The Unintended Consequences of Democratic Reforms: Electronic Voting and Criminal Violence in Brazil

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Abstract

Under what conditions can democracy reduce violent conflict? We argue that, in weakly institutionalized contexts, institutional reforms that promote the rise of programmatic parties may decrease levels of violence. We exploit the implementation of a political reform in Brazil that gradually introduced electronic voting to reduce electoral fraud. Using a regression discontinuity design, we show that violence decreased by a half standard deviation in municipalities where electronic voting was first adopted, relative to those where the technology was not implemented. We show that by reducing electoral fraud and increasing enfranchisement, electronic voting eroded the power of hegemonic political machines more likely to collude with organized criminal groups. These results, we show, cannot be explained by higher investments in security or social programs. This paper sheds light on the links between criminal violence and elections, the alternatives to iron-fist policies to curb crime, and the unintended consequences of democratic reforms in weakly institutionalized contexts.

Keywords: *democratic reforms, electronic vote, violence and fraud, Brazil*

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1 Introduction

Can democracy reduce violent conflict? A robust democratic theory tradition exalts democracies for being the only political regime in which "citizens can get rid of governments without bloodshed" (Popper, 1962, 124). This rarely tested assumption holds that "the mere possibility of being able to change governments can avoid violence" (Przeworski, 2003, 13), opening the door to the peaceful regulation of conflicts. Thus elections are considered a restful alternative to rebellion (Hampton, 1994). If competing forces restrain from employing violence when alternation rules operate, we should expect less violent confrontations once societies enact democratic reforms.

While democracy offers the promise of a more peaceful society, outbreaks of criminal and political violence are not entirely alien to the existence of electoral politics and democratic institutions. In fact, countries in Latin America (Arias, 2006), Sub-Saharan Africa (Fjelde and Höglund, 2016), and South East Asia (Staniland, 2017) are riddled with cases where democratic procedures and political participation are marred with the systematic intimidation and assassination of voters and politicians.

Empirical research displays substantive variation in the relationship between democracy and violence. While countries such as Mexico, Russia, and South Africa have witnessed epidemic waves of conflict upon democratization, nations like Argentina, Chile, and Peru followed peaceful paths. Extant theories have explained cross-national or subnational trajectories through accounts based on social characteristics (Rivera, 2016), state-criminal relationships (Arias, 2013; Arias and Barnes, 2017; Barnes, 2017; Lessing, 2017), and institutional reforms (Cruz, 2011; Magaloni, Franco-Vivanco and Melo, 2020; Magaloni and Rodriguez, 2020; Trejo, Albarracín and Tiscornia, 2018).

We contribute to this debate by studying the unintended consequences of democratizing reforms for the reduction of violence. We theorize that institutional reforms that end rampant fraud and displace dominant political machines associated with criminal groups can significantly curb levels of violent conflict, even in contexts of weak institu-

tions and widespread organized crime. We empirically study this by focusing on Brazil, a least likely case for our theory: the country suffers from widespread criminal violence, yet we show the conditions under which conflict can be moderated.

To overcome methodological problems faced by prior studies and adjudicate between competing approaches, we exploit a natural experiment following previous work on Brazil (Fujiwara, 2015; Hidalgo, 2014; Zucco and Nicolau, 2016). In 1998, more than a decade after the transit to democracy, Brazilian authorities sequentially introduced the electronic voting technology as a way to reduce electoral fraud and simplify the cumbersome voting process for the country's over 5,500 municipalities. Because the reform was part of a modernization process carried out by the federal electoral justice to universally increase political legitimacy and deter election rigging, mayors and other local party activists bore no responsibility for its design and implementation. In fact, due to the country's enormous size and multilevel federal structure, only districts with an electorate over 40,500, as measured two years before the 1998 legislative elections, shifted from traditional paper ballots—associated with widespread fraud in Brazil—to electronic voting. We leverage this arbitrary and exogenous population threshold and employ a regression discontinuity design (RDD) to compare conflict levels in municipalities barely above and barely below the threshold.

We show that the adoption of electronic voting systematically reduced violence in Brazilian municipalities.[1] Our findings indicate that the "as-if-random" assignment of municipalities to treatment substantively diminished homicide rates by one standard deviation, relative to those assigned to control. Our results suggest that the effects of electronic voting on the reduction of violence are persistent and robust several years after its implementation.

Likewise, we show that the institutional reform significantly curbed electoral vio-

[1]Because data on organized crime-related murders are unavailable for Brazil, we focus on two indicators: general violence and electoral violence. These represent appropriate proxies in Brazil, where a large proportion of violence is connected to irregular groups.

lence in those districts that shifted from traditional paper ballots to electronic machines. Using original data collected by Albarracín (2018*b*), our findings indicate that municipalities barely above the threshold experienced fewer assassinations and attacks against their politicians—current of former officeholders, public employees, candidates for public office, and local party leaders—during the electoral cycle. A series of falsification tests indicate that this result does not hold before the electronic technology was introduced or after 1998, when all municipalities used the same voting procedure. Another placebo test shows that there are no significant effects in non-election years either, lending credibility to our causal estimates.

To make sense of our results, we propose a theory in which inexpensive institutional reforms, such as electronic voting, may contain levels of violence by eroding the influence of political parties most likely to collude with criminal groups. Drawing on an extensive literature, we argue that the replacement of paper ballots with electronic voting not only (i) lowered the franchise barriers, thus allowing millions of low information citizens to cast their votes in a simpler fashion, but (ii) it also managed to reduce the prevalence of electoral fraud (Hidalgo, 2014). Both factors, we argue, boosted electoral competitiveness and substantively reduced the power of subnational political hegemonic machines that tend to collude with organized criminal groups. Overall, our explanation underscores how the strengthening of programmatic parties—through lower electoral fraud and higher enfranchisement—may have had a substantial effect on the reduction of levels of violence. As such, our argument introduces an important qualification: it is not just the presence of programmatic parties, but their strengthening, in a context of cleaner elections, what contributed to the effective reduction of violence.

We provide empirical support for these mechanisms. First, we show that the reform augmented effective enfranchisement by between 10 and 33 percent. Second, in addition to qualitative evidence revealing that fraud in the vote counting process was all but eliminated, we quantitatively document the large reduction in fraud in treated mu-

nicipalities. This is, to our knowledge, the first systematic effort to empirically measure by how much election rigging vanished. Finally, and most importantly, we show that the aforementioned two mechanisms empowered more ideological and programmatic parties at the expense of personalistic, candidate-centered organizations prone to establishing close ties with criminals. We do not find, however, empirical evidence supporting alternative explanations based on political responsiveness accounts, proven influential when accounting for redistribution to poor voters, health outcomes, and the allocation of federal public spending (Fujiwara, 2015; Schneider, Athias and Bugarin, 2020). A number of placebo and robustness checks, moreover, bolster confidence in the validity of our findings.

Within the broad scholarship on democracy and violence, we engage with three distinct bodies of literature. First, our paper is most closely related to the literature on criminals and the polity. Some scholars examine the collusive relationships between politicians and criminals (Acemoglu, Robinson and Santos, 2013; Trejo and Ley, 2018), whereas others focus on the effect of different electoral rules on organized crime (Alesina, 2019). Other works suggest that democratic transitions may trigger unexpected waves of violence. For example, political changes in Latin America expected to deepen democracy, such as political and fiscal decentralization in Colombia or subnational party alternation in Mexico, have led instead to an upsurge of violence against citizens and state officials (Blume, 2017; Trejo and Ley, 2019; Chacon, 2013; Taylor, 2009). Our findings, however, support an alternative explanation: reforms that improve the quality of democracy can also diminish levels of conflict. We thus show that the quality of elections matters: limiting electoral manipulation and fostering a fair and clean political competition can at least mitigate the negative effects produced by broader regime transitions. This is especially the case in countries that underwent thin democratization processes, namely, those that moved toward electoral democracy without establishing police reforms and transitional justice mechanisms that diminish post-authoritarian criminal violence (Trejo, Albarracín

and Tiscornia, 2018).

Second, other scholars have studied the sources of police brutality and criminal violence beyond democratization. Extant research has focused on social characteristics (Rivera, 2016), police reform (Cruz, 2011) and transitional justice (Trejo, Albarracín and Tiscornia, 2018), state crackdowns on drug cartels (Lessing, 2017), varying degrees of confrontation and collaboration between criminal organizations and state officials (Arias, 2013; Arias and Barnes, 2017; Barnes, 2017), and institutional reforms such as community policing or more human criminal justice systems (Magaloni, Franco-Vivanco and Melo, 2020; Magaloni and Rodriguez, 2020). Closely tied with this latter focus, we build on this prolific research agenda and suggest that reforms that enhance the transparency of the electoral process may lead to the removal of hegemonic subnational political machines which rely on criminal brokers to maintain their incumbency status.

Third, our paper seeks to better understand the unintended consequences of democratic reforms in weakly institutionalized contexts. While the most popular response to rising levels of violence in Latin America has been the adoption of iron-fist policies, we suggest that democratic-deepening reforms may provide an effective alternative to *mano dura* strategies that frequently undermined citizen security, human rights, and the legal order (Calderón et al., 2015; Cruz, 2016; Flores-Macías and Zarkin, 2020; Holland, 2013; Magaloni and Rodriguez, 2020; Phillips, 2015). In addition, the effects of electoral manipulation have been widely studied (Cantú, 2019; Hidalgo and Nichter, 2016; Vicente, 2014), and we complement them by showing that election quality can improve substantive outcomes such as security.

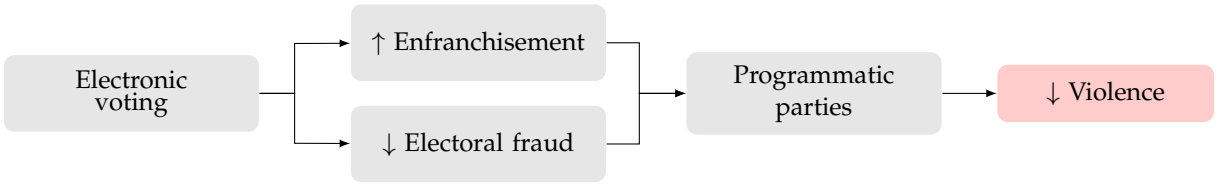
2 The Unintended Consequences of Electronic Voting

As journalists, pundits, and political analysts alike have noted, the emergence of competitive regimes in the Third Wave of democratization was frequently accompanied by a

surge in insecurity and crime. While by no means an exception, no region embodied this concomitance better than Latin America—the most violent region outside of war areas. Yet, and despite the fact that most solutions to violence in Latin America have revolved around iron-fist policies (Lessing and Willis, 2019*a*; Krause, 2014; Visconti, 2019), institutional reforms that deepen the quality of democracy may have unintended and positive consequences for peace and security.

How did electronic voting reduce homicide rates in Brazil? We contend that relatively inexpensive institutional reforms, such as electronic voting, effectively reduced levels of lethal violence by expanding the electorate and reducing fraudulent practices in the election process. As we detail below, both factors promoted the rise of programmatic political parties, while eroding the power of hegemonic political machines most likely to collude with criminal organizations. We provide a graphic illustration of our argument in Figure 1. In the following subsections, we detail the logic of the argument at each step of the causal story.

Figure 1: Theoretical Argument



2.1 How Electronic Voting Enfranchised Citizens in Brazil

While intended to reduce fraudulent practices and remove obstacles in the voting process, electronic voting had a democratizing effect: its implementation enfranchised a large contingent of voters, mostly illiterate and low-income citizens. Prior to the reform, large proportions of the electorate remained disenfranchised, as the informational demands to

cast a ballot effectively were relatively high.

Typically, casting a ballot in countries with strong parties constitutes an easy task, as voters can use the party brand as a cue to identify the political program that most closely represents their preferred position (Lupu, 2016). In contrast, in candidate-centered scenarios with high district magnitudes like Brazil, voters must opt between several (sometimes hundreds or even thousands of) candidates who run in their districts. In these scenarios, party labels are futile as they provide voters with little guidance (Marinova, 2016). This makes it hard for citizens, especially illiterate and low-income voters, to simply rely on party cues, as they provide little information to distinguish between the vast array of possibilities.[2]

Yet electronic voting in Brazil dramatically simplified the voting process, as the new machines provided voters with visual aids and feedback on every step of the process (Fujiwara, 2015). The impact of this technology was not negligible: according to some conservative estimates, it increased effective franchise in legislative elections by 10% (Fujiwara, 2015), whereas others calculate *de facto* enfranchisement augmented by 20% (de Moraes, 2012) or even 33% (Hidalgo, 2014). This represented between eight and over 25 millions "new" voters expressing their political preferences in polling stations. This was due to a substantive reduction in residual ballots after facilitation of the voting process, in particular for the poorest and least educated individuals who had difficulty in expressing their choices with paper ballots. The result was a well-documented de facto enfranchisement.

[2]Until 1998, the voting process was prone to errors and not intuitive for all swathes of population. Paper ballots did not list all possible candidates or participating political parties, but required voters to write down the name or number of their preferred options (Hidalgo, 2014). Given the large number of candidates running and different positions, blank and null votes were especially prevalent among illiterate voters (Hidalgo et al., 2010; Zucco and Nicolau, 2016).

2.2 How Electronic Voting Reduced Fraud

The implementation of electronic voting also constituted an important step towards the reduction of electoral fraud. Before the technology was in place, the counting and reporting of ballots was a cumbersome process that left the possibility open for manipulation. As a decentralized process, it was vulnerable to the penetration of political machines, which resorted to electoral manipulation to maintain their incumbency status across the country.

Electoral fraud is a costly operation usually involving a well-oiled machinery of party members, state employees, and election officials (Harvey, 2016; Simpser, 2013). While electoral fraud faces the challenge of collective action and coordinating between agents (Rundlett and Svolik, 2016), its clandestine and silent nature may make it an effective tactic to secure electoral victories (Lehoucq, 2003). Yet external changes in how the election takes place, such as election observers (Asunka et al., 2019) or security-enhancing technology, may significantly reduce the prospects for effective fraud.

In the case of Brazil, electronic voting machines protected elections from fraudulent tactics. The newly implemented technology reduced the potential for fraud at several stages by switching from a decentralized process, prone to manipulation by subnational machines, to a centralized insulated electoral bureaucracy that managed to minimize fraud during the vote count. The evidence to support this, though indirect, is revealing: while electronic voting had a negligible effect on the vote share for the incumbent coalition in regions with competitive party systems, in regions with hegemonic ruling parties, it had a negative effect on the support for incumbent candidates (Hidalgo, 2014). The reform removed most of the fraud employed by conservative dominant machines to hold onto power.

As the manipulation of electoral results subsided, the political competitiveness of subnational units governed by political machines increased: the vote shares of candidates affiliated to the governor's ruling coalitions substantively diminished in these states. In

the following subsection, we describe how the removal of subnational hegemonic machines led to the reduction of violence.

2.3 The Removal of Subnational Hegemonic Machines

Both enfranchisement and the reduction of fraud increased political competitiveness and undermined the influence of conservative political machines. On the one hand, "newer" voters were more likely to cast a party-list vote, which harmed personalistic and candidate-centered organizations while aiding ideologically coherent organizations. Moreover, mitigating the pervasiveness of fraud diluted the power of incumbent conservative machines that manipulated the vote count to stay in power.

Before the introduction of electronic machines, election fraud represented a crucial tool used by ruling political machines to maintain their hold onto power. They did so mainly by penetrating a decentralized vote tallying process in which *juntas apuradoras* (tallying committees) were in charge of counting votes (Hidalgo, 2014). Although in principle citizens appointed to those committees were unrelated to ruling machines as members were selected based on integrity and virtue (*notória idoneidade*), dominant hegemonies were frequently able to reach them out and ensure their favor, especially in rural areas and the country's northeast (Viana, 1988).

Under electronic voting, the centralization of the tabulation process, in an insulated and professional bureaucracy, made it almost impossible for incumbents to manipulate the tallying process—a practice known as *mapismo* by which machines altered polling station tabulation sheets in their favor. As a result of the reform, the share of votes conservative machines achieved significantly diminished. By some accounts, the centralization of the counting process led to a decrease of some 20 percentage points was registered in states where local hegemonies controlled subnational governments (Hidalgo, 2014). In many instances such a decline was more than enough to replace them with programmatic parties, which substantially increased their vote share.

2.4 The Decline of Hegemonic Machines and Violence

As our argument suggests, the introduction of electronic voting led to a reduction of levles of violence, as a result of the decline of personalistic and candidate-centered parties. Why did this happen? Our central claim is that the type of political party in office is not trivial for criminal politics: politicians from weak and personalistic parties are more likely to establish agreements with criminal groups relative to politicians from strong and programmatic parties.

Unlike weak parties, strong and institutionalized political parties reduce the incentives for violent electoral manipulation and electoral violence against political competition (Fjelde, 2020). Indeed, as Mares and Zhu (2015) show for the case of Germany, candidates from weak parties sought alliances with both state employees and private actors to engage in electoral intimidation. In Brazil, weak and personalistic political parties have more frequently built close ties with criminal groups than stronger party organizations, such as the PT (Albarracín, 2018*b*). Armed actors, in cases such as Brazil and Colombia, have been able to amass disproportionate political power in areas where clientelism and weak parties have been the norm (Arias, 2018, 2017). In Colombia, while members of both traditional parties—Liberal and Conservative—engaged in alliances with paramilitary groups, the core of the alliances was comprised of third and weakly organized parties with a personalistic platform (Acemoglu, Robinson and Santos, 2013).

When political competition is dominated by personal political organizations, each organization and candidate is expected to mobilize voters and acquire resources needed to maximize the number of votes. For one, this entails clientelistic practices such as vote buying to organize networks of supporters. But the lack of strong parties also encourages alliances with criminal groups, which often control local territories and populations and possess a deep knowledge of individuals living under their criminal rule (Lessing and Willis, 2019*a*; Magaloni, Franco-Vivanco and Melo, 2020). In other words, partnering with criminal brokers grants politicians access to voters, but also allows the exclusion

of political adversaries, offering a substantial comparative advantage in elections (Albarracín, 2018*b*). This mechanism is especially relevant in Brazil, as political brokers are also local candidates and thus have a vested interest in election results, but also allow them to shift partisan loyalties in search for better returns (Novaes, 2018).

2.5 Hypotheses

In sum, our theory suggests that, through enfranchisement and fraud reduction, electronic voting inadvertently contributed to the demise of parties that were more likely to favor criminal structures—responsible for a large part of Brazil's violence. Electronic voting, accordingly, contributed to the systematic reduction of homicide rates in Brazilian municipalities by strengthening more robust parties and eroding the power of political machines most likely to establish relationships with criminal groups.

The preceding discussion suggests the following hypotheses:

H1 Violence: The introduction of electronic voting had a negative effect on violence.

H2 Enfranchisement: Electronic voting lowers franchise barriers by diminishing the proportion of unintended invalid votes.

H3 Fraud: Electronic voting decreases electoral fraud.

H4 Political Machines: Electronic voting increases vote share of programmatic parties at the expense of political machines.

3 Brazilian Parties and Criminal Violence

This section describes the implementation of electronic voting, the nature of political competition in Brazil, and the landscape of criminal violence and politicians in Brazilian electoral politics.

3.1 Institutional and Electoral Context

Brazil is the largest Latin American federation, hosting some 210 million people. Its bicameral Congress is divided into a 81-member Senate (three for each of its 27 states) whose members are elected for an eight-year term and a 513-member Chamber of Deputies whose members serve for four years. The district magnitude varies from eight to 70, depending on states' population.

Shortly after the transition to democracy in 1985, Brazil's party system was characterized by its high electoral volatility, party indiscipline, and weak linkages between voters and politicians (Mainwaring and Scully, 1995). With over 30 parties across 5,570 municipalities, the country arguably has the most fragmented party system worldwide. Creating new parties is neither a difficult task nor an uncommon practice. For example, President Jair Bolsonaro left his already fractious right-wing Social Liberal Party (PSL) in November 2019—less than a year after assuming office—and launched a new one.

The country's highly fragmented party system may seem puzzling, as party competition is not structured around class, religious, ethnic, or racial cleavages. Yet its electoral rules foster both inter- and intra-party competition. Brazil's open-list proportional system allows voters to select a party list or individual candidates, which rewards individual candidates' esteem as well as their personal connections and clientelistic ties with voters.

The personalistic political machines were not a democratic creation, though, as they predated the 1964 coup. During the First Republic (1889–1930), for instance, local notables (*coronéis*) employed their private wealth, public resources, connections, and coercion to attract votes (Feierherd, 2020). Local politicians perform fundamental roles in contemporary Brazil too (Ames, 1994; Novaes, 2018). Many of them were tied to the PMDB (Party of the Brazilian Democratic Movement) before the military regime that ruled until 1985, and represented the party's roots once democratization occurred. In fact, the PMDB is typically considered a federation of state-level electoral machines (Hagopian, 1996).

Since the late 1990s, nevertheless, Brazil's party system began a gradual transformation. Its inchoate system that granted primacy to individualism through highly personalistic appeals and frequent party switching gave way to increasing stabilization, as electoral volatility declined in a context in which the same two parties, offering alternative policy choices, dominated presidential races (Santos, 2008). In addition, parties heightened their territorial penetration and strengthened organizationally, becoming more important players (Mainwaring, Power and Bizzarro, 2018). All these changes notwithstanding, the only party that crafted mass attachments and developed strong organizational roots—through alliances between unions, Catholic groups, social movements, and leftist intellectuals—is the Workers' Party (PT).

3.2 Criminal Actors and Politicians

Brazil provides an ideal setting to study how democratizing reforms affect criminal violence: despite the transit to democracy—followed by other democratizing reforms such as electronic voting—violence took hold of local politics in several regions across the country. As Hoelscher (2015) finds, violence during the military regime was uniform across all states, but after democratization, homicide rates took divergent trajectories across these states. By the start of the 21st Century, Brazil had one of the highest homicide rates in South America only followed by Colombia and Venezuela. Since the mid-1980s, Brazilians have perceived violent crime as the principal problem they face in their daily lives (Caldeira and Holston, 1999). While some of the literature on Brazil emphasizes the role of inequality, youth bulges, and the rise of drug trade (Ceccato, Haining and Kahn, 2007; Murray, Cerqueira and Kahn, 2013; Cerqueira and Lobâo, 2003) increasing evidence overwhelmingly points to the coexistence of electoral politics and criminal actors as an additional key driver of violence. Over time, the nature of criminality has mutated to a more organized type of violence with the rise of drug-trafficking organizations and militias as well as the intensification of state repression. Indeed, in 1998 federal and state legislatures

set up congressional investigative committees to prosecute OCGs through witnesses, warrants of arrests, and reviews of bank and phone accounts (Caldeira and Holston, 1999).

There exists wide spatial variation in homicide rates in Brazil. An abundant literature has documented the magnitude of the problem, both in the countryside (Alston, Libecap and Mueller, 1999; Hidalgo et al., 2010) and urban settings (Arias, 2006), with a special focus on *favelas*, informal urban settlements of squatters where state penetration has been precarious. Many of these areas are controlled and disputed by criminal factions involved with drug-trafficking operations. Urban areas with low state presence became attractive spaces for groups such as Comando Vermelho (CV) and Primeiro Comando da Capital (PCC) that sought to establish control over the territory and the retail drug trade in cities such as Rio and São Paulo. The CV's origins can be traced back to the military dictatorship in the 1970s, when left-wing militants and common criminals in prison allied for self-protection and drug trade in subsequent years. Similarly, inspired by the CV's experience, the PCC was born in Sao Paulo's prison system in the 1990's and grew to be Brazil's largest criminal organization with presence in all 27 states (Lessing and Willis, 2019*a*; Insight Crime, 2018). Due to mass incarceration policies, the prison population between 1997 and 2007 grew faster than in any other Latin American country (Walmsley, 2010) and ended up emboldening criminal networks by giving them leverage over street-level criminals (Lessing and Willis, 2019*b*). As a reaction to the presence of these groups, Brazil has also witnessed, since at least the 1908s, the emergence and expansion of militia groups, most of which involved the participation of local residents, business leaders, and police officers (Hidalgo and Lessing, 2015).

Criminal involvement in politics is not a rare occurrence in Brazil. Extensive qualitative and quantitative information has suggested that relationships between criminal groups and politicians in Brazil are widespread and take multiple forms (Bailey and Taylor, 2009; Albarracín, 2018*a*). Moreover, clientelistic networks play an important role in sustaining criminal presence in electoral politics: it is through preexisting networks of

social leaders and civic organizations that criminal groups are able to have access to local populations and state resources (Arias, 2006). While much of their presence and control can be attained in non-violent ways, violence does constitute an important component of their repertoire. Criminals may use violence against voters and state officials to restrict political competition and ultimately shape policy-making in the areas they seek to control. Violence against politicians can be used as a means to promote friendly candidates, prevent potential challengers to run for office, and against voters to shape their political preferences at the booths. Politicians, of course, are not simple victims of criminals' objectives, but agents of their relationships, especially in cases where parties are weak and political labels are unimportant (Albarracín, 2018*a*). In some cases, outbreaks of violence may emerge when relationships between politicians and local gangs weaken and when the state decides to increase political repression against them (Lessing, 2017).

4 Testing the Theory: Data and Empirical Strategy

4.1 Data

In the next sections, we estimate the temporal and spatial effects of transparency-enhancing reforms on violence. The main outcome of interest is operationalized as the number of homicides per 100,000 inhabitants in a given municipality. To measure our main dependent variable, we retrieved information from DATASUS, the Ministry of Health's mortality information system.[3] Despite official statistics might result suspicious in cases of state officials-criminals collusion, DATASUS is regarded as a highly reliable source and has been widely used by the academic community. We use the municipality as our spatial unit of analysis because as it is the level where electronic machines were introduced for the 1998 legislative elections. We assess the annual evolution of violence across Brazilian municipalities. Figure A2 of the Appendix plots municipal-level homi-

[3] http://tabnet.datasus.gov.br/cgi/deftohtm.exe?sim/cnv/obt10br.def, accessed October 24th, 2019.

cide rates between 1997 and 2000, and shows that higher levels of violence are not only concentrated in metropolis like Rio or Sao Paulo, but also in the country's center and northeast.

Even though homicide rates are not a perfect indicator of criminal violence, several recent studies have relied on this widely-available statistic to measure the level of criminal conflict where finer-grained data are not available (e.g., Trejo, Albarracín and Tiscornia, 2018; Dube, Dube and García Ponce, 2013; Dube and Naidu, 2015; Magaloni, Franco-Vivanco and Melo, 2020; Sobrino, 2019). Implicitly or explicitly, these studies follow the United Nations in defining countries with "epidemic" levels of violence when their homicide rates are above 10 per 100,000 inhabitants (UNDP, 2013). According to this definition, thus, most murders in countries such as Brazil, Mexico, and El Salvador can be attributed to OCGs, whereas in Argentina, Chile, and Uruguay most killings are committed by ordinary criminals. In the period we study, Brazil's homicide rate was always above 25 per 100,000 population (Waiselfisz, 2013), suggesting that our measure captures a large portion of organized criminal violence.

We complement homicide rates with data on electoral violence (Albarracín, 2018*b*). These data, generated from national and regional newspaper articles, aggregate assassination and assassination attempts against politicians. The dataset comprehends murders and attacks against current and former officeholders (city councilors, mayors, state and federal deputies, and governors), public employees (municipal and state secretaries), political candidates and local party activists. Thus our second outcome is a count variable that measures the intensity of criminal electoral violence for each municipality-year.

Contrary to other previous literature that solely focus on attacks against mayors (e.g., Ríos, 2012), Albarracin's data allow us to extend the analysis to a broader range of state authorities and public employees. As noted by Trejo and Ley (2019) in their work on high-profile criminal violence in Mexico, this is relevant as criminal organizations frequently target candidates, party leaders, and subnational bureaucratic structures. These

data also allow us to avoid the bias found in some studies that exclusively focus on successful assassinations, which significantly underestimate the degree of violence OCGs can employ.

We analyze the effect of electronic voting in the whole territory but in four states, where the new technology was introduced in every municipality regardless of their electorate size: Alagoas, Amapa, Rio de Janeiro, and Roraima. Municipalities in these four states represent only 4% of the total number of municipalities. While all municipalities in Alagoas and Rio adopted electronic voting because electoral rigging was especially critical, the logic in Amapa and Roraima rested on the attempt to check electoral authority's capacity to distribute the machines in remote and isolated areas. Because our final sample does not include some municipalities were both fraud and violence were particularly severe, we believe our estimates might be somewhat conservative. In other words, had Rio de Janeiro and Alagoas been included, the effects we detect would have plausibly been larger.

Electoral data come from the federal electoral authority (*Tribunal Superior Eleitoral—TSE*), which published the list of municipalities that effectively used electronic voting. Figure A1 plots 1998 electorate size and the municipal level and shows those municipalities where electronic voting was adopted. The reports indicate almost perfect compliance.[4] Further information on municipal characteristics comes from the 1991 Brazilian Census and the agricultural census of 1995 by the Brazilian Institute of Geography and Statistics (IBGE).

Additional covariates employed in this study for robustness and balance tests come from data collected mostly by Hidalgo et al. (2010). These include the following variables: agricultural income, the number of banks in a municipality, a human development index, the proportion of individuals living under extreme poverty, mean income and land inequality, the proportion of the landless population, GDP per capita (logged),

[4]Only seven out of 5,281 (0.001%) below the cutpoint had their formal petitions to use electronic machines approved by the TSE. Because noncompliance was so negligible, it does not alter the results.

the security and social budgets (logged), the annual rain deviation (as weather conditions have been often related to levels of conflict), and the unemployment rate.

4.2 Empirical Strategy: Regression Discontinuity Design

One possible way to estimate the effects of electronic voting on violence would be to regress homicide rates on the presence of the electronic machines. The problem, however, is that the presence of electronic voting, which is a function of the electorate size, is directly correlated with a broad number of geographic, political, and socio-economic factors. Consequently, a naive comparison between municipalities with and without electronic voting may confound the effect of other municipal-level characteristics.

To address this problem and estimate effects that are plausibly causal, we use a regression discontinuity design (RDD). RDD compares the outcome barely above and just below a certain threshold that determines assignment to treatment. Given that this cutoff is arbitrary, treatment and control units are expected to be similar in every covariate. In other words, insofar as the other municipal features vary continuously with the running variable—electorate size in our case—any difference in the outcome may be attributed to the treatment. If it is true that the treatment is as-if-random, then every other covariate should be balanced between control and treatment groups. In the Appendix, we provide extensive evidence that differences between treated and controlled municipalities in economic and social variables—such as GDP per capita, rural and overall population, land inequality, and education—are close to zero and statistically insignificant.

Mirroring previous studies that analyzed the effects of electronic voting (Hidalgo, 2014; Fujiwara, 2015; Zucco and Nicolau, 2016), the electorate size is our forcing variable that determines whether electronic machines or traditional paper ballots were used. In particular, electronic voting was adopted only in districts with over 40,500 population, as measured two years before the 1998 legislative elections. Formally, a municipality m received treatment T if

$$T_m = \begin{cases} 1 \text{ if electorate (t-2)} \geq 40{,}500 \\ 0 \text{ if electorate (t-2)} < 40{,}500 \end{cases}$$

Following conventional practice in the literature, we estimate local polynomial regressions with triangular kernel functions and one common MSE-optimal bandwidth selector. Concretely, while our main results stem from estimations with local linear polynomials ($p = 1$), we also report results with quadratic polynomials ($p = 2$) for robustness purposes. Because higher-order polynomials ($p > 2$) have been shown to return misleading confidence intervals, noisy weighted averages of the outcomes for the treated and control units, and sensitivity to the degree of the polynomial (Gelman and Imbens, 2019), we restrict our analyses to linear and quadratic estimations.

More specifically, because the bandwidth adopted by researchers entails a trade-off between efficiency and bias, we follow Calonico, Cattaneo and Titiunik (2014) and employ the optimal bandwidth, the bias corrected estimator, and robust standard errors. These represent an improvement upon non-parametric local polynomial estimators commonly used to create confidence intervals for treatment effects.

5 Empirical Findings

5.1 Baseline Results

Table 1 reports our main results implementing Calonico, Cattaneo and Titiunik (2014) non-parametric estimates for the period 1998-2002. Our main findings indicate that the as-if-random adoption of electronic voting machines leads to a substantive and statistically significant reduction in violence in Brazilian municipalities. Panel A presents the results stemming from first-degree local polynomials, whereas Panel B displays results of quadratic polynomials. Because covariates should not have an important impact on our

results, Table 1 does not include any controls. We, however, incorporate covariates to our main specification to improve the precision of our estimates and report the results in the Appendix.

Our results indicate that, whether we employ a linear or a quadratic polynomial, electronic voting diminishes violent conflict during term in office. Our results are significant in all specifications, although they are generally substantively larger in the quadratic specification.

Table 1: RD Effects of Electronic Voting on Homicide Rates

	Panel A: Linear polynomial *Homicide rates by period:*					
	1998	1999	2000	2001	2002	1998-2002
Electronic voting	-6.63^{**}	-6.86^{**}	-8.05^{**}	-6.79^{**}	-5.63^{*}	-6.83^{**}
	(3.00)	(3.15)	(3.29)	(3.31)	(3.25)	(2.92)
Total observations	5084	5084	5084	5084	5084	5084
Effective observations	584	452	553	562	620	531
Bandwidth	0.67	0.53	0.63	0.64	0.71	0.60
	Panel B: Quadratic polynomial *Homicide rates by period:*					
	1998	1999	2000	2001	2002	1998-2002
Electronic voting	-11.37^{***}	-9.76^{***}	-8.46^{**}	-8.37^{**}	-5.94^{*}	-8.83^{***}
	(3.48)	(3.62)	(3.63)	(3.78)	(3.36)	(3.27)
Total observations	5084	5084	5084	5084	5084	5084
Effective observations	651	670	930	846	1409	797
Bandwidth	0.67	0.53	0.63	0.64	0.71	0.83

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

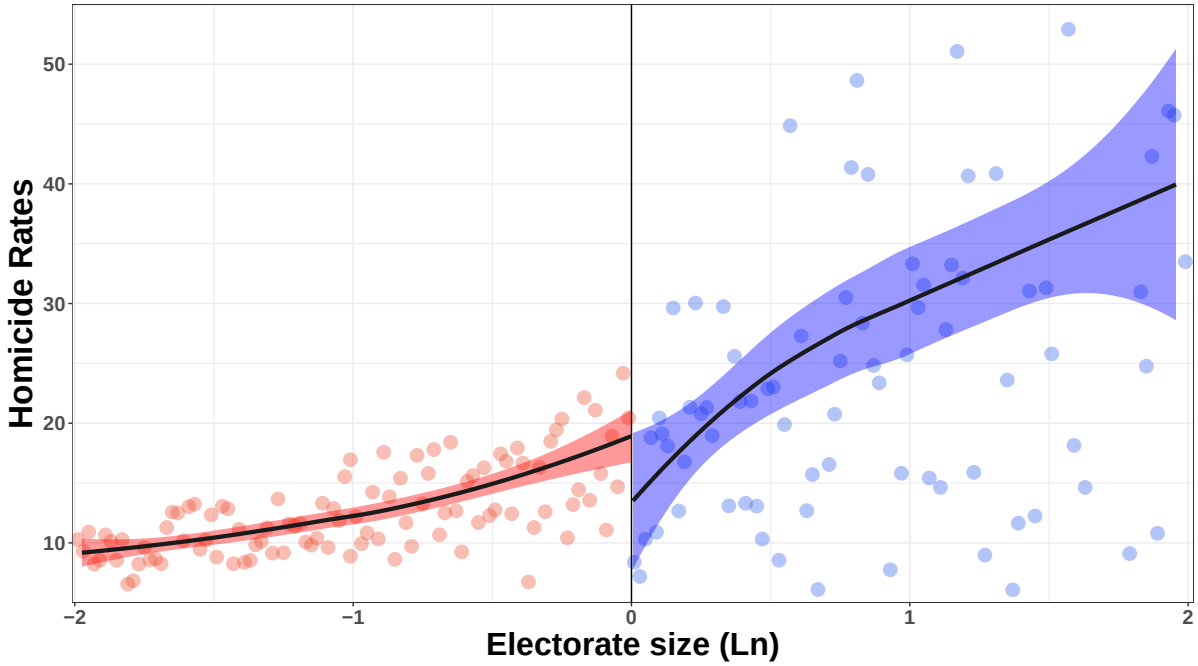
Note: All models are based on local polynomial regressions with robust biased-corrected confidence intervals, triangular kernel functions and use one common MSE optimal bandwidth selection procedure (Calonico, Cattaneo and Titiunik, 2014).

Panel A suggests that the introduction of electronic voting resulted in a reduction of 5.63 to 8.05 in the homicide rates per 100,000 inhabitants. This represents a substantively relevant decrease, as it is equivalent to 1.2 to 1.7 times the 1997 sample mean and 36%-52% of its standard deviation. Equally important, we find null effects when we use 1997 homicide rates as the dependent variable, one year prior to the introduction of electronic voting. Likewise, when using quadratic polynomials (Panel B), we find even more

substantial results: electronic voting diminished violence by 5.94 (as of 2002) to 11.37 (in 1998) murders per 100,000 population.

Figure 2 visually illustrates our results. The graph normalizes the (logged) electoral size in 1996 to set the cut point to zero and plots the effect of EV on homicide rates employing a second-degree local polynomials. The plot shows an evident negative jump in levels of violent crime across the cutoff.

Figure 2: Effect of Electronic Voting on Homicide Rates



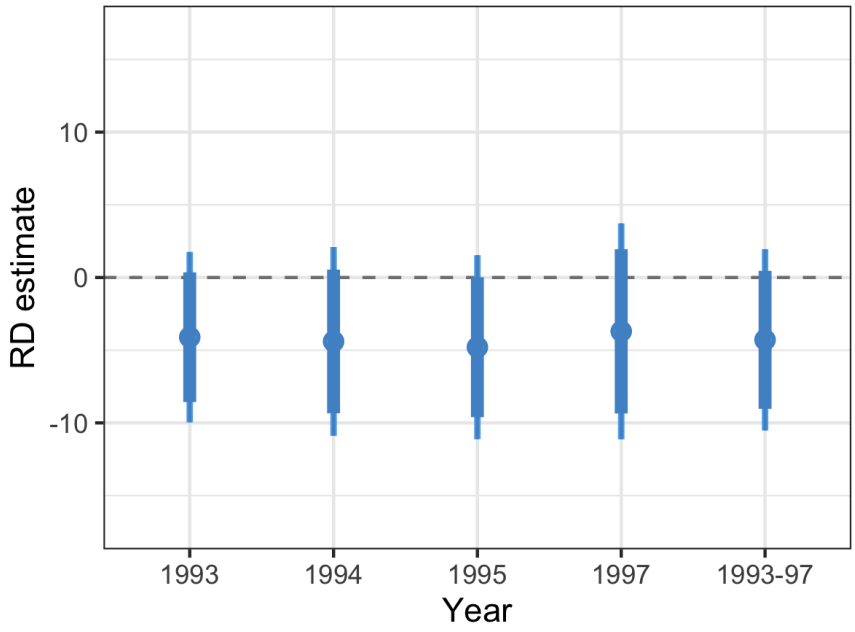
Note: The forcing variable is the electorate size (logged) normalized to set the cut point to zero. The graph plots a quadratic polynomial. Points are averages in equal-sample-sized bins of the horizontal axis variable.

5.2 Placebo and Falsification Tests

While our research design allows us to credibly estimate the effect of electronic voting on lethal violence, we provide a series of additional tests that gives us the confidence that

it was the introduction of electronic voting in 1998, and not other factors, what led to a reduction in homicide rates. Concretely, we conduct a series of falsification tests using different cutoffs, pre-treatment outcomes, and a measure of political assassinations.

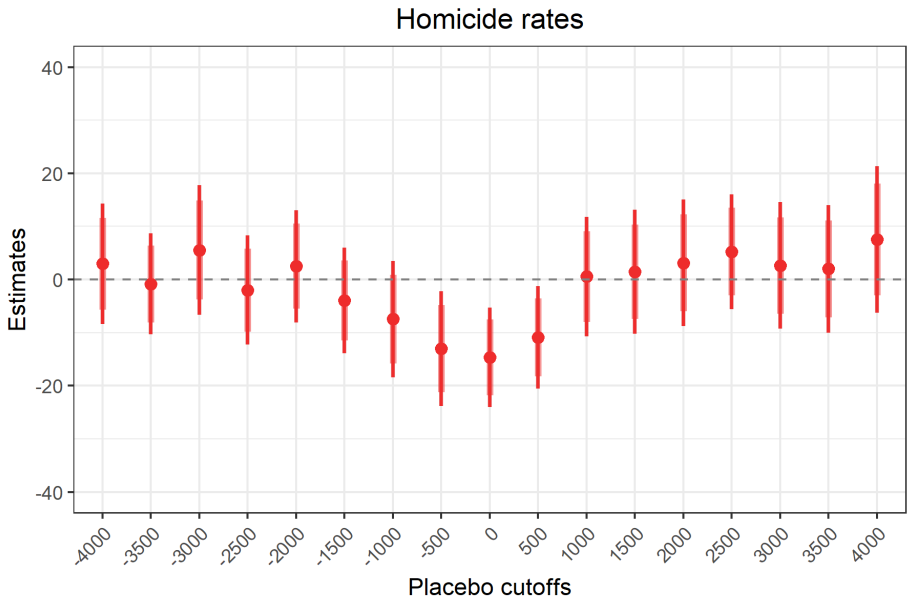
Figure 3: Placebo Test: Pre-Treatment Homicide Rates



Note: The graph plots robust bias-corrected RD estimates with 95 and 99 confidence intervals. As it is the case with the main results, all models are based on local polynomial regressions with robust biased-corrected confidence intervals, triangular kernel functions and use one common MSE optimal bandwidth selection procedure.

First, we use pre-treatment homicide rates as a placebo test. Because municipal-level homicide rates changed as a result of electronic voting, we should not expect to see statistically significant changes prior to its introduction in 1998. We plot yearly RD estimates for the 1993-1997 period, as well as its average, with 95 and 99% confidence intervals. As suggested by Figure 3, electronic voting does not have a statistically significant effect on homicide rates prior to 1998 at conventional levels. Moreover, the results are particularly insignificant in 1997, one year before the treatment year.

Figure 4: Effect at Different Cutoffs (Placebo Test)



Note: The forcing variable is the electorate size (logged) normalized to set the cut point to zero. As it is the case with the main results, all models are based on local polynomial regressions with robust biased-corrected confidence intervals, triangular kernel functions and use one common MSE optimal bandwidth selection procedure.

We also examine whether the treatment effect yields statistical significance when using other cutoffs across the range of the forcing variable. We plot the results in Figure 4. It is around the 40,500 cutoff where we should observe an effect of EV on violence. A propensity to observe significant discontinuities in correspondence of placebo cutoffs would cast doubts on the smoothness assumption behind our RD design. Thus if our empirical design is valid, we should not expect electronic voting to have negative and statistically significant effects in cutoffs different from the one that actually assigned towns to treatment and control groups. The placebo test shows that the treatment effect is only significant close to the cut point, but it vanishes and becomes statistically insignificant once we move away from the threshold. Consequently, the tendency to find significant jumps away from the actual cutoff is very low. Consistent with the baseline results, therefore, violent crime diminishes close to the true cut point, but there is no registered discontinuity

in other thresholds.

Lastly, we conduct a falsification test using political assassinations and murder attempts as an outcome variable. Our theory predicts that electoral violence should have also diminished in treated municipalities in 1998, when electronic voting was adopted in districts with an electorate size over 40,500 (as of 1996). Because this type of violence occurs in election time, we should not observe a significant drop in the number political assassinations and attacks in non-electoral years. Moreover, we should not expect any significant change in such violent events during electoral years in which all municipalities employed the same voting procedure (as occurred in 2000).

Table 2: RD Effects of Electronic Voting on Electoral Criminal Violence

	Assassinations and murder attempts			
	1998	1999	2000	2001
Electronic voting	-0.014^{*}	-0.002	0.005	-0.010
	(0.008)	(0.003)	(0.005)	(0.013)
Total observations	5237	5237	5237	5237
Effective observations	3128	380	248	403
Bandwidth	2.05	0.45	0.28	0.47

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Note: All models are based on local polynomial regressions with robust biased-corrected confidence intervals, triangular kernel functions and use one common MSE optimal bandwidth selection procedure (Calonico, Cattaneo and Titiunik, 2014).

Table 2 reports the results of the effect of electronic voting on murders and assassination attempts. We find that electoral violence substantively diminished in 1998, when only some municipalities employed electronic machines and others still used traditional paper ballots. The magnitude of the effect is substantial: it represents roughly a third of the variable's standard deviation and almost ten times its mean for 1998. Furthermore, and consistent with our argument, we fail to find significant results for non-election years

(such as 1999 and 2001) and the following election year in which all municipalities used electronic voting (2000).

6 Mechanisms

Thus far we have empirically shown that the introduction of electronic voting reduced criminal violence in Brazil. According to our argument, the introduction of this technology curbed violence by undermining the power of non-programmatic political parties most likely to collude with criminal groups. If this is the case, and following the implementation of electronic voting, we should expect to observe an increase in the valid votes-turnout ratio, a reduction of electoral fraud, and an growth in the vote share of programmatic parties. In this section, we provide additional empirical evidence that lends support to our interpretation of the causal process.

Table 3: Mechanisms I: Electoral Fraud and Enfranchisement

	Electoral Fraud					*Enfranchisement*
	(1)	(2)	(3)	(4)	(5)	(6)
Electronic voting	-0.23^{***}	-0.07^{**}	-0.24^{***}	-0.06	-0.21^{**}	0.22^{***}
	(0.08)	(0.03)	(0.08)	(0.08)	(0.09)	(0.01)
Total observations	5084	5084	5084	5084	5084	5237
Effective observations	844	1286	1019	880	1019	1383
Bandwidth	0.87	1.15	0.99	0.89	0.99	1.21

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Note: All models are based on local polynomial regressions with robust biased-corrected confidence intervals, triangular kernel functions and use one common MSE optimal bandwidth selection procedure (Calonico, Cattaneo and Titiunik, 2014).

We begin by investigating the reduction of fraud. We use a digit-based approach to measuring fraud. Election fraud was systematically used by conservative political machines to maintain their influence. To a great extent, the introduction of electronic voting was conceived of as a way to decrease such levels of electoral manipulation (Hidalgo,

2014). A digit-based approach for measuring fraud detects electoral manipulation in reported vote counts. If elections are fair, last digits and digit sequences should follow a uniform distribution (Beber and Scacco, 2012). We use results from the 1998 Federal Chamber of Deputies election from more than 280 thousand 'electoral sections' clustered within Brazil's 5,513 municipalities. More specifically, we use total vote counts as well as votes received by PT, PSDB, and PMDB—the three parties with the most widespread territorial penetration in Brazil.

We present the results in Table 3. The outcomes of interest are a set of dichotomous variables indicating the suspicion of electoral manipulation in electoral outcomes. Columns 1 and 2 identify municipalities with at least one suspicious digit proportion across multiple vote columns (in each party result) *and* in the total vote column, respectively. Measures of fraud in columns 3 through 6 adopt a stricter approach by measuring the extent to which digit frequencies vary. The coefficients suggest that electronic voting reduced electoral fraud between 0.42 and 0.54 standard deviations. Overall we find compelling evidence across all measures, except one, that municipalities where electronic voting was adopted experienced less electoral fraud relative to those where electronic voting was not implemented.

We also examine how electronic voting affected de facto enfranchisement. To measure de facto enfranchisement, we follow (Hidalgo, 2014) and use the proportion of invalid votes, both blanks and null, in treated municipalities. As column 6 of Table 3 indicates, electronic voting increased the valid votes-turnout ratio by 22 percentage points, a highly substantive result.

Lastly, we examine the effect of electronic voting on the vote share of programmatic political parties. Programmatic parties with strong brands not only have robust linkages with civil society, but also enjoy a tighter control over their members able to regulate and sanction undesired behavior within their ranks (Kitschelt and Wilkinson, 2007). In contrast, politicians in non-programmatic parties are more weakly monitored

Table 4: Mechanisms II: Vote Share of Programmatic Parties

	Programmatic parties			*Non-programmatic parties*	
	(1) PT	(2) PT-PPS-PV	(3) PT-PPS-PV-PSDB	(4) PMDB	(5) PSC-PRTB-PFL
Electronic voting	0.04^{*}	0.05^{**}	0.10^{***}	-0.01	0.02
	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)
Total observations	5237	5237	5237	5237	5237
Effective observations	611	578	591	644	539
Bandwidth	0.70	0.66	0.67	0.73	0.62

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Note: Dependent variable for model 1 is vote share of PT, for model 2 is vote share of PT, PPS & PV, model 3 is vote share of PT, PPS, PV & PSDB, and model 4 is vote share of PSC, PRTB & PFL. All models are based on local polynomial regressions with robust biased-corrected confidence intervals, triangular kernel functions and use one common MSE optimal bandwidth selection procedure (Calonico, Cattaneo and Titiunik, 2014).

and more autonomous with respect to their parties, which lowers the costs of establishing relationships with private actors, including criminal groups (Albarracín, 2018*a*; Arias, 2017; Mares and Zhu, 2015).

We report the effects of electronic voting on the vote share of programmatic politics in Table 4. Column 1 tests the effect for the Worker's Party's (PT) vote share, a quintessential example of a programmatic party. Column 2 adds two issue-oriented parties—the Popular Socialist Party (PPS) and the Green Party (PV) (Feierherd, 2020). Column 3 also includes the Brazilian Party for Social Democracy (PSDB) to these three parties, as it has been the major PT competitor in presidential races. In all these cases, we find that electronic voting had a statistically significant and positive effect on the vote share of programmatic political parties. Conversely, and as a falsification exercise, one should expect electronic voting to have a negative or insignificant effect on non-programmatic parties. To test this, we examine in columns 4 and 5 the effect of electronic voting on non-programmatic parties, including the PMDB and a set of parties with weak brands: the Social Christian Party (PSC), the Brazilian Labour Renewal Party (PRTB), and the Party

of the Liberal Front (PFL). As expected, the coefficients for these parties are not statistically significant.[5]

7 Alternative Explanations

The introduction of electronic voting in Brazil had a significant and negative effect on homicide rates. The core of our argument underscores a simple fact: violence is more likely to occur when non-programmatic and weakly branded political parties rise to power. To lend further support to our causal story, we test and rule out other alternative explanations that could undermine the validity of our argument. One competing explanation is that after 1998 politicians became more responsive to their low-income voters. More specifically, it may be the case that, aware of the massive enfranchisement, policymakers elected under the new technology targeted funds to address one of the key concerns of poor voters—insecurity. To explore this competing hypothesis, we test whether (i) the state's attempt to increase security or (ii) the investment in social programs were responsible of the reduction of violence. As we show in Table 5, we find no evidence of these alternative mechanisms.

One possibility is that homicide rates dropped because municipal governments increased social welfare spending. As electronic voting enlarged and enfranchised a much wider electorate, governments could see themselves in the obligation of addressing crime and violence through the provision of public goods, such as health and education. This would be a case of vertical accountability, whereby the government responds to an enlarged electorate through goods provision. We challenge this possibility on both logical and empirical grounds. Analytically, if social spending had any effect on the reduction of violence, we would not see the effects immediately after the implementation of electronic voting, as we found in the previous sections. Changes in social spending, in the form of

[5]Results are robust to alternative combinations of non-programmatic parties.

Table 5: Alternative Explanations: Social and Security Spending

	Panel A: Social Spending			
	1999	2000	2001	2002
Electronic voting	0.32	0.38	−0.20	0.02
	(0.49)	(0.36)	(0.32)	(0.32)
Total observations	3319	3979	4236	3565
Effective observations	248	193	195	191
Bandwidth	0.63	0.40	0.41	0.43
	Panel B: Security Budget			
	1999	2000	2001	2002
Electronic voting	−3.39	−0.52	0.19	−5.04
	3.70	2.76	2.74	3.07
Total observations	3319	3979	4236	3565
Effective observations	131	206	214	133
Bandwidth	0.37	0.42	0.44	0.32

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Note: All models are based on local polynomial regressions with robust biased-corrected confidence intervals, triangular kernel functions and use one common MSE optimal bandwidth selection procedure (Calonico, Cattaneo and Titiunik, 2014).

programs and concrete policies, take some time to materialize. Indeed we find no empirical evidence that social spending could be driving our results: in Panel A of Table 5, we estimate the effect of electronic voting on social spending from 1999 through 2002, a four-year period until after electronic voting was implemented. While coefficients have a positive direction, in no case do they reach statistical significance.

If social spending did not play any significant role, then it could be possible that increases in security spending are responsible for the reduction of homicide rates. Violence could be prevented and contained if state and municipal level governments increase security budgets. Larger funding for security, through police presence and technical capacity, could impact homicides by deterring and combating crime. We believe greater security

spending does not play a significant role. For one, like in the case of social spending (although to a lesser extent), security budget may have a delayed effect on homicide rates, as it takes some time for authorities to disburse and allocate resources and implement changes on the ground. Moreover, while greater security spending is one way to deter crime, it is also true that a stronger emphasis on security, in the context, for instance, of iron-fist policies (Cruz, 2011; Lessing and Willis, 2019*a*), could trigger more violence. Indeed, our tests show that this mechanism does not hold to empirical scrutiny. In Panel B of Table 5, we test whether electronic voting increased security budget right after electronic voting was implemented and up until 2002. We fail to find any compelling evidence to claim that electronic voting reduced homicide rates by allocating more resources to the security sector.

8 Discussion

This paper has shown that an institutional reform intended to curb widespread levels of fraud also significantly reduced levels of violence. Enhanced accountability and increased rotation in office likely dismantled criminal networks formed by hegemonic local elites with connections to the national politics. Consequently, effective enfranchisement and higher turnover resulted in lower criminal conflict. These results run contrary to recent literature that show that subnational alternation in office increases violence (Trejo and Ley, 2018) and challenge the notion that electoral violence and bribery are substitutes (Collier and Mahoney, 2012). While some anecdotal evidence suggests that incumbent coalitions unable to use fraud resorted to voter intimidation, our findings suggests that both homicide rates and violence against politicians dramatically dropped after EV adoption.[6]

Brazil's recent history displays a dramatic spike in the use of violence in a context

[6]See, e.g., "Terror Electrônico", *Agencia Globo*, September 28, 1998.

where politicians and non-state armed actors have built strategic relationships. These connections also imply that substantial parts of the country's territory are controlled not by the state but by *facções criminosas* and *milícias*—though frequently in association with the state (Lessing, 2017; Arias, 2006; Albarracín, 2018*a*). Although the country has at times intended to curb violence through pacifying police units, as in Rio de Janeiro ahead of the 2014 World Cup and the 2016 Olympic Games, authorities' dominant response throughout the country was based on a *mano dura* logic. As in other parts of Latin America and elsewhere, iron first policies have often backfired. In Mexico, for instance, President Felipe Calderón's War on Drugs largely increased criminal violence, contrary to their proponents' goals (Phillips, 2015; Calderón et al., 2015). Given the notorious failure of heavy-handed policies, democratizing reforms may offer a promising alternative.

Our findings are thus relevant for other crime-ridden countries as well. Experiences from violent places suggest that subtler reforms can better address violent conflict. In Colombia, for instance, Medellín reduced violence partly by developing a public transportation system that connected isolated low-income neighborhoods to the city's urban center (Cerdá et al., 2012). In line with our findings, other experiences also suggest the importance of dismantling criminal networks to diminish conflict levels. Cruz (2011) focuses on the need to implement security sector reforms to control violence produced by criminals in conjunction with state institutions and actors. Trejo and Nieto-Matiz (2019) show how cooperation between international organizations and local judicial institutions dismantled pacts between Guatemalan state security forces and OCGs that created criminal structures to ensure control of illicit markets. Finally, Trejo, Albarracín and Tiscornia (2018) claim that transitional justice mechanisms upon democratization helped countries limit the dramatic levels of violence suffered where such extraordinary mechanisms did not exist. Similarly, our findings suggest that removing hegemonic politicians from office can severely break up collusion with OCGs and shrink violent crime.

Lastly, our article provides compelling evidence that some transparency-enhancing

reforms can indeed reduce violence, a long-term established theoretical connection that has been either poorly investigated or faced with a mixed empirical record. While democratization is supposed to be accompanied by peace because competitive elections provide channels through which to solve political disputes, few studies were able to find such relationship in new democracies. We do find that a democratic reform diminished criminal conflict and, more related to this hypothesis, electoral violence. Rife with bribery and voter intimidation, the introduction of EV limited the possibility of committing fraud and decreased the number of political assassinations and murder attempts.

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The Unintended Consequences of Democratic Reforms: Electronic Voting and Criminal Violence in Brazil

Supplementary Information

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A.1 Municipalities that adopted electronic voting in 1998

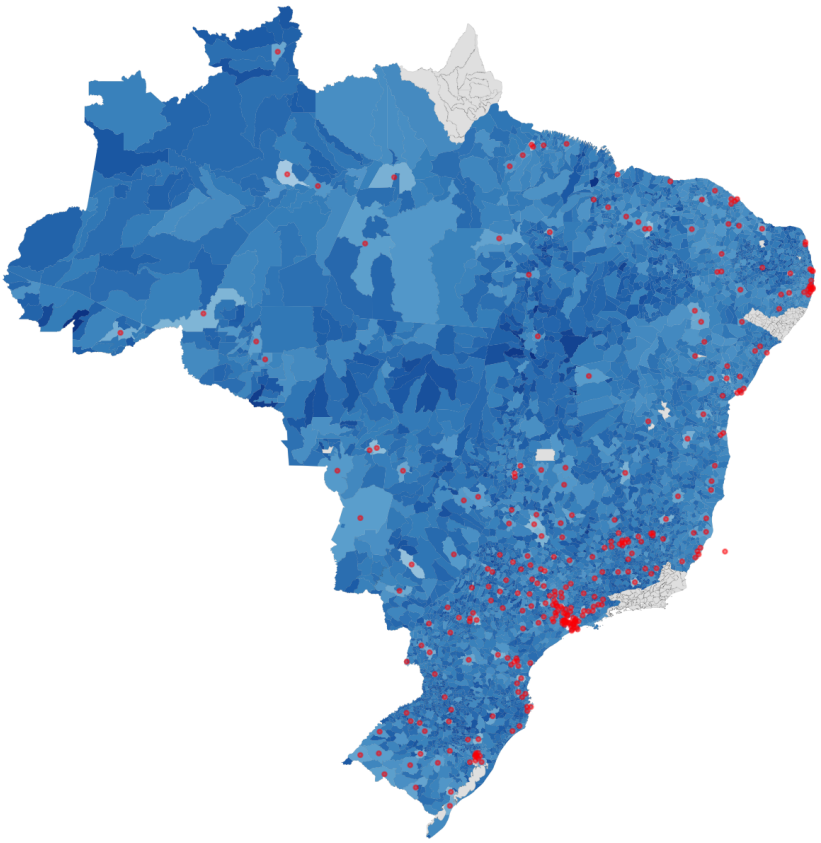

Figure A1: Municipalities that adopted electronic voting in 1998

Note: The map shows the electorate size across municipalities as of 1996, with darker regions representing a larger size. Red points represent municipalities with an electorate size above 40,500, the threshold that determined whether or not electronic voting was implemented. Municipalities in gray belong to those states—Alagoa, Amapa, Rio de Janeiro, and Roraima—where the introduction of electronic voting technology did not respond to the population threshold. These states are dropped from all analyses.

A.2 The Geography of Homicide Rates in Brazil, 1997-2000

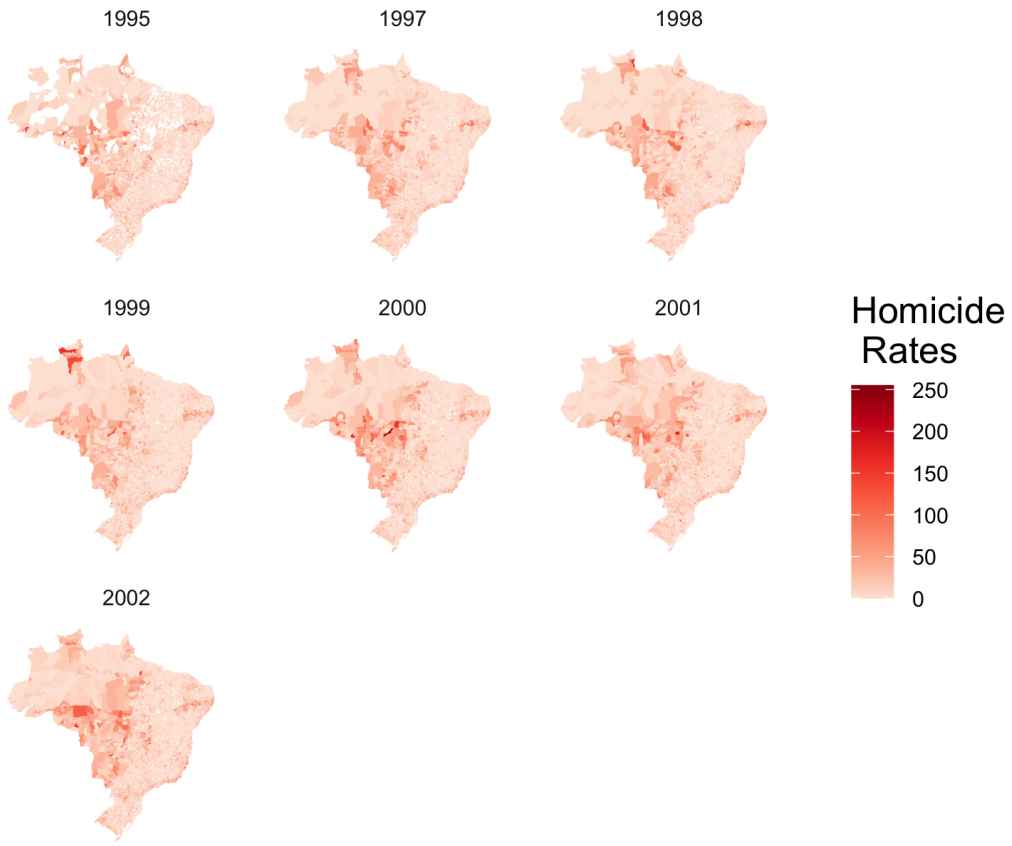

Figure A2: Homicide Rates in Brazilian Municipalities

A.3 The Geography of Electoral Violence in Brazil, 1997-2000

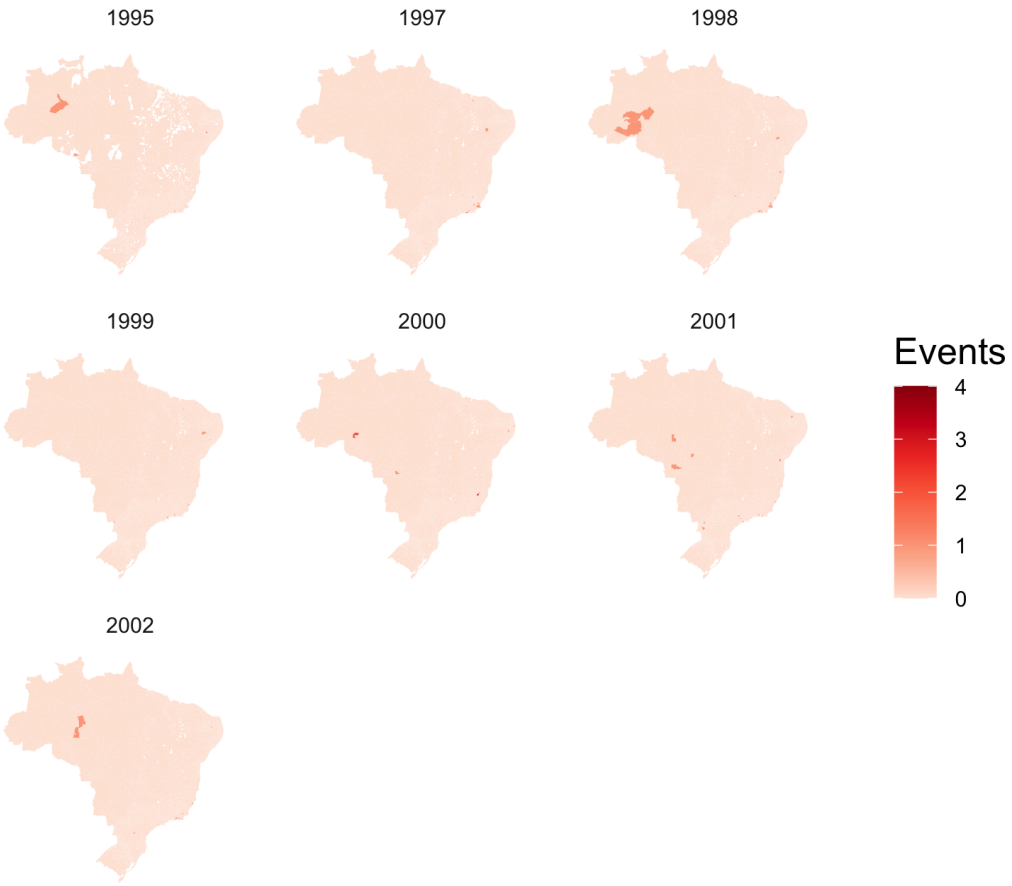

Figure A3: Number of Murder Attempts and Political Assassinations in Brazilian Municipalities

A.4 Homicide Rates in Brazil, 1993-2002

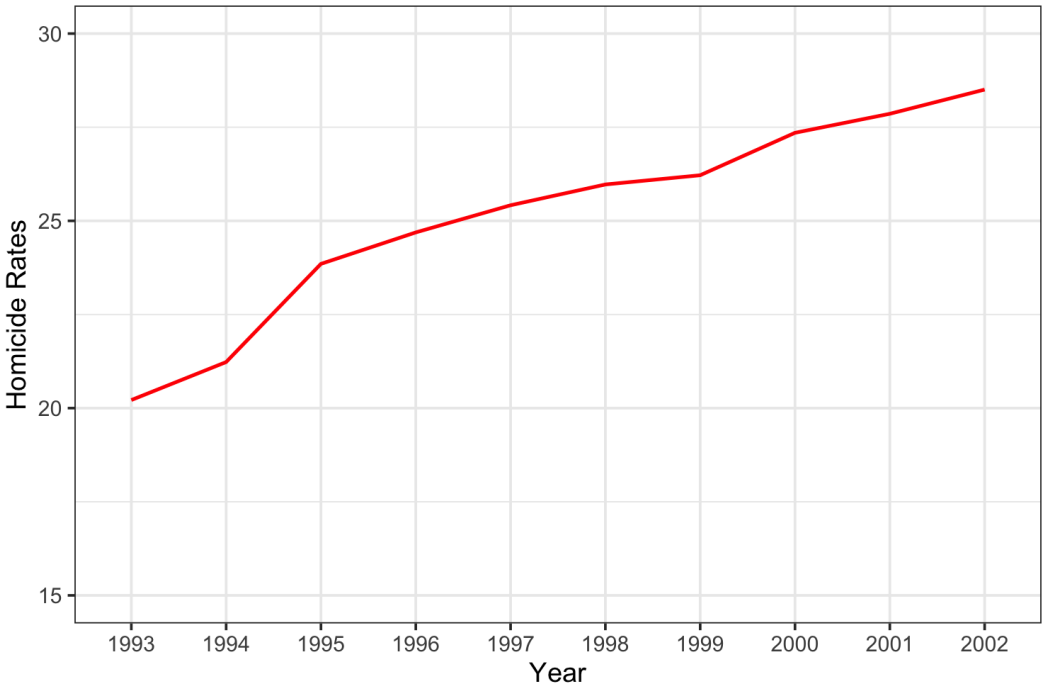

Figure A4: Homicide Rates in Brazil, 1993-2002

B Testing Model Assumptions

Credibly estimating the effect of electronic voting technology on homicide rates faces a number of challenges. For one, the new technology was not assigned in a random fashion, but based on the size of the electorate. As a result, a naive approach that regresses homicide rates on the presence of electronic voting is likely to confound the effect of this technology with a number of observed and unobserved covariates. This approach would certainly yield biased estimates. In addition, sharper critics could even suggest that the relationship between homicides and electronic voting is opposite to the one we defend in this paper: it could very well be that the prevalence of violence and fraud, which tends to be amplified in larger municipalities, prompted politicians to consider the implementation of the technology.

Our regression discontinuity design minimizes these issues and considers that whether or not an observation receives the treatment is as-if random. While this design rest on weaker and more plausible assumptions than most other observational analysis, it is still important to assess their validity in our setting.

B.1 Covariate Balance

First, our research design is based on the assumption that municipalities within a reasonable window are identical on all observed and unobserved characteristics. Because the only difference between municipalities within such window is that fact that some adopted electronic voting, any discontinuous change in violence should be attributed to the introduction of EV and not to any other factor. For instance, we would want to rule out the possibility that the distribution of electronic machines in 1998 is not correlated with a municipality's pre-treatment levels of wealth, inequality, education, development, or access to markets.

We test the plausibility of this assumption by reporting estimates of β_1 for municipal features measured prior to the establishment of EV. Concretely, Figure B1 shows balance statistics for a dozen relevant covariates using two different approaches: a local linear specification that uses observations within an optimal bandwidth and an OLS specification that uses the entire sample. When using a local linear approach—our main specification—we find no statistically significant differences at the cutpoint between treatment and control municipalities. Moreover, the fact that there are some covariates reaching statistical significance at the 5% level when using the full sample reinforces the need to focus our analysis on the RDD, which achieves excellent overall covariate balance. In sum, the RDD improves balance for most covariates and none of them is statistically significant (i.e., $p > .05$).

B.2 McCrary Test: Sorting around the Electorate Threshold

A second key assumption is that the density function of the forcing variable—electorate size—is continuous. In other words, we should not expect to observe a jump in electorate size around the cutoff of 40,500, as this would invalidate our identification strategy. If mayors and other local authorities were able to manipulate the electorate size so as to

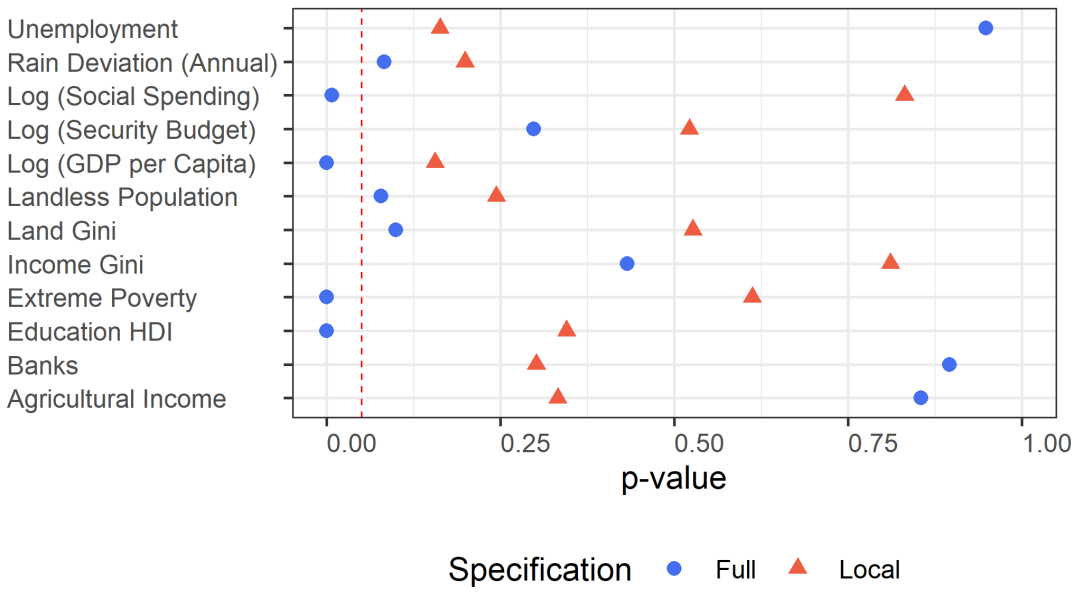

Figure B1: Covariate Balance

Note: The figure shows balance tests for a number of relevant pre-treatment covariates across Brazilian municipalities using two model specifications. Circles represent OLS estimates using the entire sample; triangles represent RD estimates based on local polynomial regressions with robust biased-corrected confidence intervals.

sort their towns and change their treatment status, then changes in levels of violence may be attributable not to EV adoption but to other factors, likely connected to the ability of municipalities to be placed at either side of the cut point. We contend that this is highly implausible: not only would changing the electorate size raise serious flags to federal authorities, but the specific way in which electronic voting was implemented made it practically impossible to manipulate the electorate size. Concretely, while the notion that electronic voting would be gradually implemented was known from 1995, the resolution on which municipalities would employ it in the 1998 elections was only anticipated a few months before the election.

We formally provide evidence of no sorting behavior, suggesting that local authorities were not able to systematically manipulate the electorate size. Following McCrary (2008), we test the null hypothesis of no discontinuous jump of the forcing variable around the cutoff. A discontinuous jump in either direction would suggest that municipalities with EV are systematically more likely to have either more or less violence, thus invalidating our results. With a p-value of .47, we fail to reject the null hypothesis of no sorting, which augments the credibility of our design. Figure B2 displays the result of this test, showing no jump in the density at the cut point.

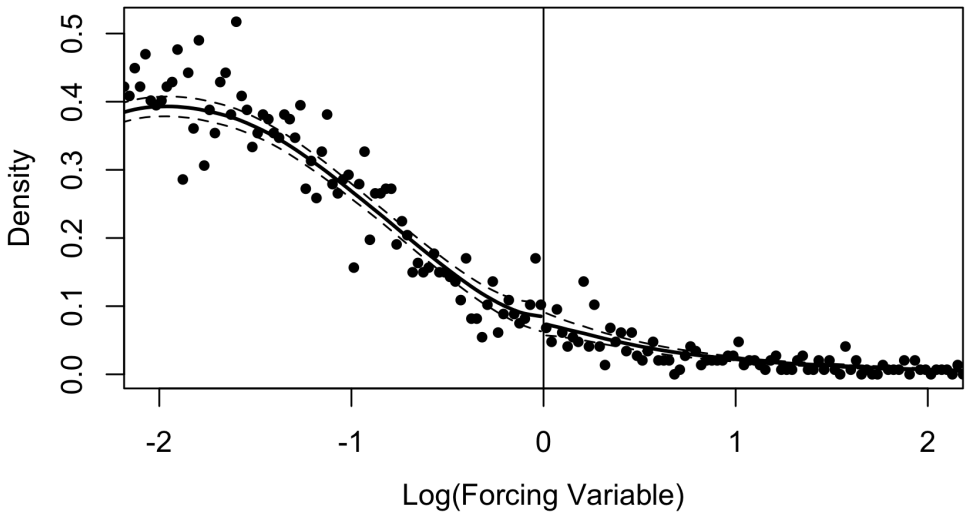

Figure B2: Density Test of Electorate Threshold

Note: The forcing variable is the electorate size normalized to set the cut point to zero. Discontinuity estimate (standard error): -0.11 (.17). P-value: .47.