Trading Old Errors for New Errors? The Impact of Electronic Voting Technology on Party Label Votes in Brazil

––Supplemental Information––

This document presents materials that are not intended for print publication, but which will be of interest to some readers. It includes the following sections:

A The Ballots

B RD Diagnostics

C Additional RD results

D Matching estimators

E RD Estimates for state legislators

F More on parties with strong up-ticket candidates

G More on the association of PLV with invalid votes for president

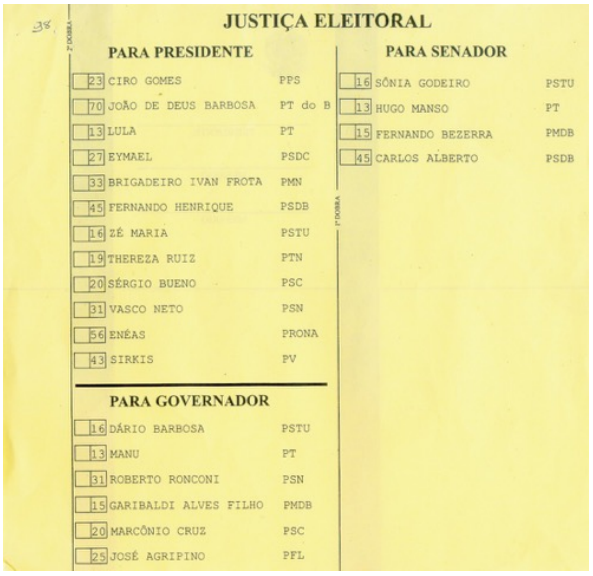
H PLV patterns in local elections over time

I Names of parties mentioned in the text

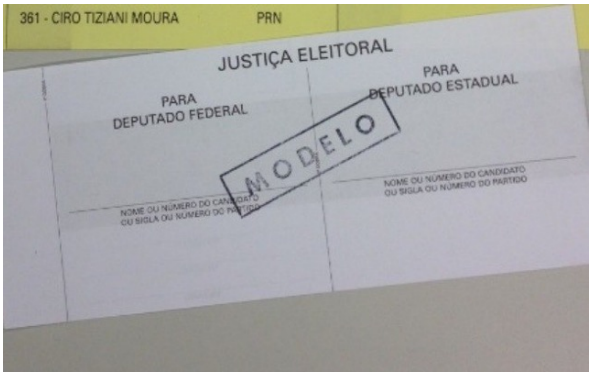
A The Ballots

Figure A.7 shows the electronic voting machine, whose interface has essentially not changed since its introduction in 1996. The numeric keys are arranged almost as in a touchtone phone, and the three keys in the bottom are for casting a blank vote (white), cancelling (red), or confirming (green).

Figure A.7: Electronic Voting Machine



(a) Majoritarian Contests



(b) Proportional Contests

Figure A.8: Paper Ballots Used in the 1998 General Elections

In the 1998 elections, the municipalities that did not employ electronic voting used two separate paper ballots (Figure A.8), one for the "majoritarian" contests (president, governors, and senators) and a separate one for the "proportional" contests (federal and state deputies). Voting on the first implied simply ticking the box beside the candidate's number and name. In the second ballot, however, voters had to write-in a name, number, or party acronym (to cast a PLV).

In the 1996 local election (Figure A.9), the paper ballot was very similar, except that the two ballots were combined into one. On the left of the ballot, voters should tick the box next to their chosen mayoral candidate, while on the right they should write-in a candidate's name, number, or a party acronym (to cast a PLV).

In prior elections, a single paper ballot was used, but the ballot also provided boxes for PLVs. As shown in Figure A.10, on the right side of the ballot, voters could write-in the name or number of their chosen candidate in the "proportional" constests, or simply tick the box of a party to cast a PLV. Not surprisingly, as reported in Table 1, the share of PLVs in the 1990 election was higher than in 1994 and 1998 (with paper ballots).

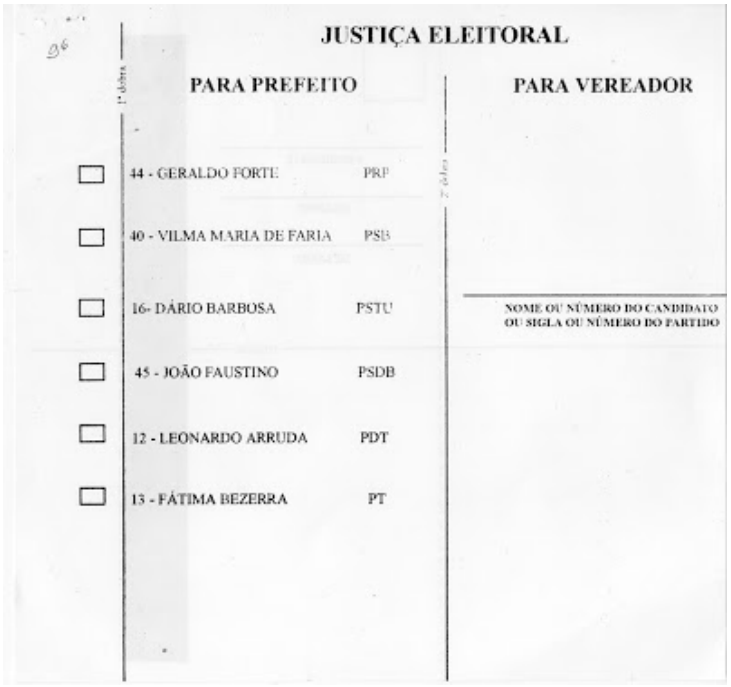
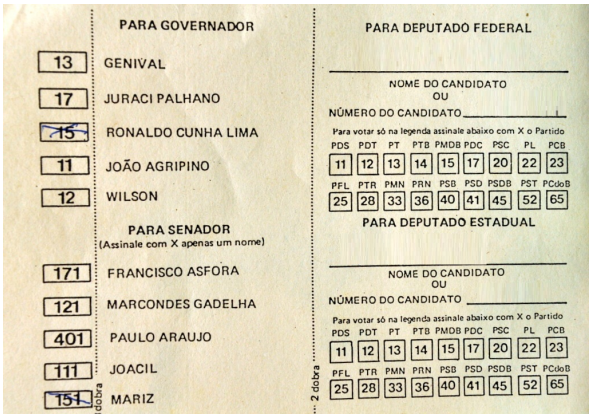


Figure A.9: Paper Ballot Used in the 1996 Local Election



(a) 1990 General Elections

(b) 1988 Local Elections

Figure A.10: Paper Ballots With Boxes for PLV

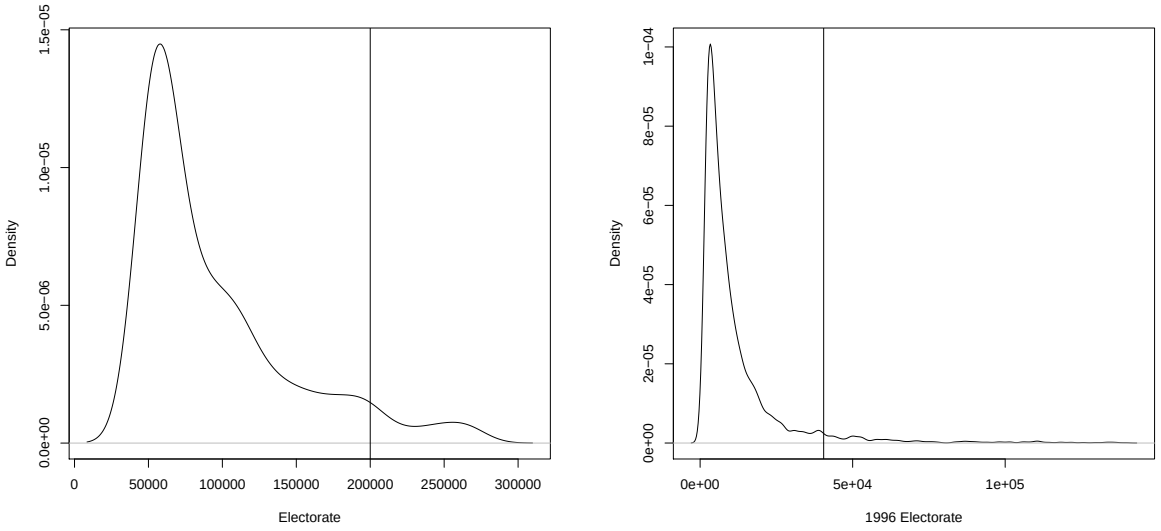
B RD Diagnostics

Figures A.11 shows there is no obvious discontinuity of the forcing variable at the cutoff for introduction of EV technology, which is not surprising given that the cutpoints were decided after the forcing variable was measured, thus limiting any strategic action by municipalities.

Figure A.12 reports the formal McCrary (2008) density test. For 1996, the test yields a θ statistic of 0.09 and p-value of 0.9. For 1998 it yields a θ statistic of -0.28 and p-value of 0.2. In neither case can we reject the null of no sorting.

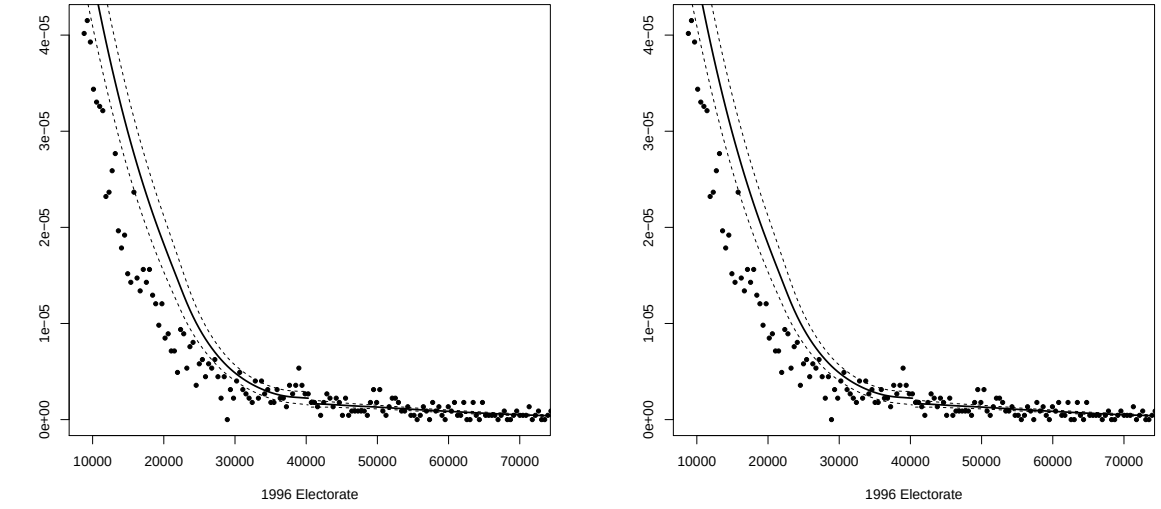
Figure A.13 shows graphical RD analysis for a number of pre-treatment covariates. Very importantly, in neither election did we see any difference on turnout relative to registered voters (top left panel). Following in clockwise rotation within each year, there are no differences on average levels of human development between control and treated group, though there might be some difference on the margin of cutoff for 1996. The share of non-white population is identical, and so are the share of votes observed by the PT and the PSDB in the previous national legislative election. Finally, GDP per capita levels are slightly larger at the very margin for 1996, which is compatible with the result for human development mentioned above, but on average, and for 1998 there are no such differences.

To sum up, the RD design is cleaner for 1998 than for 1996, which reflects, in part, the much larger number of municipalities at the margin in the latter case. Still, differences for 1996 are not substantive, and results are very similar to that observed on the superior setup of 1998.



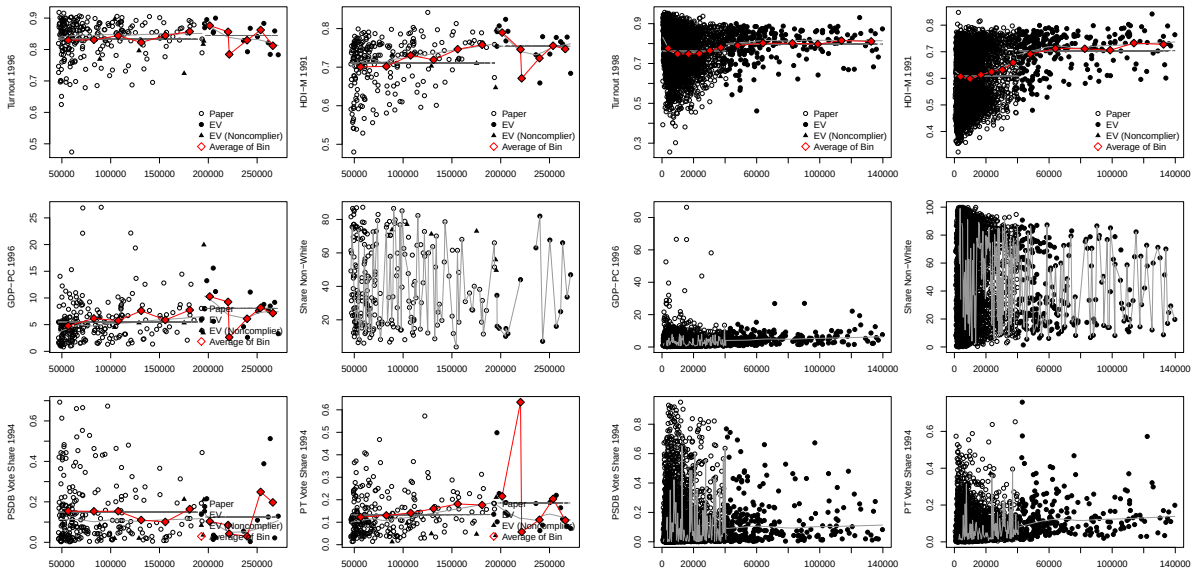
(a) 1996 Local Elections (b) 1998 General Elections

Figure A.11: Density of Forcing Variable at the Cutoff



(a) 1996 Local Elections (b) 1998 General Elections

Figure A.12: McCrary Density Test



(a) 1996 Local Elections (b) 1998 General Elections

Figure A.13: RD of Pre-Treatment Covariates

C Additional RD Results

In this section we present RD results for selected bandwidths and estimators, in table format (Table A.3). These results include difference of means estimates (DOM) in our preferred narrow band as well as Calonico, Cattaneo & Titiunik's (2014) polynomial local linear regression bias-corrected estimates with robust standard error (CCT), and conventional local linear polynomial estimates in the bandwidth selected by Imbens & Kalyanaraman's (2011)'s optimal bandwidth (IK) and Ludwig & Miller (2007) cross-validation method (CV).

Table A.3: RD Estimates for Four Estimators and Bandwidths

(a) 1996 Local Elections

	DOM	CCT	IK	CV
Effect	0.100		0.084	0.084
(SE)	0.011		0.011	0.013
p-value	<0.001		<0.001	<0.001
Bandwidth	30000		243358	179868
N	21		5390	1063

(b) 1998 General Elections

	DOM	CCT	IK	CV
Effect	0.091	0.088	0.094	0.094
(SE)	0.006	0.007	0.005	0.005
p-value	<0.001	<0.001	<0.001	<0.001
Bandwidth	4000	22084	37096	39988
N	99	678	3853	5051

Table reports difference in means RD estimates for a very narrow band around the cutpoint (DOM), as well as local linear polynomial estimates using different standard bandwidth selectors.

Numeric problems prevented us from computing CCT estimates for the 1996 local elections. But otherwise, estimates are extremely consistent across all methods, which is particularly

striking given the extreme variation in bandwidths and number of municipalities included in the analysis. Regardless of method, EV technology is associated with an increase in PLV that ranges from 8.4 and 10 percentage points, and in all approaches this effect is statistically significant.

D Matching Estimates of the EV Technology Effect

In the 1998 elections 197 municipalities below the threshold of 40,500 registered voters used EV technology. This includes 190 y municipalities in four states where EV coverage was 100% (RJ, AL, AP, and RR), which were excluded from the RD study in the main body of the paper, as well as seven other municipalities closer to the threshold, but which petitioned to be included in the program (Fujiwara 2015).

In this section, we provide alternative estimates of the EV technology effect on PLVs produced by matching treated municipalities to similar untreated ones. This, in practice, means that we include all of the 197 municipalities mentioned above as well as municipalities above but very close to the threshold (under 45k voters), that can find a suitable match just under the threshold.[30]

We matched EV technology municipalities to paper ballot municipalities on the size of the electorate (linear and squared), on level of development (linear and squared), on an indicator for macro region to which the municipality belongs, and on distance to the capital city. We employed genetic matching (**?**, **?**), with replacement, and 2-to-1 matches.

The algorithm found 339 matches to the 209 treated municipalities in the subsample. Graphical analysis (Figure A.14) shows a substantial improvement in balance across observed covariates, with maximum standardized mean differences between treatment and control groups of 0.05, and overall balance statistic of 2.4 with 3 df (p-value=0.493). This suggests no significant difference on observed covariates between control and treatment groups after matching.

Difference-of-means in the balanced sample indicates a EV technology effect on PLVs of 0.116, with a 95% confidence interval=(0.122,0.111). This estimate is very close to, but slightly larger, than the RD estimates reported in Figure 5 and Table A.3.

[30] A similar exercise is not possible for 1996 because there were fewer non-compliers and all but one of them were capital cities, which cannot be easily matched to other similar sized municipalities.

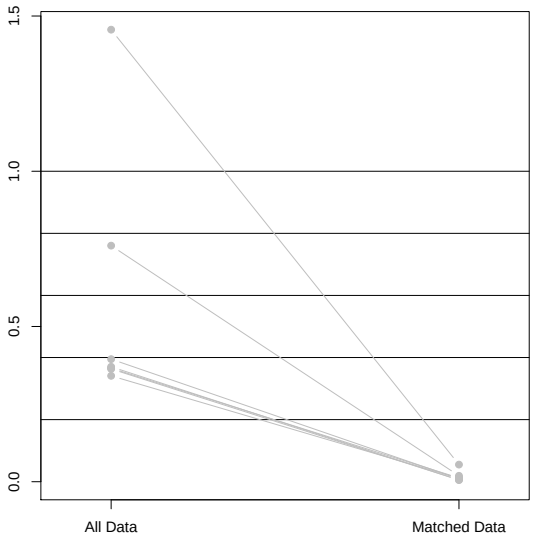
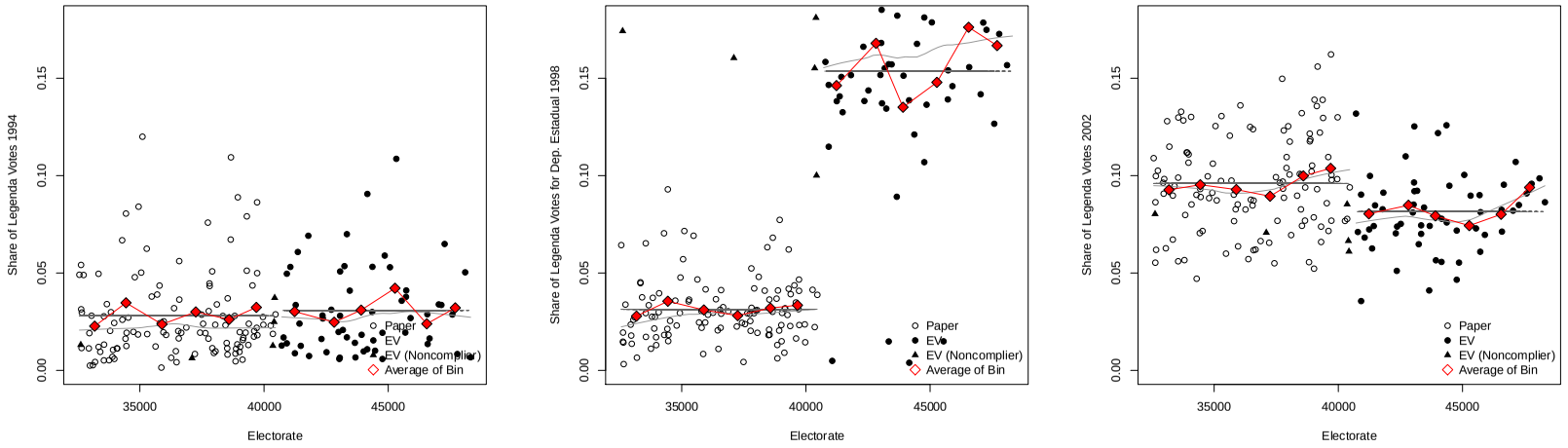


Figure A.14: Pre- and Post- Matching Covariate Imbalance

Figure shows standardized mean differences on the matching variables, between treatment and control groups, before and after matching.

E RD Estimates for State Legislators

In the main body of the paper we considered, for parsimony, only the first vote cast in the 1998 election. However, the second vote cast, for state legislators, follows the same system, and also allows for PLV. Figure A.15 shows that results for state legislator elections exhibit the same patters as for federal legislators: a sharp discontinuity is observed in the 1998 elections, but no difference between the municipalities treated and not treat with EV technology in 1998 is observed in the 1994 and 2002 elections.



(a) Party Label Votes 1994 (Placebo)

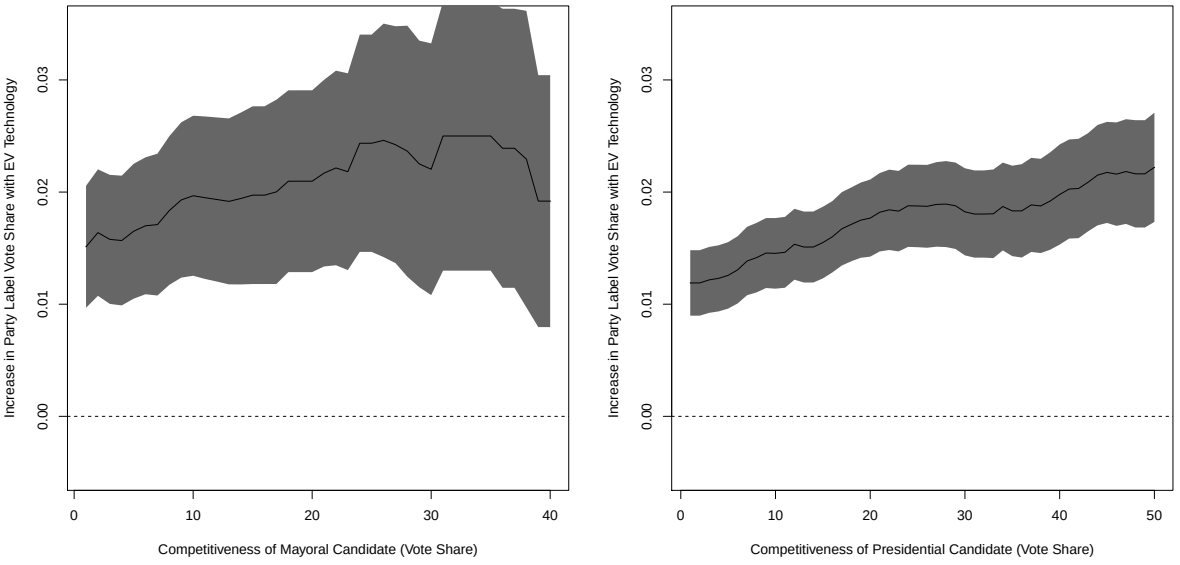
(b) Party Label Votes 1998

(c) Party Label Votes 2002 (Placebo)

Figure A.15: Regression Discontinuity for Deputado Estadual 1998

F More on Parties with Strong Up-ticket Candidates

In the main body of the paper, we showed that the increase in PLVs was larger the more competitive the party's up-ticket candidate was. In Figures 3 and 6 we showed this to be true for selected definitions of "competitiveness" of the up-ticked candidate. In Figure A.16, below, we show more complete results, for a wider range of possible definitions of competitiveness. Data include only municipalities in the respective narrowest RD bands of analysis, but consist of party/municipality observations.



(a) 1996 Local Elections

(b) 1998 General Elections

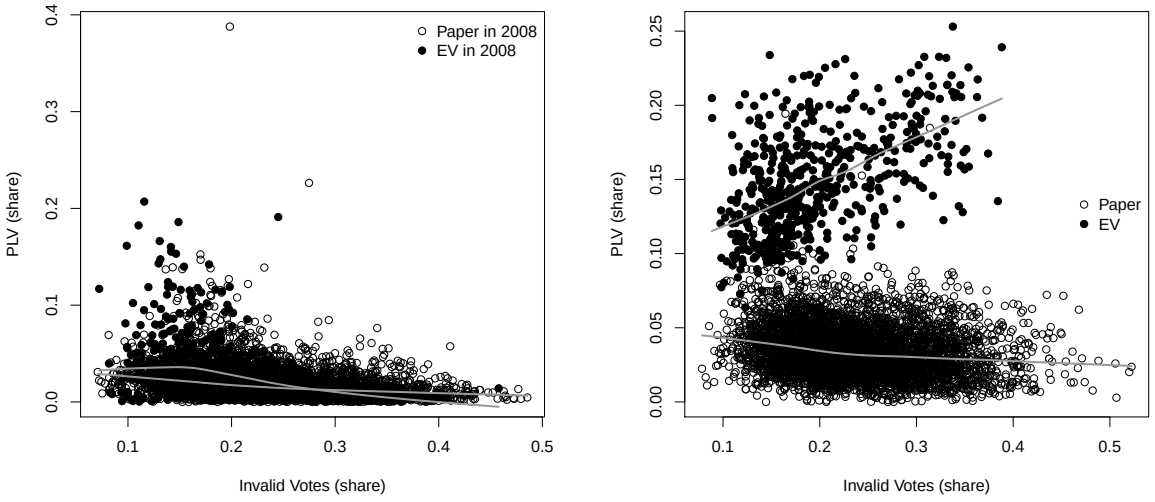
Figure A.16: Increase on Party Label Vote Shares as a Function of Competitiveness of Up-ticket Candidate

G Association of PLV with invalid votes for president

The correlations in Table 1 show that the association between PLV in elections for federal lower chamber was slightly negatively associated with invalid votes for president in 1994. This pattern was repeated in 1998 for the municipalities with paper ballots, but sharply reversed for municipalities with EV technology. This is evidence in support of hypothesis 4, which states that if EV technology induces voters to incur in the "new error," we should observe a strong positive correlation between PLVs in the first vote of the day, and invalid votes in the last vote of the day.

Figure A.17 shows how striking this evidence is, by reporting the above-mentioned correlations separately for the treatment and control groups in the year before EV was introduced. These associations are shown in the form of the lowess lines for each group. In 1994, before EV

technology, not only the relationship between PLVs in the first vote and invalid votes in the last vote was negative, but there was essentially no difference between groups prior to treatment. In 1998 a sharp difference appears, and, as predicted by hypothesis 4, the associtaion becomes positive and strong in municipalities with EV technology.



(a) 1994 (Placebo)

(b) 1998

Figure A.17: Party Label Votes and Invalid Votes for President in 1994 and 1998

H PLV patterns in local elections over time

In the main body of the paper, Table 1 reported statistics from general elections that support both Hypothesis 3 and 4 in the paper. More especificaly, it showed that i) the association between PLV shares and development levels measured by the HDI-M were positive with paper ballots and negative with EV technology and ii) the association between PLV shares in the first vote of the day and invalid votes in the last vote of the day was negative with paper ballots and positive with EV technology. Both hold for all elections for which there are data, and for the critical roll out election where the both systems of voting were used.

Table A.4 shows the same stats for local elections. We focused, in the main text, in general elections because the local elections have some empirical drawbacks. Firstly, in local election years there are only two votes (mayor and city counselor), which should reduce the probability of errors. More importantly, in the critical roll out election of 1996, the threshold for introduction of EV technology was very high, which meant that EV technology was used in few municipalities (N=57) and that this group was relatively homogenous and quite different from all other municipalities in the country. Any argument, therefore, that relies in correlations will

be of limited empirical power as there was relatively little variation in the municipalities with EV technology and the small-N makes the groups subject to the influence of outliers.

That said, overall the data are very supportive of our hypotheses, but less unambiguously than results from the general election. In all post-EV elections (2000–2012) the correlation between PLVs and HDI-M is negative and the association between PLVs and invalid votes for mayor is positive. Together, this suggests that PLVs are not intentional.

The results for critical election of 1996 partially conform to what we expected. In the EV technology municipalities we find a positive association between PLVs and invalid votes for mayor, but the association with HDI-M is also positive, though very weak. In the paper ballots, the opposite holds: we found a positive association of PLV and HDI-M, which is what we expected, but the association with invalid votes for mayor was not statistically significant. These results for 1996, however, exclude the municipality of São Paulo, which is one of the municipalities with the highest HDI-M and by far the largest in the country. In 1996, São Paulo had an extremely high share of PLVs (30%), and it, alone, swings the correlations for that group. If we include São Paulo, the correlation between PLVs and HDI-M in the group of municipalities with EV technology in 1996 is 0.06 (p=0.68), and the correlation between PLVs and invalid votes for mayor correlation is 0.04 (p=0.75).

Table A.4: Party Label Votes Over Time: 1986–2014

	Ballot Type	PLV Share	Correlations Between PLV Share and	
			HDI-M (Hypothesis 3)	Invalid Pres (Hypothesis 4)
1996	Paper write-in only	0.01	0.11*	0.04*
1996	Electronic voting	0.17	-0.03	0.14
2000	Electronic voting	0.12	-0.39*	0.35*
2004	Electronic voting	0.09	-0.29*	0.20*
2008	Electronic voting	0.10	-0.09*	0.15*
2012	Electronic voting	0.08	-0.22*	†

* indicates p-values < 0.01. PLV always refers to the first vote of the day (city counselor). Figures for 1996 are shown separately for EV technology and paper ballots. The two correlation columns refer to the linear correlation coefficient between the shares of PLVs observed in each municipality, on the one hand, and the the Human Development Index of the municipality (test of Hypothesis 3) and share of invalid votes in the legislative election (test of Hypothesis 4). Results for the EV technology municipalities in 1996 exclude the municipality of São Paulo. Results for 2012 are not yet available, but we expect to obtain them prior to publication.

I Names of Other Parties Mentioned in the Text

A few parties are listed in footnote 5.1 and not spelled out in the text.

- PMDB: Partido do Movimento Democrático Brasileiro; Party of the Brazilian Democratic Movement
- PFL: Partido da Frente Liberal; Party of the Liberal Front:

- PPB: Partido Progressista Brasileiro; Brazilian Progressive Party
- PDT: Partido Democrático Trabalhista; Democratic Worker's Party
- PTB: Partido Trabalhista Brasileiro; Brazilian Worker's Party
- PL: Partido Liberal; Liberal Party
- PSB: Partido Socialista Brasileiro; Brazilian Socialist Party
- PSD: Partido Social Democrático; Democratic Social Party