold in the geographic RDD analysis presented here. I also examine whether the aforementioned increase in registered voters caused by electronic voting, which may indicate ballot stuffing, is related to the electronic voting impact on public expenditure.

Table 7 reports the results. In the full sample, there was a 23 percent increase in health spending after the 1998 elections. This result is similar to the effect estimated in Schneider, Athias, and Bugarin (2019), who find a 25 percent increase in health spending. Nonetheless, the fact that there was no increase in public employment and education spending suggests that their results do not hold in the geographic RDD analysis.

One way to explain this result is that the increase in registered voters observed in the geographic RDD analysis may mitigate the increase in public spending. I examine this hypothesis by segregating the sample into the above- and below-median levels of malapportionment. As shown earlier, the increase in registered voters was driven by states with relatively high levels of voter influence, that is, fewer voters per congressional seat. As my proxy for electoral fraud is an increase in the number of registered voters, then municipalities with an above-median number of voters per seat should have relatively fewer cases of electoral fraud and, therefore, a larger response to the enfranchisement of low-income voters. As shown in table 7, municipalities in the above-median sample had an increase of 28 percent in public employment and 34 percent in health spending. The below-median sample

TABLE 7. Malapportionment and the Impact of Electronic Voting on Public Finance

Dependent variable	*Full sample* *(1)*	*Above median* *(2)*	*Below median* *(3)*
A. 1998 elections			
Public employment	0.039	0.286**	–0.084
	(0.073)	(0.120)	(0.090)
	[257;189]	[100;70]	[127;118]
Health expenditure	0.230***	0.337**	0.197**
	(0.083)	(0.149)	(0.089)
	[322;202]	[133;77]	[184;122]
Education expenditure	0.059	0.006	0.099
	(0.096)	(0.168)	(0.108)
	[270;193]	[88;67]	[157;121]
B. 2002 elections			
Public employment	0.017	0.227	–0.076
	(0.065)	(0.181)	(0.083)
	[323;200]	[117;72]	[138;118]
Health expenditure	0.067	0.072	0.050
	(0.068)	(0.131)	(0.087)
	[357;202]	[115;71]	[134;118]
Education expenditure	0.017	0.079	0.001
	(0.063)	(0.151)	(0.071)
	[374;207]	[107;70]	[162;120]

$^{**}p < 0.05$; $^{***}p < 0.01$.

Note: The dependent variables are the logarithm of total expenditure per capita in public employment, health, and education, respectively, in the four-year legislature term after the 1998 and 2002 elections. In columns 2 and 3, the sample is divided into states above and below the median number of voters per congressional seat. In column 2, the treatment and control groups are composed of municipalities in Rio de Janeiro, and Minas Gerais and São Paulo, respectively. In column 3, treatment and control groups are composed of municipalities in Alagoas, Amapá, and Roraima; and in Bahia, Pará, Pernambuco, and Sergipe, respectively. All regressions use the rdrobust package with triangular kernel. Robust standard errors are in parentheses; the number of observations to the left and right of the cutoff are in brackets.

saw a smaller increase in health spending and no change in public employment expenditure.

These results suggest that places that had a relatively larger increase in registered voters also had a smaller increase in public spending. One way of interpreting this result is that if an inflated electorate indicates ballot stuffing, then politicians in places with a larger increase in registered voters are less responsive to poorer voters' enfranchisement (that is, they offer a lower expansion of public spending). This would be the case if politicians are stuffing ballots to increase their chances of reelection without relying exclusively on voters' support. An alternative hypothesis to this interpretation is that states that use only electronic voting and have an above-median number of voters per congressional seat are relatively larger and more developed and are therefore allocated more public spending. If this were the case, then the positive

and significant results would persist after the 2002 elections. However, as shown in table 7, municipalities in states with an above-median number of voters per congressional seat did not experience the same increase in public spending over the four-year congressional term following the 2002 elections, when all municipalities used electronic voting. This falsification test mitigates concerns that the results are being driven by an omitted variable related to the use of electronic voting, especially in the sample containing a larger number of voters per congressional seat.[28]

Discussion, Policy Implications, and Concluding Remarks

This paper has presented empirical evidence that electronic voting increased the number of registered voters in electoral districts that used the new technology exclusively statewide. The most natural way of interpreting this result is that the new technology encouraged voters who were not participating in the Brazilian elections to register to vote. Although this is a plausible explanation, my findings indicate that at least part of the increase in registration may indicate the use of ballot stuffing (that is, having voters illegally vote more than once).

Prior to electronic voting, the primary mechanism for manipulating the outcome of elections was to inflate the number of votes during the manual vote count. By eliminating the manual count, electronic voting essentially eradicated this type of fraud. Therefore, politicians in electronic voting districts who were willing to conduct electoral fraud would have to use alternative fraudulent practices, such as having voters illegally vote more than once, which would inflate the number of registered voters. There are two ways for voters to cast more than one vote with the new technology: they can use fake social security cards to obtain extra voter ID cards, or they can acquire surplus voter ID cards that were not canceled when people either died or moved to a different electoral district. This sort of fraud takes place in Brazil and is a concern for electoral authorities, who are currently requiring voters to register their fingerprints for identification purposes. In the 2020 elections, 80 percent

28. I do not analyze the four-year congressional term following the 1994 elections because there is no information on public finance during this period for municipalities in the state of Roraima. This state is especially relevant because it is one of the states that exclusively used electronic voting, it had the smallest number of voters per congressional seat (that is, the greatest voter influence), and it experienced the largest increase in registered voters.

of Brazilian municipalities will implement fingerprint identification at the polling stations; this will be extended to all Brazilian municipalities in 2022.[29]

There are three main findings in this work that suggest the presence of ballot stuffing in response to electronic voting. First, electoral districts that used a mix of both paper ballots and electronic voting did not record a significant increase in voter registration in response to electronic voting. In contrast, there was a larger increase in voter registration in electoral districts where all voters used electronic voting, such that vote-count fraud was not possible. Second, municipalities that were more likely to be involved in fraud prior to the implementation of the new technology experienced a larger increase in voter registration. Finally, the results are driven by the electoral districts where voters have the most influence (that is, fewer voters per congressional seat) and thus where ballot stuffing is relatively more effective. The magnitude of the findings suggest that if the increase in registered voters solely reflected ballot stuffing, then, on average, close to 800 voters per municipality using electronic voting were illegally registered to vote. This finding can be reconciled with the anecdotal evidence presented on ballot stuffing in Brazil.

One problem with ballot stuffing is that it allows politicians to be less responsive to voters' demand (Debnath, Kapoor, and Ravi, 2017). In this paper, I find evidence consistent with this hypothesis. Electronic voting enfranchised low-income voters (Fujiwara, 2015), but not enough to guarantee that policymakers would respond to the demands of these newly enfranchised voters. Places that had suggestive evidence of electoral fraud experienced a weaker response to poor voters' enfranchisement in terms of public spending. However, places where the enfranchisement of the poor took place and where there was no evidence of electoral fraud had larger expenditures on public health and employment.

Many political practitioners fear that democracy may be endangered if only richer and better-educated voters participate in the election process, as it biases public policies toward their preferences. Meltzer and Richard (1981) show that the enfranchisement of poorer voters, by decreasing the income of the median voter, increases public spending, which is a progressive outcome to the extent that public goods are disproportionately paid for by richer citizens. Cascio and Washington (2013) provide empirical evidence that confirms this prediction in an analysis of the enfranchisement of Black voters in the

29. Gabriela Caesar, "27% dos eleitores ainda não têm cadastro biométrico no país," *O Globo*, October 9, 2019 (g1.globo.com/politica/eleicoes/2020/noticia/2019/10/09/27percent-dos-eleitores-ainda-nao-tem-cadastro-biometrico-no-pais.ghtml).

United States. Fujiwara (2015) and Schneider, Athias, and Bugarin (2019) show that the enfranchisement of poorer voters increases public health spending in Brazil. However, Meltzer and Richard's (1981) theoretical model is not always empirically corroborated. Hodler, Luechinger, and Stutzer (2015) find that the enfranchisement of less educated voters actually decreased government welfare spending and business taxation in Switzerland. The mechanism explaining this result is that less educated voters are more impressionable and susceptible to political campaigns, which are financed by interest groups that demand lower taxation. Hoffman, León, and Lombardi (2017) show that in Austria, making voting compulsory increased turnout but not government spending. They explain this result by showing that newly enfranchised voters had low interest in politics. Finally, Ardanaz and Scartascini (2013) and Machado (2012) show, respectively, that malapportionment and the lack of pro-poor candidates can also explain why politicians may ignore voter preferences.

When the enfranchisement of poorer voters does not cause the government to increase spending, democracy may lose its ability to represent most of its citizens. The results presented in this paper suggest that policies targeting voter enfranchisement should be complemented by policies that guarantee fair elections. If the main goal of enfranchisement is for public policies to reflect the preferences of all citizens, such that policymakers shape their policies in accordance with the priorities of the newly enfranchised, then guaranteeing fair elections is central to achieving this goal.

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