Money and Politics:
The Effects of Campaign Spending Limits on Political Entry and Competition

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Abstract

This paper examines the effects of campaign spending limits on political entry and competition. We study a reform in Brazil that imposed limits on campaign spending for mayoral elections. These limits were implemented with a discontinuous kink which we exploit for causal identification. We find that stricter limits increase political competition by creating a larger pool of candidates that is on average less wealthy. Stricter spending limits also reduce the likelihood that mayors are reelected. We interpret our reduced-form findings using a contest model with endogenous entry of candidates.

Keywords: Political Entry, Political Selection, Campaign Finance, Campaign Contributions, Incumbency Advantage

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1 Introduction

Among the many factors critical for a properly functioning democracy, few have been as widely debated as campaign financing. For some, money in politics serves as an expression of free speech and an effective instrument for informing voters and building an inclusive democracy. For others, the unrestrained use of money in politics can erode the functioning of democracy as it can lead to excessive campaigning, unequal access to power, and politicians who are beholden to special interest groups.[1]

In practice, almost every country with political pluralism has adopted some type of political finance regulation ranging from information and disclosure requirements to limits on campaign contributions and/or expenditures (Scarrow, 2007). Countries such as Canada and the UK have been limiting campaign spending by parties and individuals for many decades.[2] More recently Belgium, Chile, France, Israel, New Zealand, South Korea and many others have also adopted campaign spending caps in order to limit the role of money in elections.[3]

Despite the widespread adoption of spending limits, our understanding of how they impact the political process is limited. As we show theoretically, spending limits can affect both who enters politics and who gets elected. However, because the decision to run for office depends not only on a candidate's own characteristics, but those of his opponents, the effects of spending limits can be ambiguous. Empirically, to estimate the effects of spending limits on political behavior presents some difficult challenges. Campaign finance reform is usually applied uniformly across elections and jurisdictions, which makes it difficult to identify an appropriate comparison group. In addition, few countries provide information on the characteristics and campaign spending of both their elected and non-elected candidates. It is important to have data on both types of candidates if, as theory suggests, spending caps affect not only the identity of who is elected, but also who chooses to run.

In this paper, we provide (to our knowledge) the first causal estimates of the effects of campaign spending limits on political entry and selection. We do so in the context of a recent campaign

[1]For example, see Coate (2004), Prat (2002), Prat (2006), and Scarrow (2007).

[2]Currently, political parties in Canada can spend only 73.5 cents for every voter in districts in which they are competing. In the United Kingdom, legislation regulating expenditures has been in place since the Corrupt and Illegal Practices Prevention Act 1883. In the 2005 general election, campaign expenditure at the national level were limited to approximately US$42,000 per constituency contested.

[3]Two thirds of the OECD countries have introduced campaign spending limits for parties or candidates (Speck, 2013). One of the few exceptions among rich countries is the U.S. where the Supreme Court ruled mandatory spending limits as an unconstitutional curtailment of free speech.

finance reform in Brazil. Amid a massive corruption scandal that included the diversion of public funds to political campaigns, the Brazilian Supreme Court in 2015 decided to ban corporate donations and Congress passed a law that imposed campaign spending limits in future elections. The spending caps, which vary by municipality, create a discontinuous kink in the amount candidates can spend in local elections. We exploit this discontinuity together with a rich dataset on all candidates elected and non-elected to explore how spending limits affect the entry decisions of candidates, their characteristics, and electoral results for mayors.

Our analysis, which focuses on municipalities near the point of discontinuity, shows that places subject to lower spending limits are more politically competitive (attract more candidates). Our estimates suggest that a 25 percent decrease in spending caps leads to a 9 percent increase in the number of individuals who run for office, and an average candidate who is 40 percent less wealthy. Our results show that spending limits also affect political selection. We find that re-election rates are 11 percentage points lower in places with more stringent spending caps, suggesting that spending limits reduce incumbency advantage. We also find evidence that more stringent spending caps lead to the election of less wealthy candidates, and of candidates who spend less of their own funds in their campaigns.

We interpret these reduced-form results using a contest model with endogenous candidate entry. In this model, candidates differ in their effectiveness of spending and their cost of fundraising. Candidates then choose whether to enter the race and how much to spend, taking into account both spending limits and the equilibrium responses of their opponents. Given the best response functions of potential candidates, we then estimate the model via maximum likelihood.

The estimation of the model complements our reduced-form analysis in three notable ways. First, we can examine how spending caps affect candidate entry based on a candidate's effectiveness of spending and ability to raise funds: two unobservable traits that are important for computing the elasticity of vote shares with respect to campaign spending and for understanding the welfare effects of spending caps. Second, our reduced-form finding that lower spending caps decrease the likelihood of being reelected can be explained by two factors: a reduction in spending that disproportionately affects incumbents more than challengers, or the entry of new candidates. By estimating the model, we can compute the relative contributions of these two channels, and thus assess from a policy perspective whether spending caps can affect reelection rates, even in environments with high barriers to entry into politics. Finally, whereas the reduced-form analysis is restricted to the estimation of a localized effect at the threshold, the structural estimates allow us to consider the effects of adopting different spending limits.

Our model fits the data well and reproduces all of our quasi-experimental findings. Our model's estimates suggest that fundraising tends to be less costly for incumbents than for challengers, indicating that if all else were equal, incumbents will raise and spend more money in equilibrium than challengers. Incumbents also tend to be more effective spenders than challengers, implying that if all candidates within a municipality spent the same amount on campaigning, the incumbent would be the most likely to win. Interestingly, we also find a significant positive correlation between effectiveness in spending and cost of fundraising for both incumbents and challengers. Candidates who are likely to spend the most–i.e. the candidates with the lowest fundrasing costs–will be candidates who, if every candidate spent the same amount, attract fewer votes.

From these estimates, we also compute the elasticity of vote share with respect to campaign spending. We find that on average, increasing campaign spending by 1 percent results in an increase of 0.74 percent in the vote share of challengers, compared to 0.64 percent for incumbents. These numbers translate to a marginal cost of a vote of R$22 ($6.6) for the average challenger and R$27 ($8.1) for the average incumbent in our sample. The larger elasticity estimate for challengers is consistent with the extensive literature evaluating the returns to campaign spending (e.g. Gerber (2004)). In contrast to previous studies, a key driver to our result is the unobserved heterogeneity in fundraising abilities, which leads incumbents to invest a higher share of the total expenditures in the election. Hence, the lower incumbent elasticity is the result of equilibrium expenditure decisions, rather than the consequence of a fundamental ineffectiveness in incumbent campaigning.

These differences in unobserved heterogeneity between incumbents and challengers also have implications for how one should interpret our reduced-form finding that stricter spending caps reduce the electoral performance of incumbents. Because incumbents have to pay more for a vote and are more likely to be constrained by the cap, a stricter cap reduces the incumbent's vote share disproportionately more than those of the challengers, independent of the number of challengers in the race. At the same time, a stricter spending cap increases entry by new challengers, which can also reduce the incumbent's vote share. With our structural estimates, we can distinguish between these two mechanisms.

We find that both channels play a role, and that their relative effect sizes depend on the threshold. For example, in our simulations, lowering the spending cap from R$100,000 to R$50,000 reduces the average incumbent vote share by 6 percentage points. But if entry of new candidates is restricted, as is the case in a 2-party electoral system, then the lowering of the cap would only lead to 3 percentage points decline. The entry effect becomes relatively more important as the spending cap is decreased: reducing the limit to R$25,000 from R$100,000 implies a 14 percentage points reduction in incumbent vote share, and 57% of that can be attributed to an entry effect. Overall, our findings highlight that in order to assess the effects of the introduction of campaign spending limits, one must take care to not only consider the equilibrium effects of the policy on the current candidates contesting the election, but also on the entry of new candidates.

Our findings contribute directly to a large literature that examines the effects of regulating campaign spending (e.g. Austen-Smith (1987); Prat (2002); Coate (2004); Ashworth (2006)). While there is a rich theoretical literature studying the effects of limits on campaign donations and spending (e.g. Che and Gale (1998); Fang (2002); Pastine and Pastine (2012); Cotton (2012)), empirical studies are rare. The key challenge to causal identification is the potential endogeneity of spending caps. Indeed, while many polities around the world have implemented limits, their presence and magnitude are likely to be correlated with other unobserved factors which also affect potential outcomes. To address this issue, several studies have exploited state-level differences in contribution limits in the U.S. (e.g. Stratmann and Aparicio-Castillo (2006); Barber (2016)). To our knowledge, the only other empirical investigation of the effects of campaign spending limits is Milligan and Rekkas (2008), who study spending caps in Canadian federal elections, and find that higher limits are associated with higher incumbent spending, fewer candidates, and lower voter turnout. Different from these studies, we examine the effects of spending limits on a series of novel outcomes including detailed candidate characteristics for both the elected and non-elected. Furthermore, our research design has the advantage that it requires weaker assumptions to identify the causal effect of spending limits.

Our study also relates to a large literature that examines the effects of campaign spending on electoral outcomes (e.g Levitt (1994); Gerber (1998); Erikson and Palfrey (2000); Da Silveira and De Mello (2011)). The vast majority of these empirical studies estimate this relationship in the reduced-form, while trying to control for the unobserved heterogeneity that affects both spending and vote share. We estimate this relationship using our estimated model which has the advantage that it directly accounts for candidates' unobserved heterogeneity both in their effectiveness of spending and ability to raise funds. In this respect, our approach is related to Bombardini and Trebbi (2011) who compute the elasticity based on a bargaining model involving politicians and interest groups. Moreover, even though the effect of campaign spending on electoral outcomes is an important input into the design of any campaign finance reform, it is only one piece of the puzzle. As our findings highlight, campaign finance affects not only who enters politics but how many. Accounting for these entry decisions thus becomes critical when using any estimate of the effects of campaign spending on electoral outcomes to guide policy.

Finally, our work also speaks to research on the identity of politicians and whether limits to campaign spending might level out the playing field between richer and poorer candidates. There is a growing literature following the citizen-candidate models of Osborne and Slivinski (1996) and Besley and Coate (1997) suggesting that identity matters for policy implementation (e.g. Chattopadhyay and Duflo (2004); Besley et al. (2011); Corvalan et al. (2016)). In countries where inequality is high, access to political power might be easier for richer candidates and this might have direct consequences on who gets elected and which types of policies are implemented. Our work suggests that imposing spending caps reduces the average wealth of candidates that run for and are elected as mayor.

The rest of the paper is organized as follows. Section 2 describes Brazil's campaign financing laws and presents the data used in the empirical analysis. Section 3 presents the theoretical framework. Section 4 discusses our research design and in Section 5 we present our reduced-form findings, as well as our estimates of the model. Section 6 concludes.

2 Background and Data

In this section, we describe campaign financing in Brazil and the 2015 campaign financing law, which was established in response to the "Car Wash" operation that uncovered one of the world's largest political corruption scandals. The law introduced limits on how much candidates from different municipalities can spend. These differential spending limits form the basis of our identification strategy. We then discuss our data, and present some basic descriptive statistics.

2.1 Municipal Elections and Campaign Financing

Local elections in Brazil are held every four years, with the most recent election taking place in October of 2016. Candidates need to be registered as a member of a political party in order to run for a political office. The elections are held to elect a municipal mayor and a local council. For municipalities with less than 200,000 registered voters, which represents 98.3 percent of all municipalities, mayors are elected based on simple plurality. For municipalities with 200,000 or more registered voters, candidates for mayor must be elected with at least 50 percent of the votes or a second round runoff is held. Once elected, mayors then face a two-term limit. In contrast, local legislators are elected based on an open-list political representation system, and can be reelected indefinitely. Mayors are important political figures in Brazil. Each year, municipalities receive millions of dollars from federal and state governments to provide basic public services such as primary education, health care, and sanitation. The mayor is the agenda setter in how the resources are spent and allocated.[4]

Political parties are financed yearly by private contributions and public funds (Fundo Partidário), which are distributed based on the share of votes a party received in the previous election for Congress. All private contributions have to be made prior to the elections to either the political party or directly to an individual candidate. Donations to the parties can be then redistributed to individual candidates. Individuals are allowed to contribute up to 10% of their annual income, unless contributing to their own campaign, in which case there are no limits. Prior to 2015, corporations could contribute up to 2% of gross annual revenues, and there were no restrictions on either total contributions or total campaign spending. Also, Political Action Committees do not exist in Brazil. Campaign spending in Brazil has to be made by individual candidates or political parties on their behalf.

Similar to the U.S., both street campaigns and media ads are important forms of campaigning. But different from the U.S., candidates do not need to buy time on TV or radio. In Brazil, TV and radio ads are free and air at predetermined times of the day as determined by Brazil's electoral law. Airtime is distributed according to the share of votes that the candidate for mayor's coalition has in Congress (see Da Silveira and De Mello (2011)). While airtime is free, candidates do have to spend resources on producing the ads.

2.2 The 2015 Campaign Finance Reform

On March 14, 2014, Brazil's Federal Police launched an investigation into a local money laundering scheme involving gas stations. This investigation, entitled "Lava Jato", has since become one of the largest corruption scandals in the world as investigators uncovered a large corruption scheme involving Petrobras and the largest construction companies in Brazil. Since then, investigators have already uncovered over R$6 billion in paid bribes, charged over 175 people with criminal offenses, and secured 93 convictions. Among those convicted, included key members of Brazil's Workers' Party (PT), the PP, and the PMDB who were all found guilty of diverting billions of dollars through procurement contracts to fund their political campaigns.

In response to the scandal, Brazil's Supreme Court decided to ban all corporate donations to candidates and parties. This decision led the Brazilian Congress to pass a law on September 2015 that

[4] See Ferraz and Finan (2011) for institutional details on Brazil's local politics.

further limited campaign spending in future elections.[5] The law states that candidates running for mayor are limited to spend the maximum of either R$100,000 (approximately $30,000) or 70% of the highest amount spent by a candidate in the same municipality in the previous election. As stated, the law creates a kink in the amount that candidates can spend at around R$142,858 (70% of R$142,858 is R$100,000.6). For any value lower than R$142,858 the cap is given by R$100,000 while for higher values the cap is given by 70% of the largest value spent in the previous election.

The law also stipulated that the caps set by the 70% rule and disclosed in December 2015 should be adjusted by the accumulated inflation between the 2012 and 2016 elections (see Figure 1 for a timeline of the events leading up the 2016 elections). For municipalities capped at R$100,000, they increased the limit by 8.04 percent, which corresponds to the increase in the INPC price index between October 2015 (the month the law was issued) and October 2016. For municipalities capped at 70 percent of the maximum amount spent in the 2012 election, the cap was adjusted by 33.7 percent, which corresponds to the increase in the price index that took place between October 2012 and June 2016. As a result, the inflation-adjusted caps created a discontinuous kink in the campaign spending limits of about 25 percent, which is what our research design will exploit (see Figure 2).[6]

The spending limits apply to any: i) spending made directly by the candidate, ii) spending made by the party on behalf of the candidate, iii) transfers made by the candidate to other candidates (within or across parties) or to political parties, iv) campaign donations estimated in kind or computed as gifts. Candidates that spend more than the limit are subject to severe punishment including a fee of 5 to 10 times the amount that exceeds the limit, ineligibility to run for any political office for 8 years and potential prosecution by electoral courts.

Campaign contributions and expenditures are tightly regulated in Brazil. All candidates and parties have to open a bank account exclusively for campaign purposes. All transactions for both contributions and expenditures need to be reported to the Electoral Court within 72 hours and must identify all the entities involved. Every transaction is monitored and made public as soon as the Electoral Court receives the information.

[5] See http://www.planalto.gov.br/ccivil_03/_ato2015-2018/2015/lei/l13165.htm.

[6] The information on the spending caps is publicly available and can be assessed at the Electoral Court webpage at: http://www.tse.jus.br/eleicoes/eleicoes-2016/prestacao-de-contas/divulgacao-dos-limites-legais-de-campanha.

2.3 Data

The data used here come from two sources. The election data come from Brazil's Electoral Commission (TSE). We complement these data with information from the 2010 population census, aggregated at the municipality level. The census data include basic demographic and socio-economic characteristics of the municipality, such as: population size, average income, literary rates, and share of the urban population.

The electoral data in Brazil is unusually rich. The data we use in the analysis covers all candidates that ran for mayor in 2012 and 2016. In addition to their election results, for each candidate we know a basic set demographic characteristics, such as their gender, age, education level, and self-reported wealth, as well as their campaign contributions and expenditures. Based on this information, we compute at the municipal level, our main political outcomes: campaign spending, the number of candidates that ran for mayor, characteristics of the candidate pool, and re-election rates.

Descriptive statistics for the 2016 elections appear in Table 1. On average, elections for mayor attract 3 candidates. Only 13 percent of candidates are female, and only 50 percent of candidates have a college degree. The average candidate in a municipality self-declares asset holdings of about R$1,000,000, but this number masks a lot of heterogeneity as the maximum amount self declared by a candidate in a municipality ranges from R$43,600 to R$24.2 million. In Brazil, incumbents do not enjoy much of an incumbency advantage. Conditional on running for reelection, incumbents were only re-elected in 48.2 percent of municipalities, and received on average 46.8 percent of the votes. In the analysis, we drop open seats (where the mayor is term-limited) so that the sample remains comparable when considering the effects of the spending limits on incumbents.

3 Model

Our model builds on the extensive literature studying contests and all-pay auctions in the context of political lobbying and campaigning.[7] In our framework, we extend the n-player contest model with generalized technologies of Cornes and Hartley (2005) in order to incorporate two types of campaign technologies, where one is subject to a cap and the other is not.[8]

[7] For example, see Tullock (1980), Baron (1994), Siegel (2009) and Jia et al. (2013). For a review of the literature, see Corchón (2007) and Konrad (2009).

[8] Although the contest model has not, to our knowledge, been applied to study campaign spending caps, it has been extended to consider the effect of public campaign spending laws (Klumpp et al., 2015).

We consider an environment in which $I \geq 2$ candidates compete in an election. Each candidate, indexed by i, chooses how much to spend across two technologies: she chooses an amount x_i to spend through formal channels, which is reported to the election commission, and an amount z_i to spend through informal channels. Informal spending, which isn't reported to the electoral commission, can include anything from effort spent campaigning on her social media accounts to the use of illicit forms of campaigning, such as vote buying. The candidate's total *input* into the electoral contest is the weighted sum $y_i \equiv a_i x_i + b_i z_i$, where a_i and b_i are measures of each technology's effectiveness in producing votes. We assume that $b_i < a_i$ for all candidates, so that spending through formal means is more effective. We will refer to a_i interchangeably as the *campaign effectiveness* or *popularity* of a candidate. After each candidate simultaneously chooses her campaign expenditures, each voter selects his preferred candidate in the election.

Voters. We assume there is a continuum of voters who vote sincerely. Each voter's payoff from electing a candidate i is increasing with diminishing returns in the candidate's input into the electoral race. Thus, voters are "impressionable" and respond to campaign spending (Grossman and Helpman, 1996). After the candidates have selected their expenditures, an electoral shock ξ_{in} is drawn independently for each voter-candidate pair. Therefore, voter n's utility if he votes for candidate i is

$$v_{in} = \log(y_i) + \xi_{in} \tag{1}$$

We normalize the voter's utility to $v_{0n} = 0$ if he chooses to abstain. We assume that ξ_{in} are drawn independently from a type I extreme-value distribution, and thus it follows that the share of voters who select candidate i is

$$p_i = \frac{y_i}{1 + \sum_{k=1}^{I} y_k} \tag{2}$$

A candidate's vote share is given by the share of non-abstaining voters who select that candidate, which is

$$s_i = \frac{y_i}{\sum_{k=1}^{I} y_k}. \tag{3}$$

Politicians. For parsimony, we will assume that candidates seek solely to maximize their expected vote shares net of the costs of campaigning.[9] Normalizing the benefits from the vote share

[9]Equivalently, we can assume that politicians seek to maximize the probability of being elected net of the costs of campaigning by letting equation (3) denote the politician's probability of winning the election.

to 1, we write the candidate's utility function as

$$u_i = s_i - c_i(x_i + z_i) \tag{4}$$

where we assume that the marginal cost to raising campaign contributions is c_i, whether those funds end up being reported or not. Hence, each candidate will simultaneously choose how much to spend through formal and informal channels taking into account each other's strategies. While her formal spending is capped at $\bar{x}$, she can spend unlimited amounts informally. Let x_{-i} and z_{-i} denote the formal and informal spending of the other candidates.

Her maximization problem is

$$\max_{0 \le x_i \le \bar{x}, z_i \ge 0} s_i(x_i, x_{-i}, z_i, z_{-i}) - c_i(x_i + z_i) \tag{5}$$

where we write the spending vectors $x := (x_1, ..., x_I) = (x_i, x_{-i})$ and $z := (z_1, ..., z_I) = (z_i, z_{-i})$. The solution concept we use is that of a pure-strategy Nash equilibrium: a vector of expenditure levels in which each candidate's expenditures maximizes her payoff given the expenditures of her opponents.

To solve this problem, we first note that given any pair of spending vectors (x_{-i}, z_{-i}), candidate i's marginal utility is always higher with respect to formal spending compared to informal spending. Therefore, the candidate will only spend through informal channels when she is binding at the cap. Second, given the structure of the game, candidate i's best response (x_i, z_i) can be written as a function of the aggregate input of other candidates $\tilde{Y}_i := \sum_{k \neq i} y_k$. Specifically, the best response function is:

$$(x_i, z_i) = \begin{cases} (0,0) & \text{if } x_i^* \le 0 \\ (x_i^*, 0) & \text{if } 0 < x_i^* < \bar{x} \\ (\bar{x}, 0) & \text{if } x_i^* \ge \bar{x}_i \text{ and } z_i^* \le 0 \\ (\bar{x}, z_i^*) & \text{otherwise} \end{cases} \tag{6}$$

where $x_i^* = \frac{1}{a_i}\left[\sqrt{\frac{a_i}{c_i}\tilde{Y}_i} - \tilde{Y}_i\right]$, and $z_i^* = \frac{1}{b_i}\left[\sqrt{\frac{b_i}{c_i}\tilde{Y}_i} - \tilde{Y}_i\right] - \frac{a_i \bar{x}}{b_i}$. Equation 6 distinguishes between four cases. In the first, the candidate does not enter the race because the costs of doing so outweighs her benefits. In the second case, the candidate enters the race and spends exclusively through formal means some amount under the cap. In the third, she spends the exact amount of the cap through formal channels, but does not spend additional funds informally. In the fourth and final case, the candidate spends up to the cap through formal channels, and then spends on top of this through informal channels.

Proposition 1. *There is a unique pure strategy Nash equilibrium for the simultaneous-move subgame played by the candidates.*

Proof. First, rewrite the best response function $\left(x_i(\tilde{Y}_i), z_i(\tilde{Y}_i)\right)$ into the input $y_i(\tilde{Y}_i)$ chosen by each candidate as a best response of the aggregate inputs of other candidates (see Appendix A.1 for additional details). Then, transform these best response functions into share functions $s_i(Y)$ which represent the share of total inputs that a candidate will spend as a best response when total spending by other candidates is $\tilde{Y}_i \equiv Y - y_i$. We derive this function to be

$$s_i(Y) = \max\left\{\min\left\{\max\left\{1 - \frac{c_i Y}{a_i}, 0\right\}, \frac{a_i \bar{x}}{Y}\right\}, 1 - \frac{c_i Y}{b_i}\right\} \tag{7}$$

We can then sum the individual share functions into an aggregate share function: $S(Y) = \sum_{k=1}^{I} s_k(Y)$. This function is greater than 1 for sufficiently small values of Y, equal to zero for sufficiently large values of Y, is strictly decreasing whenever positive, and is continuous. Thus, there is a unique Y^* such that $S(Y^*) = 1$, which is the aggregate input in equilibrium. This value pins down the unique equilibrium spending (x_i, z_i) of each candidate. $\square$

Comparative Statics We next consider how the spending cap $\bar{x}$ affects equilibrium outcomes. For the remainder of this section, we assume that there is at least one candidate whose formal spending is binding at the cap (otherwise, there are trivially no effects from a marginal change in the cap). For expositional purposes, we also assume that no candidate is at a knife-edge case whenever computing derivatives (i.e. we ignore the special cases $x_i^* = 0$, $x_i^* = \bar{x}$, and $z_i^* = 0$). The proofs for this section are included in Appendix A.1.

Lemma 1. *Total equilibrium inputs in the contest are increasing in the spending cap, i.e.* $\frac{\partial Y^*}{\partial \bar{x}} > 0$.

Proposition 2. *The effects of spending limits on campaign expenditures.*

$$\frac{\partial x_i^*}{\partial \bar{x}} = \begin{cases} \frac{1}{a_i}\frac{\partial Y^*}{\partial \bar{x}}\left(1 - \frac{2c_i Y^*}{a_i}\right) & \textit{if } 0 < x_i^* < \bar{x} \\ 1 & \textit{otherwise} \end{cases}$$

$$\frac{\partial z_i^*}{\partial \bar{x}} = \begin{cases} \frac{1}{b_i}\left[\frac{\partial Y^*}{\partial \bar{x}}\left(1 - \frac{2c_i Y^*}{b_i}\right) - a_i\right] & \textit{if } z_i^* > 0 \\ 0 & \textit{otherwise} \end{cases}$$

While the above lemma states that total equilibrium inputs are increasing in the cap, the proposition shows that each candidate's expenditures is not necessarily increasing in the cap. This result is an extension to previous findings in the literature studying contests and all-pay auctions in the context of political lobbying.[10] To illustrate why formal spending is not necessarily increasing in the spending cap, consider a situation where there are two high-effectiveness entrants spending at the cap and a low-effectiveness entrant spending less than the cap. Whereas the binding candidates will increase their spending with an increase in the cap, the non-binding candidate will only increase her spending if her effectiveness is sufficiently high relative to her cost of fundraising (if $a_i > 2c_iY^*$).

Let us now consider a candidate who spends informally in equilibrium. A similar condition then determines whether this candidate will increase her inputs when the spending cap increases: i.e if $b_i > 2c_iY^*$. Whether this translates to an increase in informal spending is less obvious, as the candidate will substitute informal spending for formal spending. If other candidates are sufficiently increasing their inputs as a reaction to the increase in the cap ($\partial Y^*/\partial\bar{x}$ is large), it is possible for the candidate to increase both formal and informal spending. Otherwise, she will decrease informal spending because of substitution to formal spending.

Proposition 3. *The effects of spending limits on political entry.*

A candidate enters the race if and only if

$$\frac{a_i}{c_i} > Y^* \tag{8}$$

Therefore, the number of entrants in equilibrium decreases in the spending limit.

We find that increasing the spending cap decreases the number of entrants. Intuitively, this is because in equilibrium, total inputs into the contest Y are increasing in the spending limit. Thus, with higher spending limits, elections are more competitive in the sense that a candidate must make more expenditures to achieve the same vote share. On the other hand, the candidate's fundraising cost is the same for any cap, and hence she is less likely to enter when the cap is high.

An increase in the spending limit will also affect the composition of the pool of entrants. Equation (8) shows that the threshold to entry depends on the ratio of the candidate's popularity a_i to the marginal cost c_i. As the spending cap increases, the entrants with the lowest ratios will exit first.

[10] Che and Gale (1998) consider a two-player all-pay auction and show that bid caps may increase total expenditures. On the other hand, considering an n-player contest, Fang (2002) finds that imposing an exogenous cap never increases total expenditures. In contrast to Fang (2002), our model also allows bidders to differ in their abilities to convert expenditures into inputs in the contest function, and hence we find that bid caps may have either effect in the n-player contest.

Suppose that a and c are uncorrelated across candidates. Then, increasing the limit will cause the entrants with the highest fundraising costs to drop out of the race. If the cost to fundraising is lower for wealthier candidates, this would result in a wealthier entrant pool. In addition, the entrant pool will be composed of more popular candidates. In this sense, only the most electable candidates will choose to run when limits are generous. If we suppose instead that a and c are correlated, then we cannot make such stark predictions. When structurally estimating the model in Section 5.5, we will flexibly allow a and c to be positively or negatively correlated in order to investigate the effects of the policy change on candidate entry.

Proposition 4. *The effects of spending limits on electoral outcomes.*

Increasing the spending limit decreases the vote share of the candidates whose equilibrium formal spending is less than the cap, and increases the vote share of the candidates whose equilibrium formal spending equals the cap.

Finally, we show that an increase in the spending limit may increase or decrease an entrant's vote share. The main finding is intuitive: the candidates who spend less than the cap will face a more competitive contest under the high cap. This result has implications regarding the effect of spending limits on incumbency advantage. If incumbent characteristics are such that they are more likely to be binding spenders than challengers, then incumbency advantage will increase in the spending limit.

4 Research Design

We are interested in estimating the causal effects of campaign spending limits on political entry and selection. As we discussed in Section 2, prior to the 2016 municipal elections the Brazilian government imposed a cap on the amount of money a candidate could spend in the election. The law created a discontinuous kink in the spending cap for municipalities with a candidate that spent above R$142,857 in the 2012 elections.

Visually, the effects of the law on candidate spending for the 2016 elections can be clearly seen in Figure 3. For municipalities that did not have a 2012 candidate who spent above R$142,857, their candidates were capped at R$108,039. For the municipalities above this threshold, the spending cap jumps up by about 25 percent and then increases linearly as determined by the rule. It is also clear from Figure 3 that the caps were not binding for the majority of the municipalities. As a result, one should interpret our findings as intent-to-treat estimates.

To identify the effects of spending limits, we exploit the discontinuity at R\$142,857 using a standard regression discontinuity design approach. Let $S_{m,2012}$ denote the maximum amount spent by a candidate in municipality m during the 2012 elections. The treatment effect on outcome $Y_{m,2016}$ of the spending cap is given by:

$$\text{Treatment Effect} = \lim_{s \downarrow 142,857} E[Y_{m,2016}|S_{m,2012} = s] - \lim_{s \uparrow 142,857} E[Y_{m,2016}|S_{m,2012} = s]. \tag{9}$$

The first conditional expectation measures the expected outcome at the threshold for municipalities in which candidates' campaign spending is capped at R\$133,700. The second conditional expectation function measures the expected outcome at the threshold for municipalities in which candidates' campaign spending is capped at R\$108,039. Under the assumption that these two conditional expectations are continuous in s, this difference estimates the causal effect of campaign spending limits on political outcomes, at the point of discontinuity.

We estimate these conditional expectations by local linear regression using only data within a bandwidth h of the threshold. Formally, we estimate the following OLS model, for $S_{m,2012} \in (142,857 - h, 142,857 + h)$,

$$Y_{m,2016} = \alpha + \beta \mathbb{1}\{S_{m,2012} > 142,857\} + \delta_0 S_{m,2012} + \delta_1 S_{m,2012} \mathbb{1}\{S_{m,2012} > 142,857\} + \varepsilon_{m,2016} \tag{10}$$

where $\mathbb{1}\{S_{m,2012} > 142,857\}$ is an indicator equal to 1 when $S_{m,2012} > 142,857$, and $\varepsilon_{m,2016}$ represents the error term. The parameter β measures the treatment effect. For our choice of bandwidth h, we rely on the approach developed by Calonico et al. (2014). This optimal bandwidth choice is a function of the data and is thus different for each outcome, $Y_{m,2016}$. We also explore the robustness of our results to alternative bandwidth sizes.

Before presenting our results, it is important to test the validity of our research design. In Panel (a) of Figure 4 we plot the density of our "running variable", $S_{m,2012}$. Unsurprisingly, we do not find any evidence of manipulation or endogenous sorting around the discontinuity threshold. This is completely expected: campaign expenditures are made public immediately following each election, and no one could have anticipated the recent law change back in 2012. As a point of comparison, Panel (b) of Figure 4 plots the distribution of campaign spending for the 2016 election. In contrast to the previous plot, Panel (b) does exhibit substantial bunching at the spending cap of R\$108,039.

Another general concern associated with regression discontinuity designs is the possibility that other determinants of our outcomes of interest are also varying discontinuously at the cutoff point. Although we cannot directly test this assumption for unobserved characteristics, we can examine whether any observable characteristics of the municipality also exhibit discontinuous jumps at the cutoff point. In Figure 5, we present a series of plots, exploring various municipal characteristics that are correlated with our political outcomes of interest, such as GDP per capita, illiteracy, and the share of the urban population.[11] In each graph, we plot a bin scatter of the municipal characteristic against the maximum amount a candidate spent in the municipality during the 2012 elections (i.e. our running variable). In addition to these binned averages, we also fit a second-order polynomial on each side of the point of discontinuity and 95% confidence intervals for each bin. We do not find any evidence of other characteristics jumping at the cutoff point. All the differences are close to zero in magnitude and statistically insignificant. Importantly, these comparisons also include our main political outcomes of interest but measured for the 2012 elections (i.e. the "pre-treatment period").

5 Results

5.1 Effects of Spending Caps on Campaign Expenditures and Contributions

In this section, we estimate the causal effects of the spending caps on candidates' campaign spending and contributions. We begin with the graphical evidence. In Panel A of Figure 6, we plot binned averages of the amount candidates spent in the 2016 elections against our running variable (the maximum amount spent by a candidate in the 2012 elections centered at R$142,857). We also fit a second-order polynomial, separately estimated on each side of the discontinuity. The discontinuity at zero provides an estimate of the gap in candidates' campaign spending imposed by the law. The estimated discontinuity implies that a 25 percent increase in the spending cap increased maximum campaign spending by approximately 12 percent during the 2016 elections for municipalities near the discontinuity. In Panel B, we reproduce the graph presented in Panel A, but for the mean amount spent by a candidate. We see a similar increase of approximately 10 percent, which further suggests that the caps did bind for many candidates.

We refine the graphical analysis in Table 3. Each row corresponds to a different dependent variable, and each numbered column presents the estimated impact for a different regression specification. In column 1, we present our baseline estimates of Equation 10, using the bandwidth proposed by

[11] These plots represent only a subset of the characteristics for which we tested. Table 2 presents the entire set. Out of the 18 municipality characteristics tested, only one displayed a discontinuous jump at the cutoff point (population). For this reason, we control for the municipal characteristics measured in the 2010 Census in our analysis.

Calonico et al. (2014). In columns 2 and 3, we explore the robustness of our estimates to different bandwidth choices. In column 4, we further test the sensitivity of our results by fitting a local quadratic polynomial on each side of the discontinuity instead of a local linear polynomial.

Our results are robust to these various modeling choices. In our baseline specification, the highest-spending candidate just to the left of the discontinuity spent on average R$84,823 to become mayor, compared to R$95,036 for candidates in municipalities just to the right of the discontinuity. This represents a 12.0 percent increase in spending. The point estimates in columns 2-4 are similar: they indicate increases in maximum spending ranging from 11.6 to 13.9 percent. The estimates on average spending, although a bit noisier, are also consistent across specifications. They imply that the higher spending cap led to increases in mean spending ranging from 8.5 to 11.7 percent.

The theory does not provide clear predictions on the effects of a spending cap on the minimum or total amount spent in an election. In some cases, a higher spending cap will induce the minimum-spending candidate to reduce spending further, or even exit the race. Thus increasing the spending cap does not necessarily lead to an increase in the minimum or total spending within a race. Consistent with the theory, we do not find significant effects on either of these two outcomes. The minimum amount spent by a candidate is similar on both sides of the point of discontinuity: we estimate a statistically insignificant increase of R$989. Similarly, we also find a statistically insignificant increase in total spending of about 4 percent at the cutoff point.

In Table 4, we consider the effects of spending caps on the amount and composition of the candidates' campaign contributions. On average, candidates spend 99% of their campaign contributions.[12] Reflecting our findings on spending, we find that the average amount of campaign contributions raised by candidates are R$6,179 higher for municipalities with the higher limit. Approximately 75% of this increase comes in the form of candidates financing their own campaigns, which likely stems from the law's ban on corporate donations. In 2012, candidates received on average 16 percent of their contributions from corporations, and self-financed 25 percent of their campaigns. In contrast, 2016 candidates self-financed 40 percent of their campaign expenditures. We can interpret these results in two ways. On the one hand, in the face of the corporate ban, the higher caps induced the existing candidates to contribute more to their own campaigns. On the other hand, higher caps may have attracted a wealthier pool of candidates with greater financial means to run for office. We examine this possibility in the next section.

[12] In Brazil, candidates are not allowed to accumulate war chests.

5.2 Do Spending Caps Affect Candidate Entry?

According to our model, the number of candidates who enter the race should decrease as spending limits increase. Additionally, higher spending limits may also attract individuals who have a higher ex-ante probability of winning. We test these predictions in Table 5. As before, the rows indicate different dependent variables, and the numbered columns present the estimated effects of the caps for different modeling choices.

Spending caps affect the entry decisions of potential candidates. Compared to the municipalities just to the right of the threshold (i.e. the less constrained municipalities), the cap led to a 0.26 increase in the number of candidates for municipalities capped at R$108,039. On average, 2.9 candidates run for mayor, so this effect represents a 9 percent increase in the size of the candidate pool. This result is presented visually in Figure 7. In contrast to the plot presented in Panel C of Figure 5, which displayed the effects on the number of candidates who participated in the 2012 elections, we see a significant jump in the number candidates at the point of discontinuity.

To test whether this increase in candidate entry actually increased political competition, we study the effect of the cap on the effective number of candidates. This measure is computed by taking the inverse of the sum of squared vote shares of each running candidate within an electoral race. If all candidates have the same vote share, then this measure is equal to the actual number of candidates. At the other extreme, if one candidate wins every vote, then the effective number of candidates is one. If a change in the spending cap only leads to the entry or exit of candidates winning few or no votes, then we would not find an effect on the effective number of candidates. On the contrary, we find that the more restrictive spending cap increases the effective number of candidates by 0.143, suggesting that the restrictive cap did increase the competitiveness of mayoral races.

In Table 5, we also test whether higher caps affected the types of parties that entered the contest based on their size and ideology. To measure ideology, we rely on a measure of party position along a left-to-right scale as created by Power and Zucco (2012). The index, which ranks parties from 1 (="left") to 10 (="right"), is constructed from a survey of federal legislators elected in 2006. We find no evidence that the caps impacted the average ideological score of the candidate pool, nor the tails of the distribution. The increase in political competition was also not entirely the result of smaller parties entering into the race: higher caps reduced the number of smaller parties by 6 percent, although the effects are imprecisely measured.[13]

[13] We define the "small" parties to be all political parties except for the six most successful in the 2012 municipal elections: the PMDB, PP, PSB, PDB, PSDB and PT. Together, these six parties won the majority of mayoral elections in 2012. In total, there are thus 30 small parties in the 2016 elections. Our results are robust to the choice of party

To examine whether higher spending limits also induce greater participation from individuals with a higher ex-ante propensity to get elected, we first estimate the probability of winning the 2016 election based on the follow set of observable characteristics: gender, age, race, education level, political experience, party affiliation and self-reported assets. We estimate this propensity score for the sample of candidates that are outside the bandwidth of the RD regressions. The results, which are reported in Table A.1, suggest that candidates who are male, wealthier, incumbents, or have more political experience are more likely to win. Based on these estimates, we then impute a candidate's ex-ante probability of winning the election.

We find that individuals with higher expected winning probabilities are more likely to participate in municipalities with a higher spending limit. For a 25 percent increase in the spending limits, high-propensity types are 2.0 percentage points more likely to enter, which represents a 6 percent increase.

To see where these effects are coming from, in the remaining rows, we estimate the effects on individual attributes of the candidate pool. Although the estimates tend to be fairly noisy across the various attributes, higher limits do appear to affect an important factor: they tend to attract wealthier candidates. In our baseline specification, the average level of assets among candidates is 40 percent higher in municipalities with a higher spending cap. This result is perhaps unsurprising given our finding that the majority of the extra spending under the high-cap is self-funded.

5.3 Spending Caps and Political Selection

While restricting campaign spending does increase political competition, it appears to do so at the cost of attracting individuals with a lower ex-ante propensity to be elected. Whether spending caps affect political selection is therefore an empirical question.

The graphical evidence presented in Figure 8 suggest that it does. Here, we plot binned averages of re-election rates against the maximum amount spent in the municipality by a candidate for the 2012 elections. In computing this graph, we restrict the sample to the 2,721 incumbents who were eligible for re-election. We see a positive jump in the reelection rate at the point of discontinuity.

In Table 6 we refine the analysis further, by considering a range of alternative specifications and by conditioning on whether or not the mayor ran for re-election. In Panel A we consider all incumbents who are not term-limited, whereas in Panel B we consider only those who run for re-election. When

classification.

considering the whole sample of eligible incumbents, re-election rates increase by 11 percentage points at the point of discontinuity, which is a sizable effect given that the baseline re-election rate is only 23 percent. Among those that ran for re-election, the effects are similar: we estimate a 16 percentage point increase in the re-election rate from a baseline of 38 percent. To further analyze whether incumbents benefit from the higher cap, we test whether incumbents see their vote shares increase or decrease as a function of the cap. We find that incumbent vote shares increase by 6.6 percentage points under the higher cap.

Considering the apparent incumbency advantage granted by the higher spending cap, it is plausible that more incumbents choose to run for re-election under the high cap. We do not, however, find this to be the case. Although the standard errors are admittedly large, incumbents are not more likely to run for re-election in places with higher spending limits.

Why do incumbents benefit from the higher spending limit? According to the model, a candidate's electoral success depends on her share of inputs into the competition. Increasing the cap will benefit the incumbent if it induces fewer challengers to enter the race, or in addition if challengers cannot match the incumbent's increase in spending due to higher fundraising costs. The data are also consistent with this latter hypothesis. We find that incumbent spending increases significantly by R$10,312 under the high spending cap. On the other hand, total challenger spending hardly increases by a statistically insignificant R$1,108.

In Table 7, we explore whether the spending caps also affected the characteristics of the winners. Other than being an incumbent, we do not find much evidence that the caps changed the identity of the winner. The one exception is that there is some evidence that the caps led to the election of wealthier candidates (at the 90% significance level). Interestingly, the spending caps also did not impact the likelihood that a mayor from the Workers' Party (PT) won, despite the party experiencing sweeping losses in local elections throughout the country due to its involvement in the national corruption scandal.

Finally, in Table 8, we investigate the effects of the spending caps on the contributions of the winning candidates. We find that the winners under the high cap raised more campaign funds on average than those under the low cap. Moreover, our results suggest that the entirety of this difference is explained by the difference in the amount of funds that candidates self-finance. Indeed, we do not find evidence that winners under the high cap have raised more individual, party, or other donations. Thus, together with our evidence of the effect of caps on candidate assets, our results suggest that high spending limits benefit wealthier candidates, who spend their own funds to get elected.

Corporate Donations Recall that in addition to imposing spending caps, the law also banned corporate donations. Thus we might expect the spending caps to bind less in places where candidates were more reliant on corporations for their donations. This is what we see in Table 9. In this table, we reestimate all of our main treatment effects by whether the municipality was above or below the median municipality in the share of corporate donations received in 2012. For incumbent outcomes, we split the sample by above or below the median incumbent's share of corporate donations received in 2012. The effect sizes on all our outcomes are much larger for municipalities and incumbents below the median. For instance, in column 1 we see that the treatment effect on maximum spending in 2016 for municipalities below the median is three times larger ($17,304 compared to $5,496) than for those above the median. Similarly, for incumbent candidates below the median, higher spending caps increased re-election rates by 18 percentage points, compared to a -1.4 percentage points for candidates above the median. Overall these results reinforce the importance of money in determining the entry and selection decisions of politicians.

5.4 Spending Caps, Campaign Technologies, and Information

In addition to our findings on candidate entry and selection, our model suggests that candidates who face a stricter cap may also resort to alternatives forms of campaigning that are unlikely to count against their spending limit, such as the use of social media, or relying on "dark money".

Social Media To test whether politicians are substituting towards more social media use, we estimate the impact of spending limits on Facebook campaigning activity by mayoral candidates.[14] To find a candidate's Facebook page, we searched on Google for the "Candidate's Ballot Name + Candidate's Number + City name+ Facebook" and scraped the link of the first Google search result using the Facebook API.[15] This procedure indicates that 35% of mayoral candidates had a Facebook page during the election period.[16] For each candidate, we count the number of Facebook posts and the number of reactions that followers had for each post (likes and comments). Figure A.1 plots the daily number of Facebook posts by mayoral candidates in 2016. It shows that candidates disproportionately use Facebook during the election period, especially in the days just before the election.

[14] Brazil is one of the largest users of Facebook in the world.

[15] A candidate was coded as not having a Facebook page if: i) the first search result was not a Facebook page, ii) the Facebook page was of a news web site, iii) the search for two different candidates yielded the same Facebook page.

[16] Similar results were found by manually searching a small sample of candidates' Facebook pages.

Table 10 presents our estimates of the effect of spending limits on the probability that a candidate had a Facebook page, the number of posts, and the number of reactions. We find that a high spending limit reduces the likelihood of having a Facebook page by 6 percentage points (or 18 percent given a mean of 0.345). A higher limit also reduces the average number of posts by candidates by 18 percent and the number of reactions (e.g. likes) of these posts by 35%. These results suggest mayoral candidates facing a low cap did invest more on social media campaigning.[17]

Dark Money Another technology that politicians who are constrained by the cap might resort to is the use of dark money. A common vehicle for dark money to appear in politics is for the politician to claim the donation (and hence the expenditure) as in-kind. In these cases there is no formal receipt of the contribution (i.e. no paper trail) and the value of the contribution is then estimated by the political party. An example of such a contribution is the use of a restaurant to host a fund-raising event. In this case, the party might under-declare the value of the contribution.

In Table 11, we estimate the effects of the spending caps on the amount of contributions, distinguishing between cash contributions versus in-kind. We present the estimates for both the pool of candidates, as well as the election winners. In both cases, the effects of the caps are on cash contributions, as opposed to the in-kind contributions. Although politicians may channel dark money in other ways, we do not find any evidence that spending caps impacted the types of contributions politicians receive.

Party Spending When parties spend on behalf of their candidates, this expenditure counts against the candidate's spending totals and is thus subject to the limits. However, there are some cases where the party's contribution to a candidate's campaign cannot be determined, which can occur, for instance, when the party hosts an event or produces an advertisement for several of its candidates. Given that we observe party expenditures, we can investigate whether parties exploit this loophole by testing for whether party expenditures also respond to the spending caps. But as the Figure 9 depicts, we do not find any evidence that parties are substituting for the lack of spending in the municipalities with the lower limit.

Voter Knowledge A key argument against imposing spending caps is that with less spending, voters may become less informed. In the previous section we showed that campaigning through

[17] We also estimated the effects separately for incumbents and challengers. Although our point estimates for the effect are slightly larger for challengers, we cannot reject the null hypothesis that the effects between challengers and incumbents are the same.

social media and citizen engagement through Facebook increased when municipalities face a more stringent cap of campaign spending, which goes against the idea that caps make citizens less informed. In this section we use two alternative measures of voter knowledge to test this hypothesis. First, several studies have documented a strong association between political knowledge and both turnout and invalid votes (e.g. Lassen (2005)). We test whether turnout is lower and invalid votes are higher when candidates face a lower spending cap. Second, we use a direct measure of information by counting the number of times candidates' names are searched on Google.

In Table 12 we report estimates of the effects of spending caps on turnout and the share of blank or invalid votes. Although these are imperfect proxies for voter information, we find no evidence to support the hypothesis that lower spending caps will lead to less informed voters. In both cases, our estimates are precisely estimated zeros.

To further evaluate the impact of spending limits on voters' knowledge, we estimate its impact on the number of times candidates names are searched on Google. If a higher spending limit increases electorate knowledge, it is likely that more voters will search for mayoral candidates by their names online. We used Google Adwords too construct the number of monthly searches each candidate received[18]. Google Adwords only gives ranges on the number of searches: 0-10, 10-100, 100 - 1k, 1k - 10k, 10k-100k, etc. Hence, we created an index of Google searches. Table A.3 shows the distribution of this index across candidates in September 2016.

Figure A.2 plots the evolution of the number of Google searches for candidates' names. The plot clearly shows that voters interest on candidates grows as the election becomes closer, peaking in September, the month just before the election. We use average index of Google searches across candidates to test whether spending caps affect searches. Table 13 reports the impact of the high spending cap on the average index of Google searches across candidates in a municipality. Results suggest that a higher spending limit does not lead to an increase in the number of searches for candidates' names. In fact, the point estimates suggest a decrease in the number of searches under the high cap, although these results are not significant at usual levels of confidence. If voters were to become more informed under the high cap, challengers were the ones who would probably get a larger increase in searches since they are less well known in the beginning of the race. When we break the results by incumbents' and challengers' searches, results suggest that a higher spending limit does not affect incumbents' names searches and, if anything, reduces searches for challengers' names.

[18] First, we drop all candidates that in the same state have the same ballot name (978 candidates). After that, Adwords gives us the number of searches candidates ballot name had in the states where they are running.

An alternative interpretation of the analysis above is that more information about a candidate leads to less Google searches because voters already know about the candidate. To test whether Google searches are complements or substitutes with information, we correlate Google searches with TV and radio advertising time across candidates. Radio and TV political advertising is regulated and candidates' air time is a function of the representativeness of their party coalition in Congress.[19] Results in Table A.4 show that candidates' ad time share is positively correlated with his Google searches after controlling for municipality fixed effects and several candidates' characteristics. This can be interpreted as evidence that as voters get more informed about candidates they search more about them on Google.

In sum, the results above using different proxies of access to information suggest that the spending limit does not affect voters' knowledge.

5.5 Model Estimation and Discussion

In this section, we estimate the model presented in Section 3 to complement our reduced-form analysis in three notable ways. First, the structural estimates inform us further on the effects of spending caps on the selection of candidates who run for office. In the reduced-form analysis, we found that spending caps alter the observable characteristics of candidates entering politics; here, we investigate the effects of the caps on two types of unobserved heterogeneity: campaign effectiveness and fundraising costs. This distinction provides additional insights on the elasticity of vote shares with respect to campaign spending and on the welfare effects of spending caps. Second, whereas the reduced-form analysis is restricted to the estimation of a local effect, the structural estimates allow us to consider the effects of various alternative spending caps. Third, we decompose the effects of the spending cap on incumbent electoral outcomes into two channels: a spending effect and an entry effect. This decomposition allows us to investigate why spending caps harm the electoral prospects of incumbents.

Estimation We estimate the model via maximum likelihood (see Appendix A.2 for the details). In order for the sample to be comparable to those used in the reduced-form analysis, we restrict the estimation sample to municipalities within a 50 percent bandwidth of the discontinuity.

Indexing candidates by i and municipalities by j, we write a candidate's type as the vector (a_{ij}, c_{ij}),

[19] 10% of airtime is splited equally among all candidates in the municipality and 90% is split according to the seat share of their coalition in Congress.

where a_{ij} is the candidate's campaign effectiveness or popularity, and c_{ij} is the marginal cost of raising campaign contributions.[20] We assume that each candidate's type is drawn from a bivariate lognormal distribution $F(\mu^k, \Sigma^k)$, where $k \in \{\text{Incumbent}, \text{Challenger}\}$ indicates that incumbents and challengers are drawn from separate distributions. We make this distinction between incumbents and challengers to capture not only selection, but also the possibility that being elected into office may give rise to structural advantages or disadvantages to fundraising and campaigning.

To estimate the model, we search for the parameter vectors and matrices $\mu^{\text{Inc}}, \Sigma^{\text{Inc}}, \mu^{\text{Cha}}, \Sigma^{\text{Cha}}$ which maximize the likelihood of observing the data on vote shares p_{ij} and campaign expenditures x_{ij}. Intuitively, the campaign effectiveness moments are identified by the relation between expenditures and vote shares (equation (2)). A candidate with relatively low expenditures and a high vote share is a candidate with an effective campaign. Given the campaign effectiveness of each candidate within a race, the fundraising cost of each candidate is then identified by the equilibrium spending conditions (equation (6)). Consider the following simple example. Suppose that two candidates in separate elections have the same campaign effectiveness and that in both elections, the set of challengers have the same characteristics. Then if one candidate spends more than the other, this implies that her fundraising cost is relatively lower.

Estimates for campaign effectiveness and fundraising costs How do incumbents and challengers differ? Figure 10 plots the marginal distributions of the campaign effectiveness (a) and fundraising costs (c) implied by our maximum likelihood estimates. We find that fundraising tends to be less costly for incumbents than for challengers, indicating that all else equal, incumbents will raise and spend more money in equilibrium than challengers.

Given the existing literature on the effects of campaign spending, it is unclear whether we should expect campaign effectiveness to be greater for incumbents or challengers. On the one hand, several studies have found that vote shares are more sensitive to challenger than to incumbent spending (e.g. Jacobson (1990)). On the other hand, since incumbents have lower fundraising costs, we should expect incumbents to spend a relatively larger fraction of total expenditures in elections than challengers, which mechanically leads to vote shares being less sensitive to changes in incumbent spending. Here, we find that incumbents tend to be more popular than challengers. This implies that if all candidates within a municipality spent the same amount on campaigning, the incumbent would be the most likely to win.[21]

[20] We assume that $b_{ij} = 0$ for all candidates, such that there is no informal spending.

[21] Although the two methodologies differ, this result is also consistent with the positive effect we estimate for incumbents in our reduced-form regression (see Table A.1).

The full set of maximum likelihood estimates are reported in Table 14. Of particular interest, we estimate a significant positive correlation between popularity and fundraising costs, whether we consider incumbents or challengers. This correlation implies that those candidates who are likely to spend the most–i.e. the candidates with the lowest costs–will be candidates who, if every candidate spent the same amount, attract fewer votes. Thus, voters often face a tradeoff between voting for a high-spending, low-popularity candidate, and a low-spending, high-popularity candidate.

Our estimates can also be employed to compute vote share elasticities with respect to campaign spending. In the model, the marginal effect of an increase in spending on the vote share depends on four factors: the candidate's own spending level, her campaign effectiveness, spending by other candidates, and the campaign effectiveness of other candidates. Thus, we can estimate for each entrant her vote share elasticity taking as given the equilibrium spending amounts we observe in the data. Specifically, we estimate for each candidate the change in her vote share if we increase her spending by one percent, holding constant the spending by all other candidates. We find that on average, increasing campaign spending by 1 percent results in an increase of 0.74 percent in the vote share of challengers, compared to 0.64 percent for incumbents. These numbers translate to a marginal cost of a vote of R$22 ($6.6) for the average challenger and R$27 ($8.1) for the average incumbent in our sample. The larger elasticity estimate for challengers is consistent with the extensive literature evaluating the returns to campaign spending. In contrast to previous work (e.g. Bombardini and Trebbi (2011), Levitt (1994)), a key driver to the result in our case is the heterogeneity in the cost of fundraising, which leads incumbents to invest a higher share of the total inputs in the contest. Hence, the lower incumbent elasticity is not the result of campaigning being inherently less effective for incumbents, but rather it is due to the fundraising advantages of incumbents.

Simulating alternative campaign spending caps Using our maximum likelihood estimates, we solve for the equilibrium in 50,000 simulated municipalities for a series of counterfactual spending caps. The results of our simulations for spending caps ranging from R$25,000 to R$225,000 mirror closely our main reduced-form findings. The number of candidates who enter the race decreases in the cap (Figure 11a). Moreover, mean campaign spending increases in the cap (Figure 11b), and does so to a greater extent for incumbents than challengers (Figure 11c). Finally, incumbent vote shares increase in the cap (Figure 11d). Each of these effects is nonlinear: increasing the cap has diminishing returns, which are especially rapid for incumbents' electoral benefits.

Our finding that popularity and fundraising cost are positively correlated entails a trade-off in voter welfare, which arises when the spending cap is increased. On the one hand, a higher spending cap implies that the winner is more likely to have spent more, which according to our estimates, is something that voters value. On the other hand, a high-spending winner is more likely to have a low fundraising cost (Figure 11f) and is thus more likely to be less intrinsically popular with voters (Figure 11e). Whether voters ultimately benefit from spending caps will depend on which of these two effects is largest.[22]

Why do spending caps harm incumbents? Campaign spending and candidate entry In this section, we further explore the result that stricter spending caps harm the electoral outcomes of incumbents. In the reduced-form analysis, we found two plausible mechanisms underlying this result: first, when the cap is decreased, incumbents reduce campaign spending more than challengers and second, more challengers contest the election. To estimate which of these channels is more important, we turn to our model estimates.

According to our structural estimates, incumbents have an advantage over challengers in the cost of fundraising for their campaigns. Thus, consistent with the data, incumbents tend to spend more than challengers and are more likely to be spending near or at the cap. Therefore, imposing a stricter cap will have a direct *spending effect* which harms the incumbent, independent of the number of challengers in the race. At the same time, we showed in Section 3 that reducing the spending cap will reduce the total inputs invested by all candidates into the election, increasing entry by new challengers. Therefore, imposing a stricter cap will also harm the incumbent through an *entry effect*.

To decompose the effect of spending limits on the electoral outcomes of incumbents, we simulate the model under two alternative environments for spending caps ranging from R$100,000 to R$25,000. In the first environment, we compute the equilibrium of the full model for each spending cap, thereby allowing the cap to influence the election through both the spending and the entry effects. In the second, we isolate the spending effect by imposing the set of candidates contesting the election to remain fixed under each simulated spending cap to the set of entrants when the cap is R$100,000. Figure 12 plots the results of these simulations. We find that reducing the spending cap from R$100,000 to R$50,000 reduces the average incumbent vote share by 3 percentage points when only the spending channel is permitted, while it is reduced by 6 percentage points when both spending and entry effects are accounted for. We find that the entry effect becomes relatively more

[22] In the model, we assume a reduced-form relationship between campaign spending and voter preferences without explicitly modeling the process in which campaign spending alters voter behavior (e.g. Prat (2002)). Given our data, we cannot distinguish between alternative theories of voter decision-making, rendering a welfare analysis impracticable.

important as the spending cap is decreased: further decreasing the limit to R$25,000 implies an additional reduction of 3 percentage points from the spending effect compared to 8 percentage points from the combination of entry and spending effects. In sum, our findings highlight that in order to assess the effects of the introduction of campaign spending limits, one must take care to not only consider the equilibrium effects of the policy on the current candidates contesting the election, but also on the entry of new candidates.

6 Conclusion

The role of money in politics is widely debated in many democracies. This paper examines the effects of limiting how much money candidates can spend on their campaigns. We exploit a natural experiment induced by an electoral reform in Brazil that set a lower spending cap for some municipalities compared to others. Using data on number of candidates, their characteristics, and voting outcomes we find that setting a more stringent limit on campaign spending increases political competition, reduces the chances of richer candidates getting elected, and reduces incumbency advantage.

These findings suggest that in countries where high levels of spending have become an equilibrium outcome due to corruption and the influence of special interests, setting a spending limit might increase political competition and allow for new entrants into politics. In countries where political elites come disproportionately from richer families, this policy might also reduce the concentration of political power in the hands of richer individuals. These effects might have direct and indirect consequences for policy outcomes.

By reducing the cost of political campaigns, spending limits might also reduce the incentives incumbent politicians have to divert resources from public funds for their campaigns. Whether campaign spending limits reduce corruption or affect project choices by elected politicians are important topics for future research.

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09/29/2015	Law 13.165 establishes preliminary limits on campaign spending for the 2016 election
07/05/2016	Beginning of intra-party campaign for mayor candidate
07/20/2016	Establish final limits on campaign spending valid for 2016 election
07/20/2016-08/05/2016	Parties chose candidates
08/15/2016	Last day for candidacy registration
08/16/2016- 09/30/2016	Campaign period
10/02/16	Municipal elections

Figure 1: Timeline

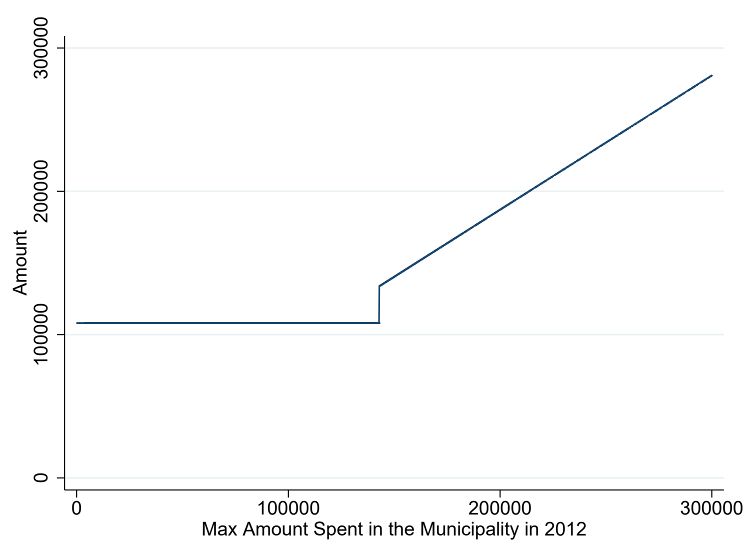
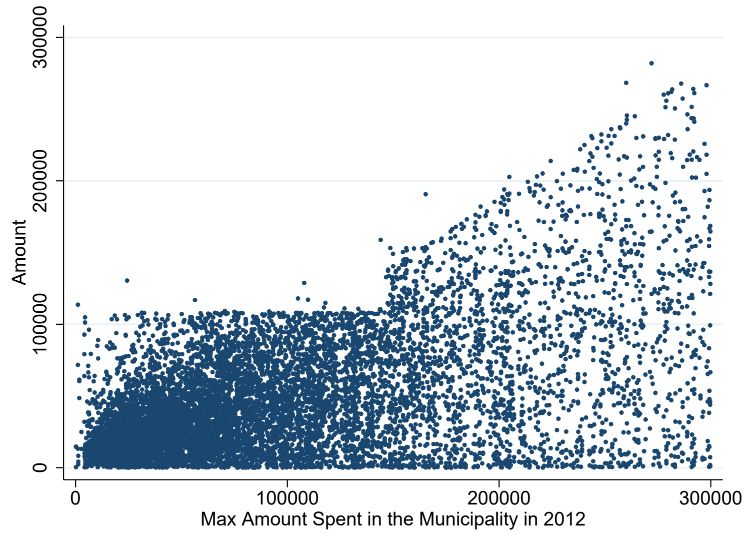


Figure 2: Campaign Spending Limits in 2016

(a) Candidate spending

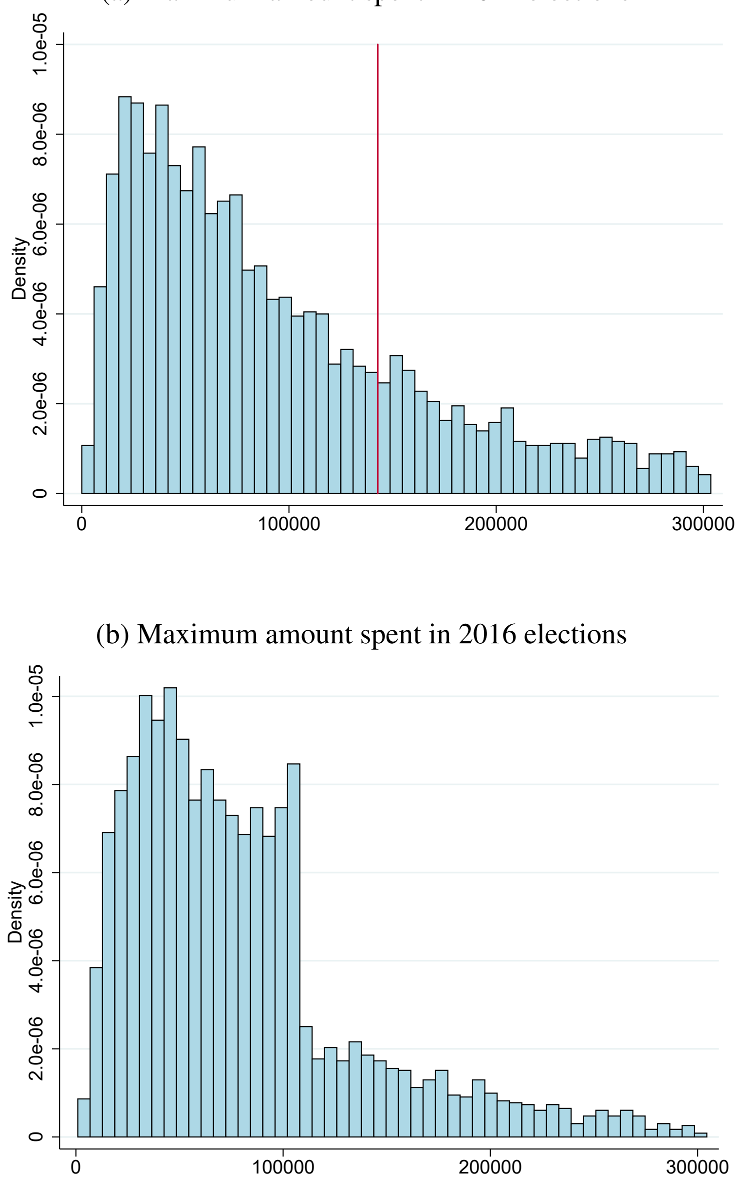


(b) Maximum spending by municipality

Figure 3: Campaign Spending in the 2016 Elections

Notes: In panel (a), each point denotes the amount spent by a candidate in the 2016 elections. In panel (b), each point denotes the maximum amount spent by a candidate by municipality in the 2016 elections.

(a) Maximum amount spent in 2012 elections



(b) Maximum amount spent in 2016 elections

Figure 4: Campaign Spending in the 2012 and 2016 Elections

Notes: Panel (a) plots the distribution of the running variable, the maximum amount spent by a candidate within a municipality in the 2012 elections. The red line denotes the discontinuity of the rule at R$142,857. Panel (b) plots the distribution of the maximum spent on campaigning by a candidate within a municipality in the 2016 elections.

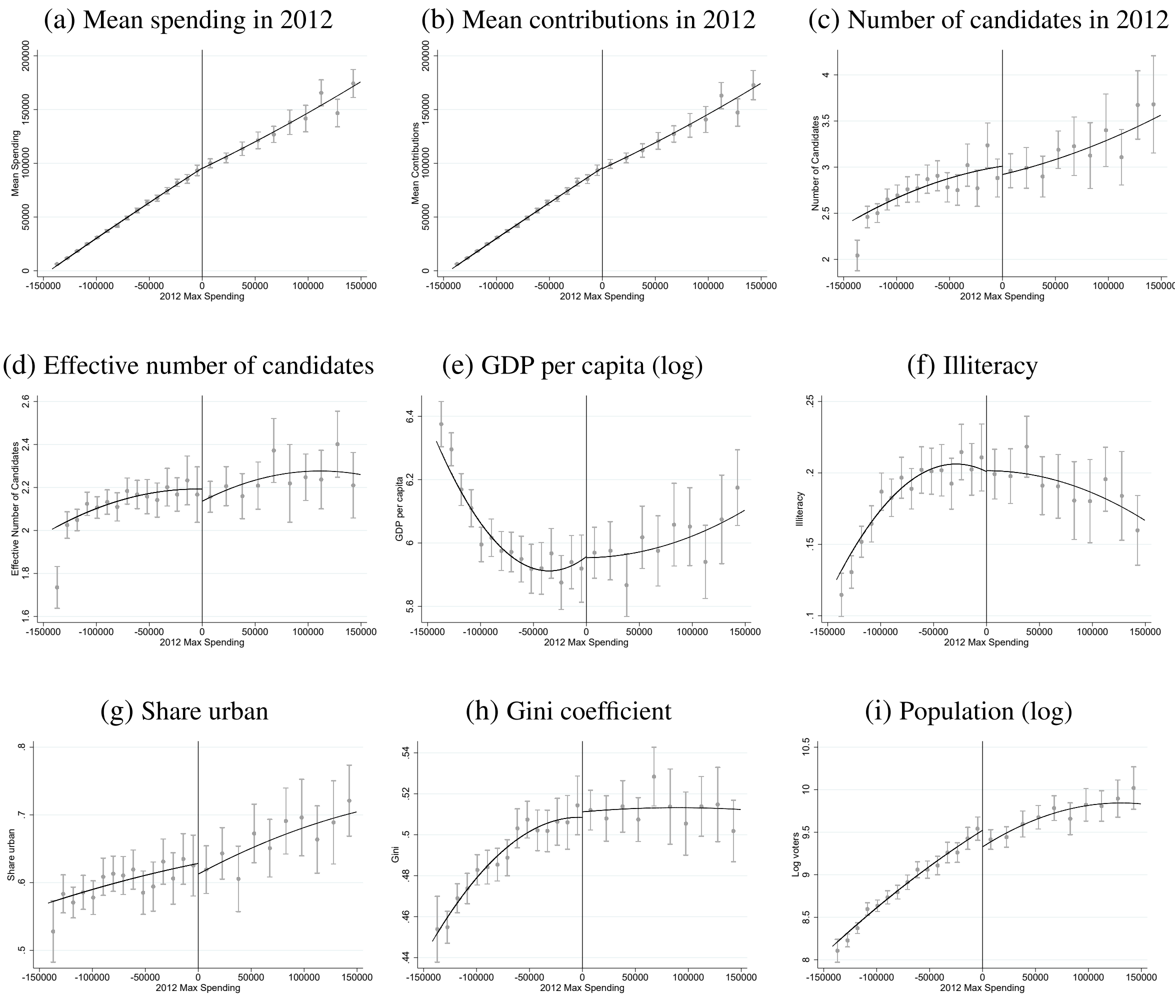
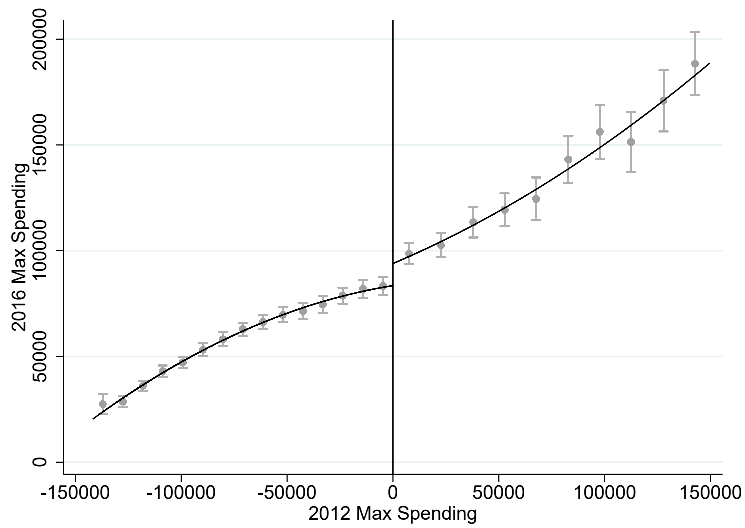


Figure 5: Discontinuities in Municipal-level Baseline Covariates

Notes: These figures plot the results of RD regressions of various municipal characteristics on maximum spending in 2012 (the running variable). The horizontal axis denotes the difference in maximum spending relative to the discontinuity at R$142,857. In each regression, a global second-order polynomial is estimated on each side of the discontinuity. Each point denotes the sample-average within a bin. 95% confidence intervals for each bin are computed using the methods of Calonico et al. (2014).

(a) Maximum candidate spending



(b) Mean candidate spending

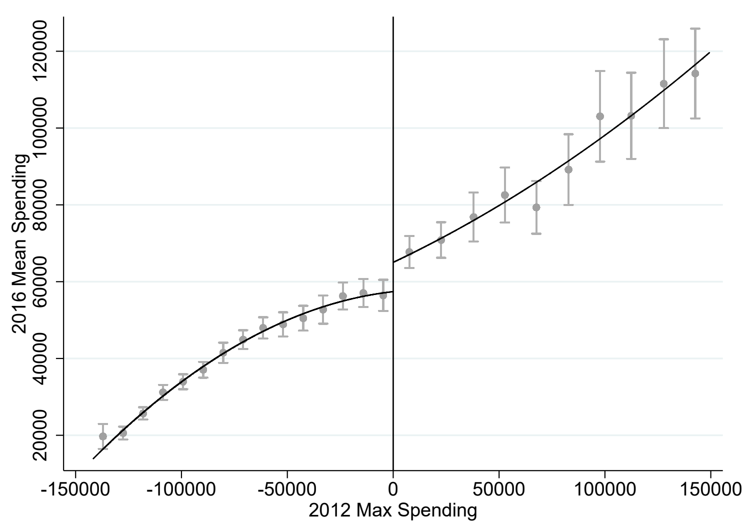
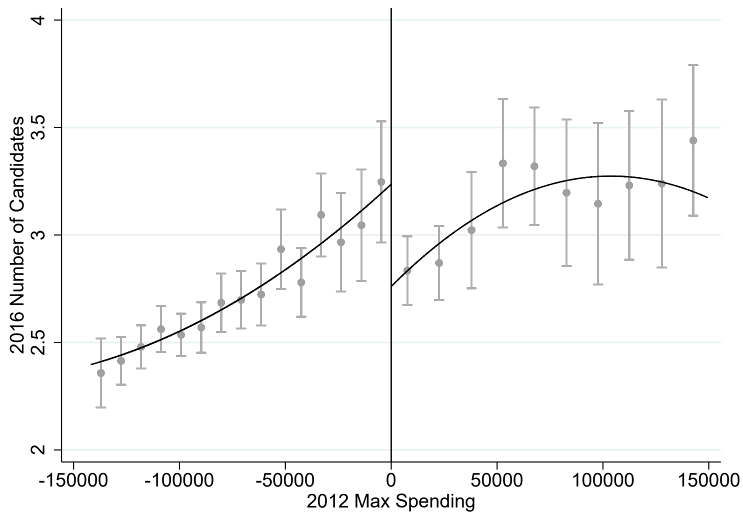


Figure 6: Effects of Spending Limits on Campaign Expenditures

Notes: This figure plots the results of the regression discontinuity design, where the dependent variable is respectively (a) the maximum spending by candidates and (b) the mean spending by candidates. The horizontal axis denotes the difference in maximum spending relative to the discontinuity at R$142,857. In each regression, a global second-order polynomial is estimated on each side of the discontinuity. Each point denotes the sample-average within a bin and its corresponding 95% confidence interval.

(a) Number of candidates



(b) Effective number of candidates

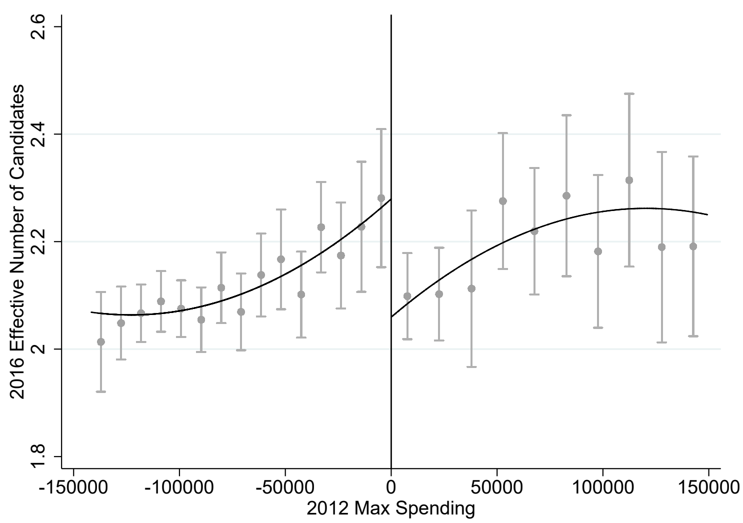


Figure 7: Effects of Campaign Spending Limits on Political Competition

Notes: This figure plots the results of the regression discontinuity design, where the dependent variable is (a) the number of candidates, and (b) the effective number of candidates. The horizontal axis denotes the difference in maximum spending relative to the discontinuity at R$142,857. In each regression, a global second-order polynomial is estimated on each side of the discontinuity. Each point denotes the sample-average within a bin and its corresponding 95% confidence interval.

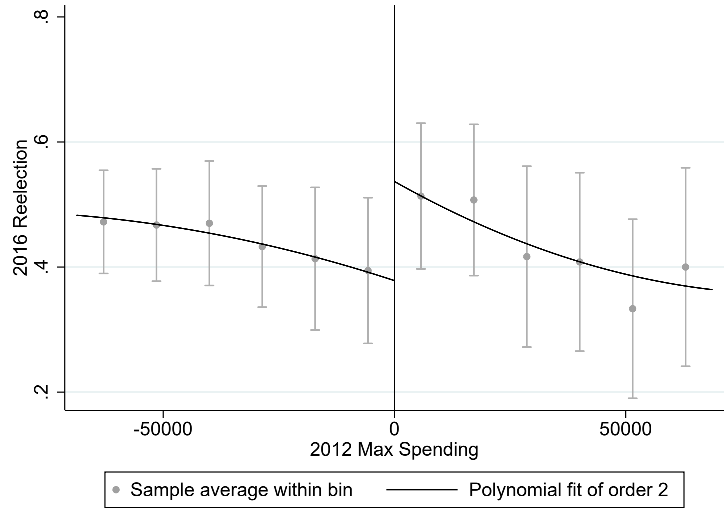


Figure 8: Effects of Campaign Spending Limits on Reelection

Notes: This figure plots the results of the regression discontinuity design, where the dependent variable is a dummy for whether the incumbent is reelected. The sample is restricted to incumbents who run for reelection. The horizontal axis denotes the difference in maximum spending relative to the discontinuity at R$142,857. In each regression, a global second-order polynomial is estimated on each side of the discontinuity. Each point denotes the sample-average within a bin and its corresponding 95% confidence interval.

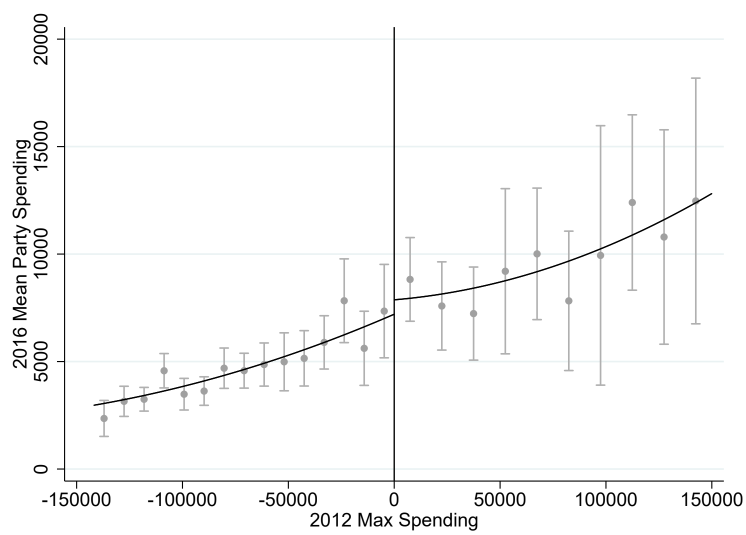


Figure 9: Effects of Spending Limits on Party Spending

Notes: This figure plots the results of the regression discontinuity design, where the dependent variable is the mean spending by parties. The horizontal axis denotes the difference in maximum spending relative to the discontinuity at R$142,857. In each regression, a global second-order polynomial is estimated on each side of the discontinuity. Each point denotes the sample-average within a bin and its corresponding 95% confidence interval.

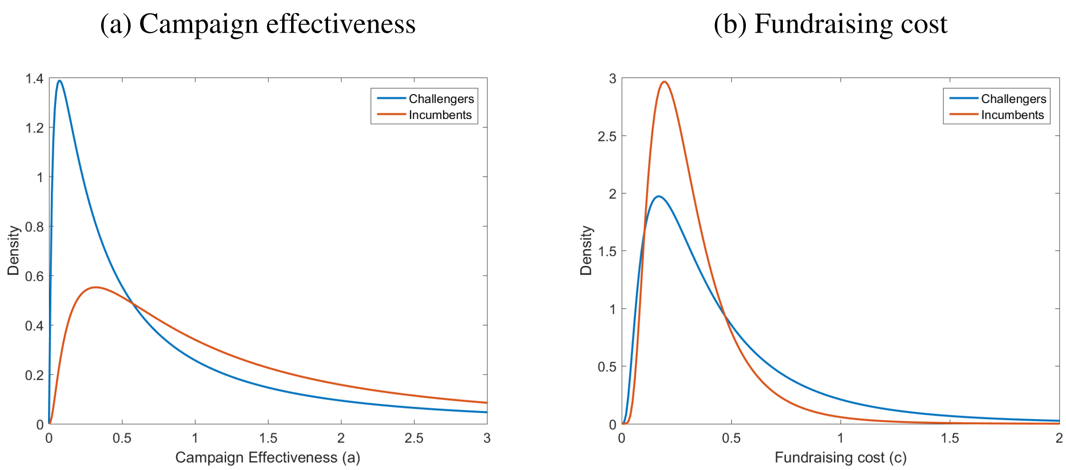


Figure 10: Estimated marginal distributions

Notes: This figure plots the marginal distributions implied by the maximum likelihood estimates.

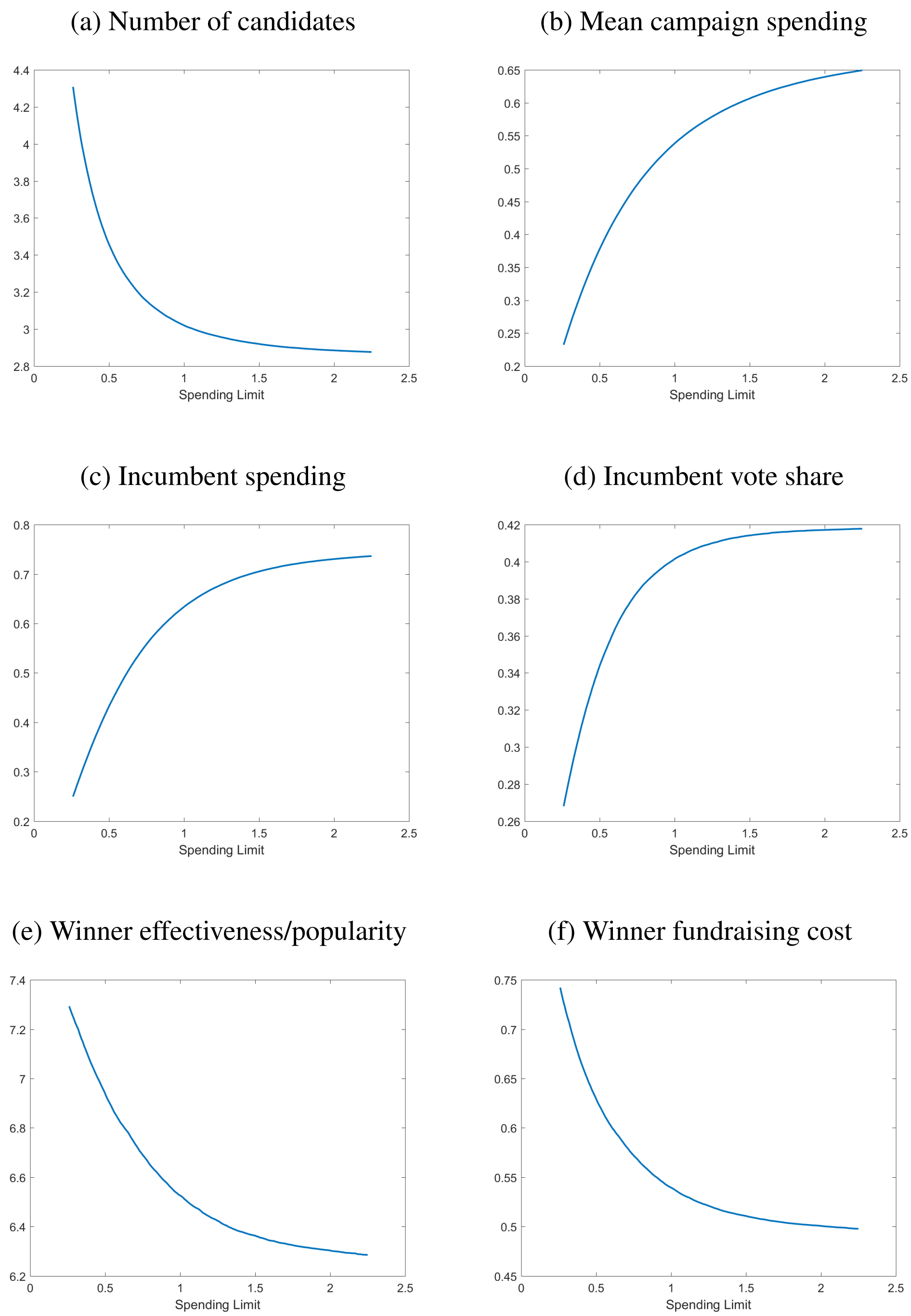


Figure 11: Simulations

Notes: This figure plots the means of various equilibrium outcomes against simulated spending caps. The unit for monetary values is R$100,000. For each simulated spending cap, 50,000 draws are made.

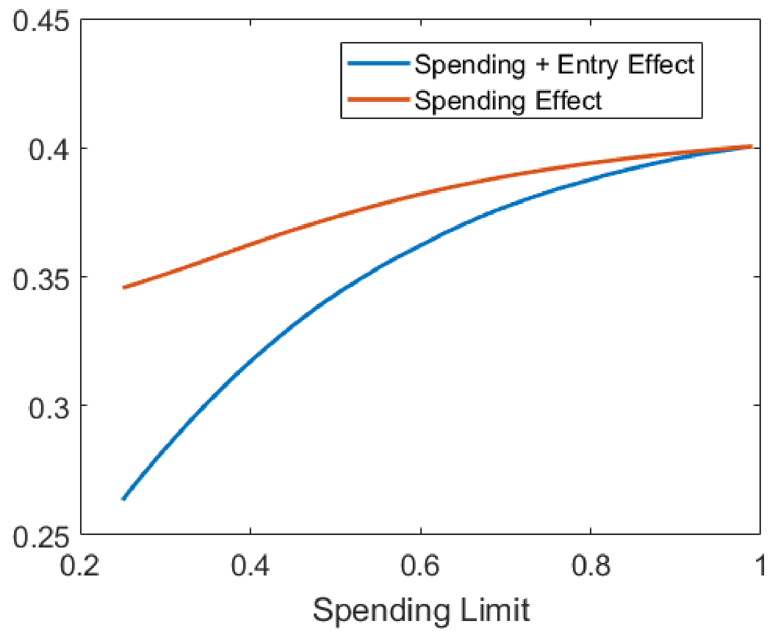


Figure 12: Decomposing the effect of spending limits on incumbent vote shares

Notes: This figure plots the mean incumbent vote share for varying simulated spending caps. The unit for monetary values is R$100,000. For each simulated spending cap, 50,000 draws are made.

Table 1: Summary Statistics

	Mean (1)	Standard Deviation (2)	Observations (3)
Panel A: Within-Municipality Average Candidate Characteristics			
Campaign spending (R$1000)	77.28	145.97	5562
Campaign contributions (R$1000)	74.94	122.17	5562
Own funds	29.98	54.62	5562
Individual donations	31.15	50.38	5562
Party donations	11.35	49.79	5562
All other donations	0.15	2.09	5562
Female	0.125	0.207	5562
Age	49.21	11.25	5562
High school	0.830	0.249	5562
College	0.505	0.333	5562
Political experience	0.944	0.620	5562
Assets (R$1000)	1006.80	5483.58	5562
Propensity to win	0.361	0.081	5562
Panel B: Municipality Characteristics			
Number of candidates	2.925	1.333	5562
GDP per capita	6.080	0.501	5544
Illiteracy	0.174	0.107	5544
Share urban	0.639	0.220	5544
Gini coefficient	0.494	0.066	5544
Log voters	9.225	1.078	5562
Hiring limit	137.22	192.72	5562
Open seat	0.241		5562
Panel C: Incumbent Outcomes			
Reelection	0.482		2618
Incumbent vote share	0.468	0.184	2618

Notes: This table displays means and standard deviations of various characteristics computed for the municipality and incumbent samples. In panel A, statistics on campaign spending, female gender, age, high school and college completion, assets, and propensity to win are computed for municipality-level means. In panel B, the statistics are calculated for municipality-level characteristics. The "open seat" variable is a dummy for whether the seat in 2012 is occupied by a term-limited mayor. In panel C, statistics for reelection and the incumbent vote share are computed for the sample of incumbents who rerun in 2016.

Table 2: Covariate Smoothness

Dependent Variable	Mean (1)	Observations (2)	Estimate (3)
Panel A: Municipal Characteristics in 2010			
GDP per capita (log)	5.911	2558	0.012
	(0.031)		(0.040)
Illiteracy	0.208	2201	-0.002
	(0.008)		(0.010)
Share Urban	0.625	2419	-0.015
	(0.014)		(0.018)
Gini Coefficient	0.511	2431	-0.000
	(0.005)		(0.006)
Population (log)	9.509	1986	-0.158**
	(0.053)		(0.068)
Panel B: Mean Candidate Characteristics in 2012			
Number of Candidates	3.052	1763	-0.007
	(0.086)		(0.108)
Effective Number of Candidates	2.203	1902	-0.030
	(0.042)		(0.048)
Small Party	0.425	2270	0.004
	(0.020)		(0.025)
Female	0.121	2553	0.022
	(0.013)		(0.016)
Age	47.962	2433	0.072
	(0.437)		(0.548)
High School Degree	0.853	2024	0.001
	(0.018)		(0.023)
College Degree	0.509	1986	0.037
	(0.024)		(0.030)
Campaign Spending	94396.87	1057	-1965.04
	(2431.97)		(2921.36)
Campaign Contributions	94737.97	1085	-2551.47
	(2364.50)		(2882.86)
Own Funds	24319.94	1297	2572.27
	(1796.36)		(2464.03)
Individual Donations	36355.43	1538	-1498.32
	(1762.72)		(2202.32)
Party Donations	10572.97	1036	-2074.31
	(1389.72)		(1688.48)
Corporate Donations	15876.27	1233	937.79
	(1518.43)		(2145.03)
Wealth (log)	11.551	2199	-0.017
	(0.154)		(0.183)

Notes: Standard errors are in parentheses. The mean in column (1) is the estimated value of the dependent variable for a municipality at the cutoff point whose spending limit is $R108,039 in 2016. The bandwidth is selected with the optimal procedure by Calonico et al. (2014) and the number of observations is reported in column (2). Each figure in column (3) reports the estimate and standard error for the treatment effect from a separate regression. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3: Effects of Spending Limits on Campaign Expenditures

	Mean	Obs	(1)	(2)	(3)	(4)
Maximum Spending	84823.66	1068	10212.56***	9834.92***	10337.88***	11781.30***
	(2283.84)		(2971.87)	(3280.29)	(2758.98)	(3502.78)
Mean Spending	58471.54	1274	5705.95**	4940.07*	5540.17**	6833.53**
	(1875.60)		(2461.39)	(2763.56)	(2251.89)	(2946.03)
Minimum Spending	32829.54	1745	988.86	16.68	1452.29	-408.74
	(2090.75)		(2820.98)	(3175.00)	(2582.36)	(3777.42)
Total Spending	169000.64	1159	7335.85	11682.88	7156.26	12238.92
	(6006.29)		(7511.99)	(8425.47)	(6850.61)	(8760.41)
Bandwidth	CCT	CCT	CCT	75% CCT	125% CCT	CCT
Polynomial Order	One	One	One	One	One	Two

Notes: Each figure in columns (1)-(4) reports the estimate and standard error of a separate regression. Standard errors are in parentheses. The mean is the estimated value, based on specification (1), of the dependent variable for a municipality at the cutoff point whose spending limit is $R108,039. The dependent variables are respectively the mean, maximum, minimum, and total campaign expenditures by candidates computed at the municipality-level. The CCT bandwidth is selected with the optimal procedure by Calonico et al. (2014), and the number of observations under this bandwidth is reported in the table. State fixed effects and municipal controls (income per capita, illiteracy, share urban, population, gini coefficient) are included in all regressions. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Effects of Spending Limits on Campaign Contributions

	Mean	Obs	(1)	(2)	(3)	(4)
Overall Contributions	58270.00	1332	6179.41**	5754.40**	5641.58**	6988.09**
	(1845.51)		(2441.96)	(2732.77)	(2232.75)	(3064.40)
Own Funds	23889.92	1459	4641.85**	4487.98*	3648.77*	4262.16*
	(1459.86)		(2162.27)	(2426.65)	(1963.48)	(2581.21)
Individual Donations	25747.75	1439	200.07	280.40	489.96	266.29
	(1325.32)		(1752.67)	(1937.98)	(1621.45)	(2186.17)
Party Donations	7074.12	1429	1210.84	1201.15	963.01	1377.40
	(790.16)		(1060.98)	(1200.61)	(968.80)	(1263.92)
All Other Donations	113.91	1626	12.34	-14.16	15.50	3.30
	(45.62)		(63.50)	(64.28)	(63.73)	(69.08)
Bandwidth	CCT	CCT	CCT	75% CCT	125% CCT	CCT
Polynomial Order	One	One	One	One	One	Two

Notes: Each figure in columns (1)-(4) reports the estimate and standard error of a separate regression. Standard errors are in parentheses. The mean is the estimated value, based on specification (1), of the dependent variable for a municipality at the cutoff point whose spending limit is $R108,039. Each dependent variables is a municipality-level mean. "Overall Contributions" is equal to the sum of the four categories: own, individual, party, and other contributions. State fixed effects and municipal controls (income per capita, illiteracy, share urban, population, gini coefficient) are included in all regressions. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: Effects of Campaign Spending Limits on Candidate Entry

	Mean	Obs	(1)	(2)	(3)	(4)
Number of Candidates	3.187	2012	-0.256**	-0.279**	-0.247***	-0.279**
	(0.092)		(0.102)	(0.119)	(0.092)	(0.132)
Effective Number of Candidates	2.253	2198	-0.143***	-0.164***	-0.129***	-0.184***
	(0.042)		(0.049)	(0.056)	(0.044)	(0.068)
Propensity to Win	0.352	1985	0.020***	0.022***	0.018***	0.022***
	(0.005)		(0.007)	(0.008)	(0.006)	(0.008)
Small Party	0.488	2166	-0.038	-0.044	-0.037	-0.049
	(0.021)		(0.026)	(0.031)	(0.024)	(0.030)
Average Ideology Index	5.122	2237	0.059	0.003	0.068	-0.101
	(0.081)		(0.100)	(0.114)	(0.091)	(0.144)
Maximum Ideology Index	6.263	2076	-0.109	-0.197	-0.072	-0.196
	(0.112)		(0.131)	(0.152)	(0.118)	(0.166)
Minimum Ideology Index	3.981	2277	0.198	0.158	0.188	0.120
	(0.106)		(0.129)	(0.145)	(0.119)	(0.173)
Female	0.156	1863	-0.030	-0.034	-0.018	-0.043*
	(0.016)		(0.020)	(0.023)	(0.018)	(0.025)
Age	49.094	2468	-0.364	-0.202	-0.407	-0.154
	(0.453)		(0.539)	(0.608)	(0.494)	(0.756)
White	0.617	1771	-0.021	-0.019	-0.013	-0.028
	(0.022)		(0.027)	(0.031)	(0.024)	(0.033)
College Degree	0.562	2083	-0.025	-0.017	-0.025	-0.028
	(0.021)		(0.027)	(0.031)	(0.025)	(0.031)
Political Experience	0.866	2254	0.062	0.053	0.044	0.056
	(0.040)		(0.048)	(0.055)	(0.044)	(0.067)
Wealth (log)	11.477	1811	0.401*	0.483**	0.313	0.498**
	(0.175)		(0.214)	(0.247)	(0.194)	(0.253)
Bandwidth	CCT	CCT	CCT	75% CCT	125% CCT	CCT
Polynomial Order	One	One	One	One	One	Two

Notes: Each figure in columns (1)-(4) reports the estimate and standard error of a separate regression. Standard errors are in parentheses. The mean is the estimated value, based on specification (1), of the dependent variable for a municipality at the cutoff point whose spending limit is $R108,039. The dependent variables are two measures of the number of candidates who run for office, followed by municipality-level averages of various candidate characteristics. The "Propensity to Win" denotes the propensity for a candidate to win an election based on his observable characteristics (see Table A.1). State fixed effects and municipal controls (income per capita, illiteracy, share urban, population, gini coefficient) are included in all regressions. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 6: Effects of Campaign Spending Limits on Incumbents

	Mean	Obs	(1)	(2)	(3)	(4)
Panel A: All incumbents						
Rerun	0.605	1559	0.057	0.029	0.057	0.054
	(0.040)		(0.049)	(0.057)	(0.043)	(0.061)
Reelection	0.226	1726	0.110***	0.122**	0.088**	0.110**
	(0.030)		(0.042)	(0.048)	(0.037)	(0.050)
Panel B: Incumbents who rerun in 2016						
Reelection	0.384	762	0.160**	0.182**	0.145**	0.141**
	(0.050)		(0.062)	(0.072)	(0.058)	(0.068)
Change in Vote Share	-0.133	678	0.066**	0.078**	0.055**	0.066*
	(0.024)		(0.030)	(0.032)	(0.027)	(0.034)
Incumbent Spending	73442.98	682	10311.77**	9059.49**	10360.66**	11370.41**
	(2903.77)		(4348.01)	(4514.72)	(4183.28)	(5484.85)
Total Challenger Spending	98797.86	878	1107.77	-715.63	2436.11	1137.01
	(5462.11)		(7411.32)	(8117.57)	(6645.58)	(9993.36)
Mean Challenger Spending	49012.44	976	3970.59	3699.74	3483.18	4872.82
	(2443.98)		(3440.95)	(3784.47)	(3157.33)	(4349.70)
Bandwidth	CCT	CCT	CCT	75% CCT	125% CCT	CCT
Polynomial Order	One	One	One	One	One	Two

Notes: Each figure in columns (1)-(4) reports the estimate and standard error of a separate regression. Standard errors in parentheses, clustered by state-party. The mean is the estimated value, based on specification (1), of the dependent variable for a municipality at the cutoff point whose spending limit is $R108,039. State and party fixed effects and municipal controls (income per capita, illiteracy, share urban, population, gini coefficient and 2012 incumbent spending) are included in all regressions. In Panel A, the sample consists of all incumbents who are not term-limited. In Panel B, the sample consists of incumbent mayors who choose to rerun in 2016. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 7: Effects of Campaign Spending Limits on Political Selection

	Mean	Obs	(1)	(2)	(3)	(4)
Propensity to Win	0.382	2112	0.017	0.022*	0.016*	0.020
	(0.008)		(0.011)	(0.012)	(0.010)	(0.013)
Female	0.138	2024	0.007	-0.000	0.013	-0.004
	(0.025)		(0.032)	(0.037)	(0.029)	(0.039)
Age	49.299	2359	-0.483	-0.649	-0.503	-0.804
	(0.765)		(0.964)	(1.097)	(0.883)	(1.354)
White	0.634	2204	0.002	0.003	0.003	0.001
	(0.032)		(0.040)	(0.046)	(0.036)	(0.047)
College Degree	0.547	2520	0.002	0.004	0.000	0.025
	(0.031)		(0.039)	(0.044)	(0.036)	(0.056)
Political Experience	0.898	1903	0.059	0.088	0.041	0.070
	(0.075)		(0.094)	(0.109)	(0.085)	(0.104)
Wealth (log)	11.749	2814	0.514*	0.525*	0.436*	0.573
	(0.230)		(0.266)	(0.301)	(0.242)	(0.359)
Worker's Party (PT)	0.033	2608	-0.003	-0.005	-0.000	-0.005
	(0.012)		(0.015)	(0.017)	(0.013)	(0.019)
Ideology Index	5.290	1774	-0.000	0.031	-0.030	-0.021
	(0.124)		(0.142)	(0.162)	(0.130)	(0.158)
Bandwidth	CCT	CCT	CCT	75% CCT	125% CCT	CCT
Polynomial Order	One	One	One	One	One	Two

Notes: Each figure in columns (1)-(4) reports the estimate and standard error of a separate regression. Standard errors are in parentheses. The mean is the estimated value, based on specification (1), of the dependent variable for a municipality at the cutoff point whose spending limit is $R108,039. The dependent variables are characteristics of the winning candidates. The "Propensity to Win" dependent variable denotes the propensity for a candidate to win an election based on his observable characteristics (see Table A.1). State fixed effects and municipal controls (income per capita, illiteracy, share urban, population, gini coefficient) are included in all regressions. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 8: Effects of Campaign Spending Limits on the Campaign Contributions of Winners

	Mean	Obs	(1)	(2)	(3)	(4)
Overall Contributions	76140.38	1093	9136.78***	9187.39**	8617.55***	10628.05**
	(2542.77)		(3479.48)	(3888.34)	(3193.54)	(4170.59)
Own Funds	29448.08	1361	10747.16***	11125.72***	9352.32***	11907.39***
	(2541.11)		(3711.19)	(4162.91)	(3358.36)	(4594.10)
Individual Donations	38930.25	1163	-3208.61	-3639.71	-2809.18	-3728.12
	(2550.80)		(3479.94)	(3847.64)	(3222.52)	(4139.73)
Party Donations	7964.54	1227	1195.99	2455.58	528.46	3290.46
	(1442.29)		(2010.14)	(2171.93)	(1879.62)	(2472.87)
All Other Donations	245.42	1846	-24.93	-78.32	11.33	-76.18
	(117.59)		(172.86)	(181.01)	(167.22)	(196.99)
Bandwidth	CCT	CCT	CCT	75% CCT	125% CCT	CCT
Polynomial Order	One	One	One	One	One	Two

Notes: Each figure in columns (1)-(4) reports the estimate and standard error of a separate regression. Standard errors are in parentheses. The mean is the estimated value, based on specification (1), of the dependent variable for a municipality at the cutoff point whose spending limit is $R108,039. The "Overall Contributions" dependent variable is equal to the sum of the four categories: own, individual, party, and other contributions. State fixed effects and municipal controls (income per capita, illiteracy, share urban, population, gini coefficient) are included in all regressions. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 9: Effects of Campaign Spending Limits by Share of 2012 Corporate Donations

	Mean	Obs	(1)	(2)	(3)	(4)
Panel A: Below Median Share of Corporate Donations in 2012						
Maximum Spending	82450.465	534	17304.056***	18357.440***	14936.448***	19489.695***
	(3658.919)		(4803.955)	(5478.423)	(4361.799)	(5991.893)
Mean Spending	56655.308	583	9243.377**	9430.619**	9399.121***	9425.856*
	(2750.589)		(3953.143)	(4438.245)	(3597.305)	(5034.645)
Number of Candidates	3.149	937	-0.306**	-0.293	-0.269**	-0.314
	(0.131)		(0.153)	(0.185)	(0.135)	(0.223)
EN of Candidates	2.288	600	-0.253**	-0.249**	-0.228***	-0.280***
	(0.089)		(0.099)	(0.118)	(0.085)	(0.108)
Propensity to Win	0.359	874	0.027**	0.028**	0.022**	0.030**
	(0.008)		(0.011)	(0.013)	(0.010)	(0.014)
Rerun	0.582	922	0.178**	0.191**	0.163**	0.188**
	(0.055)		(0.070)	(0.082)	(0.064)	(0.093)
Reelected	0.184	864	0.175***	0.196**	0.167**	0.201**
	(0.045)		(0.066)	(0.077)	(0.060)	(0.089)
Panel B: Above Median Share of Corporate Donations in 2012						
Maximum Spending	86313.603	596	5495.459	5658.972	5347.118	7516.717 *
	(2853.364)		(3964.858)	(4454.577)	(3649.249)	(4278.022)
Mean Spending	59790.033	715	3416.040	2775.321	2500.413	4134.394
	(2483.740)		(3241.966)	(3642.183)	(2964.136)	(3749.992)
Number of Candidates	3.189	989	-0.251*	-0.306*	-0.229*	-0.297
	(0.130)		(0.144)	(0.162)	(0.132)	(0.183)
EN of Candidates	2.272	1220	-0.119*	-0.123*	-0.123**	-0.116
	(0.055)		(0.065)	(0.073)	(0.061)	(0.087)
Propensity to Win	0.346	1362	0.019**	0.018 **	0.019***	0.018
	(0.006)		(0.008)	(0.009)	(0.007)	(0.012)
Rerun	0.635	1179	-0.014	-0.007	-0.008	-0.020
	(0.051)		(0.060)	(0.070)	(0.055)	(0.084)
Reelected	0.278	1226	0.020	0.050	0.015	0.077
	(0.046)		(0.054)	(0.062)	(0.049)	(0.080)
Bandwidth	CCT	CCT	CCT	75% CCT	125% CCT	CCT
Polynomial Order	One	One	One	One	One	Two

Notes: Each figure in columns (1)-(4) reports the estimate and standard error of a separate regression. Standard errors are in parentheses. The mean is the estimated value, based on specification (1), of the dependent variable for a municipality at the cutoff point whose spending limit is $R108,039. The results in Panel A for Maximum Spending, Mean Spending, Number of Candidates, Effective Number of Candidates and Propensity to win only include municipalities below the median municipality in the share of corporate donations received in 2012. The results in Panel A for Rerun and Reelection probabilities only include municipalities where the incumbent candidate was below the median incumbent in the share of corporate donations received in 2012. Symmetrically, Panel B only includes municipalities and incumbent candidates above the median. State fixed effects and municipal controls (income per capita, illiteracy, share urban, population, gini coefficient) are included in all regressions. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 10: Effects of Spending Limits on Facebook Campaign Activity

	Mean	Obs	(1)	(2)	(3)	(4)
Has Facebook Page	0.345	1919	-0.060**	-0.084**	-0.044*	-0.088**
	(0.023)		(0.029)	(0.034)	(0.026)	(0.037)
Number of Posts (log)	1.191	1914	-0.182*	-0.231*	-0.136	-0.203
	(0.087)		(0.110)	(0.127)	(0.100)	(0.128)
Number of Reactions (log)	2.283	1816	-0.354*	-0.426*	-0.250	-0.421*
	(0.172)		(0.214)	(0.247)	(0.192)	(0.254)
Bandwidth	CCT	CCT	CCT	75% CCT	125% CCT	CCT
Polynomial Order	One	One	One	One	One	Two

Notes: Each figure in columns (1)-(4) reports the estimate and standard error of a separate regression. Standard errors are in parentheses. The mean is the estimated value, based on specification (1), of the dependent variable for a municipality at the cutoff point whose spending limit is $R108,039. The dependent variables are respectively the proportion of candidates with a Facebook Page, the log plus one of the average number of candidates' posts and the log plus one of the average number of reactions candidates' posts got computed at the municipality-level between the beginning of the campaign period and election day. The CCT bandwidth is selected with the optimal procedure by Calonico et al. (2014) , and the number of observations under this bandwidth is reported in the table. State fixed effects and municipal controls (income per capita, illiteracy, share urban, population, gini coefficient) are included in all regressions. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 11: Effects of Spending Limits on In-Kind versus Cash Contributions

	Mean	Obs	(1)	(2)	(3)	(4)
Panel A: Candidates						
Estimated Donations	10827.874	2143	796.145	867.618	718.126	966.594
	(534.242)		(737.883)	(854.836)	(675.718)	(945.401)
Money Donations	47301.296	1325	5512.462**	4777.192*	4796.944*	6265.976*
	(1859.203)		(2380.400)	(2666.112)	(2172.280)	(2986.047)
Panel B: Winners						
Estimated Donations	14396.408	1583	-1050.121	-1193.842	-816.557	-758.768
	(1010.294)		(1317.140)	(1493.318)	(1174.397)	(1560.678)
Money Donations	61368.192	1053	10149.728***	9716.734**	10070.159***	11824.313***
	(2628.278)		(3614.709)	(4006.428)	(3322.418)	(4292.634)
Bandwidth	CCT	CCT	CCT	75% CCT	125% CCT	CCT
Polynomial Order	One	One	One	One	One	Two

Notes: Each figure in columns (1)-(4) reports the estimate and standard error of a separate regression. Standard errors are in parentheses. The mean is the estimated value, based on specification (1), of the dependent variable for a municipality at the cutoff point whose spending limit is $R108,039. For each panel, the dependent variables are respectively the amount of contributions given in kind (Estimated Donations) and the amount of contributions given in cash (Money Donations). The CCT bandwidth is selected with the optimal procedure by Calonico et al. (2014) , and the number of observations under this bandwidth is reported in the table. State fixed effects and municipal controls (income per capita, illiteracy, share urban, population, gini coefficient) are included in all regressions. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 12: Effects of Campaign Spending Limits on Voter Information

	Mean	Obs	(1)	(2)	(3)	(4)
Turnout	0.839	2645	-0.005	-0.005	-0.005	-0.005
	(0.003)		(0.003)	(0.004)	(0.003)	(0.004)
Share of Blank or Invalid Votes	0.069	2193	0.012	0.013	0.010	0.014
	(0.005)		(0.007)	(0.008)	(0.007)	(0.009)
Bandwidth	CCT	CCT	CCT	75% CCT	125% CCT	CCT
Polynomial Order	One	One	One	One	One	Two

Notes: Each figure in columns (1)-(4) reports the estimate and standard error of a separate regression. Standard errors are in parentheses. The mean is the estimated value, based on specification (1), of the dependent variable for a municipality at the cutoff point whose spending limit is $R108,039. The "Turnout" dependent variable is the number of votes divided by the number of eligible voters. The "Share of Blank or Invalid Votes" dependent variable denotes the number of votes cast which are either blank or invalid divided by the number of eligible voters. State fixed effects and municipal controls (income per capita, illiteracy, share urban, population, gini coefficient) are included in all regressions. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 13: Effects of Spending Limits on Google Searches

	Mean	Obs	(1)	(2)	(3)	(4)
Google Searches	0.919	2267	-0.034	-0.040	-0.020	-0.044
	(0.043)		(0.050)	(0.058)	(0.045)	(0.063)
Incumbents' Google Searches	1.017	1429	-0.012	0.028	-0.022	0.119
	(0.073)		(0.085)	(0.096)	(0.078)	(0.126)
Challengers' Google Searches	0.932	1808	-0.102*	-0.081	-0.081	-0.114
	(0.055)		(0.064)	(0.075)	(0.058)	(0.079)
Bandwidth	CCT	CCT	CCT	75% CCT	125% CCT	CCT
Polynomial Order	One	One	One	One	One	Two

Notes: Each figure in columns (1)-(4) reports the estimate and standard error of a separate regression. Standard errors are in parentheses. The mean is the estimated value, based on specification (1), of the dependent variable for a municipality at the cutoff point whose spending limit is $R108,039. The dependent variables are respectively the average September Google searches index for all mayoral candidates, for incumbents and for challengers computed at the municipality-level. The CCT bandwidth is selected with the optimal procedure by Calonico et al. (2014) , and the number of observations under this bandwidth is reported in the table. State fixed effects and municipal controls (income per capita, illiteracy, share urban, population, gini coefficient) are included in all regressions. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 14: Parameter Estimates

	Challengers	Incumbents
Mean effectiveness/popularity (μ_a)	1.555	2.378
	(0.040)	(0.063)
Mean fund-raising cost (μ_c)	0.488	0.324
	(0.009)	(0.009)
Variance of effectiveness/popularity (σ_a^2)	6.882	7.910
	(0.475)	(0.886)
Variance of fund-raising cost (σ_c^2)	0.177	0.054
	(0.014)	(0.003)
Correlation between effectiveness and cost (ρ_{ac})	0.538	0.673
	(0.012)	(0.015)
Mean elasticity of vote share with respect to campaign spending	0.739	0.642
	(0.003)	(0.004)

Notes: This table displays the parameter estimates obtained using maximum likelihood. The elasticity of the vote share with respect to campaign spending is computed for each candidate given the equilibrium spending we observe in the data. Standard errors are in parentheses.

A Online Appendix

A.1 Additional details for the model section

Additional details for the proof to Proposition 1 The best response function $\left(x_i(\tilde{Y}_i), z_i(\tilde{Y}_i)\right)$ can be transformed to the best response function $y_i(\tilde{Y}_i)$ as follows:

$$y_i = \begin{cases} 0 & \text{if } y_i^+ \le 0 \\ y_i^+ & \text{if } 0 \le y_i^+ \le \bar{y}_i \\ \bar{y}_i & \text{if } y_i^- \le \bar{y}_i \le y_i^+ \\ y_i^- & \text{if } \bar{y}_i \le y_i^- \end{cases} \tag{11}$$

where $y_i^+ = \sqrt{\frac{a_i}{c_i}\tilde{Y}_i} - \tilde{Y}_i$, $y_i^- = \sqrt{\frac{b_i}{c_i}\tilde{Y}_i} - \tilde{Y}_i$, and $\bar{y}_i = a_i\bar{x}$.

Then, we make the transformation $s_i(Y) = \frac{y_i(\tilde{Y}_i)}{Y}$ with $Y = \tilde{Y}_i + y_i$ and we obtain equation (7).

Lemma 1 *Total equilibrium inputs in the contest are increasing in the spending cap, i.e.* $\frac{\partial Y^*}{\partial \bar{x}} > 0$.

Proof: By equation (7), we have $\frac{\partial s_k(Y)}{\partial \bar{x}} > 0$ for $Y > 0$ if k is binding and $\frac{\partial s_j(Y)}{\partial \bar{x}} = 0$ for $Y > 0$ if j is not binding. Therefore, since at least one candidate is binding, $\frac{\partial S(Y)}{\partial \bar{x}} > 0$ for $Y > 0$. Recall that equilibrium total inputs Y^* is given by $S(Y^*) = 1$. Hence it follows that $\frac{\partial Y^*}{\partial \bar{x}} > 0$.

Proposition 2 *(The effects of spending limits on campaign expenditures.)*

$$\frac{\partial x_i^*}{\partial \bar{x}} = \begin{cases} \frac{1}{a_i}\frac{\partial Y^*}{\partial \bar{x}}\left(1 - \frac{2c_iY^*}{a_i}\right) & \text{if } 0 < x_i^* < \bar{x} \\ 1 & \text{otherwise} \end{cases}$$

$$\frac{\partial z_i^*}{\partial \bar{x}} = \begin{cases} \frac{1}{b_i}\left[\frac{\partial Y^*}{\partial \bar{x}}\left(1 - \frac{2c_iY^*}{b_i}\right) - a_i\right] & \text{if } z_i^* > 0 \\ 0 & \text{otherwise} \end{cases}$$

Proof: Suppose that $0 < x_i^* < \bar{x}$. Then $s_i(Y) = 1 - \frac{c_iY}{a_i}$, and $x_i(Y) \equiv \frac{Ys_i(Y)}{a_i} = \frac{Y}{a_i} - \frac{c_iY^2}{a_i^2}$. Then the first result follows by differentiating $x_i(Y)$ with respect to $\bar{x}$. Suppose instead that $x_i^* > \bar{x}$. Then $x_i = \bar{x}$ and the result follows immediately.

Now suppose that $z_i^* > 0$. Then $s_i(Y) = 1 - \frac{c_iY}{b_i}$, $y_i(Y) = Y - \frac{c_iY^2}{b_i}$ and $x_i(Y) = \bar{x}$. Therefore, since

$y_i \equiv a_i x_i(Y) + b_i z_i(Y)$, we have $z_i(Y) = \frac{Y}{b_i} - \frac{c_i Y^2}{b_i^2} - \frac{a_i \bar{x}}{b_i}$. The result then follows by differentiating $z_i(Y)$ with respect to $\bar{x}$. Finally, suppose that $z_i^* < 0$. Then $z_i = 0$ and the result follows immediately.

Proposition 3 *(The effects of spending limits on political entry.) A candidate enters the race if and only if*

$$\frac{a_i}{c_i} > Y^*$$

Therefore, the number of entrants in equilibrium decreases in the spending limit.

Proof: From Lemma 1, we have that $\frac{\partial Y^*}{\partial \bar{x}} > 0$, that is, total inputs are increasing in the spending cap. From equation (7), the condition for strictly positive spending (and hence by definition, entry) is $\frac{a_i}{c_i} > Y^*$. Therefore the number of candidates for which this condition holds is decreasing in Y^*, and hence decreasing in the spending limit $\bar{x}$.

Proposition 4 *(The effects of spending limits on electoral outcomes.) Increasing the spending limit decreases the vote share of the candidates whose equilibrium formal spending is less than the cap, and increases the vote share of the candidates whose equilibrium formal spending equals the cap.*

Proof: Let $\mathscr{J}$ denote the set of candidates who are non-binding and let j index elements of this set. Then $s_j(Y) = 1 - \frac{c_j Y}{a_j}$. Since $\frac{\partial Y^*}{\partial \bar{x}} > 0$ by Lemma 1, we have $\frac{\partial s_j(Y^*)}{\partial \bar{x}} < 0$ for all $j \in \mathscr{J}$. Therefore $\frac{\partial \sum_{j \in \mathscr{J}} s_j(Y^*)}{\partial \bar{x}} < 0$, i.e. the vote share of non-binding candidates is decreasing in the spending limit.

Let $\mathscr{B}$ denote the set of candidates who are binding and index the elements of this set by b. These are candidates whose formal spending is equal to the spending limit, and whose informal spending may or may not be strictly positive. We have $S(Y) = \sum_{j \in \mathscr{J}} s_j(Y) + \sum_{b \in \mathscr{B}} s_b(Y)$. Since in equilibrium we must have $S(Y^*) = 1$, we have $\frac{\partial S(Y^*)}{\partial \bar{x}} = 0$. Therefore $\frac{\partial \sum_{b \in \mathscr{B}} s_b(Y^*)}{\partial \bar{x}} > 0$, that is the vote share of binding candidates is increasing in the spending limit.[23]

A.2 Additional details for the model estimation section

Data. Our data consist of the vote shares p_{ij} and expenditures x_{ij} of potential candidates $i = 0, 1, ..., I$, in municipalities $j = 1, ..., J$, where the candidate indexed by zero represents the outside

[23]Note that this not necessarily imply that the vote share is increasing for *each* binding candidate.

option of abstaining from voting. Denote the matrix $\mathbf{y} := (p_{ij}, x_{ij})$. We also have data on spending limits $\bar{x}_j$ for municipalities $j = 1, ...J$, which we take as exogenous. Denote this vector by $\mathbf{x}$.

So that the estimation sample is similar to those used in the reduced-form analysis, we restrict the sample to municipalities within a 50 percent bandwidth of the discontinuity (i.e. where spending in 2012 was within 50 percent of R$108,000). As in the reduced-form analysis, we drop open seat elections. In addition, we drop candidates who obtain exactly zero votes (116 observations), and uncontested elections (30 observations). Thus our estimation sample consists of 3032 candidates competing in 1102 municipal elections. The maximum number of entrants in an election is 9, and thus we set $I = 9$, for $J = 1102$ municipalities.

Estimation. We estimate the model using maximum likelihood. To do so, we make the following assumptions. First, we assume that each candidate's type, (a_{ij}, c_{ij}), is drawn independently from a bivariate lognormal distribution $F(\mu^k, \Sigma^k)$, which differs whether the candidate ij is an incumbent or a challenger. Second, since we cannot separately identify the individual parameter b_{ij} for each candidate, we will assume that the effectiveness of informal spending is $b_{ij} = 0$, so that no candidate chooses to spend informally in equilibrium.[24] Thus, our goal will be to maximize the likelihood of observing the data $\mathbf{y}$ given the parameters (μ^k, Σ^k) for $k = \{\text{Incumbent}, \text{Challenger}\}$ and spending limits $\mathbf{x}$. Because the estimation procedure is the same for incumbents and challengers, we henceforth drop the subscript k to simplify the notation.

Consider a municipality j. Since we observe each entrant i's vote share (p_{ij}) and turnout $(1 - p_{0j})$ and we assume a continuum of voters, we can derive the empirical total inputs Y_j by summing over equation (2), which gives us $Y_j = \frac{\sum_i p_{ij}}{1 - \sum_i p_{ij}}$. Next, in order to compute the likelihood function, we must consider separately three types of candidates: non-entrants, non-binding entrants, and binding entrants.

Consider first a non-binding entrant i. In this case, we exactly identify the quality and cost draws (a_{ij}, c_{ij}) by solving the system of equations (2) and (7). This yields $a_{ij} = \frac{s_{ij} Y_j}{x_{ij}}$ and $c_{ij} = \frac{s_{ij}(1 - s_{ij})}{x_{ij}}$, where $s_{ij} = \frac{p_{ij}(1 + Y_j)}{Y_j}$. Hence, the likelihood for i in municipality j is given by $f\left(\frac{s_{ij} Y_j}{x_{ij}}, \frac{s_{ij}(1 - s_{ij})}{x_{ij}}\right)$, where f denotes the probability density function of the bivariate lognormal distribution $F(\mu, \Sigma)$.

Consider next a binding entrant i. Here, we cannot point identify the type (a_{ij}, c_{ij}) which generated the data. However, since we know that the candidate spent $\bar{x}$, this implies that $a_{ij} = \frac{s_{ij} Y_j}{\bar{x}}$. Given this a_{ij}, we determine the range of costs such that $x^*_{ij} \geq \bar{x}$. This condition is equivalent to the condition

[24] We also estimated the model under the assumption that $b_{ij} = \theta a_{ij}$ for some constant $0 < \theta < 1$. The results are almost identical when setting $\theta = 0, 0.1, 0.5, 0.9$.

from equation (7) that $1-\frac{c_{ij}Y_j}{a_{ij}} \geq \frac{a_i\bar{x}_j}{Y_j}$, which we can rewrite with the substitution $a_{ij}=\frac{s_{ij}Y_j}{\bar{x}}$ as $c_{ij} \leq \frac{s_{ij}(1-s_{ij})}{\bar{x}}$. Therefore we can write the likelihood as $\int_0^{s_{ij}(1-s_{ij})/\bar{x}} f\left(\frac{s_{ij}Y_j}{\bar{x}}, c\right)\,\mathrm{d}c$.

Consider lastly a non-entrant i. Since we do not observe this candidate's expenditures nor his vote share, we cannot point identify a_{ij} or c_{ij}. Instead, given the equilibrium spending of other candidates, we can identify the set of possible quality-cost pairs. The condition for entry is given by $a_{ij}/c_{ij} < Y_j$, which can be rewritten as $\exp(\delta_{ij}-\gamma_{ij}) < Y_j$, where we make the change of variables $a \equiv \exp(\delta)$ and $c \equiv \exp(\gamma)$. Hence we can rewrite the condition as $\eta_{ij} < \log(Y_j)$, where η_{ij} is a draw from a normal distribution with mean $\mu_a - \mu_c$ and variance $\sigma_a^2+\sigma_c^2-2\sigma_{ac}$. Denoting the cumulative distribution function of the standard normal distribution by Φ, we thus have derived the likelihood of a non-entrant as $\Phi\left(\frac{\log(Y_j)-\mu_a+\mu_c}{\sqrt{\sigma_a^2+\sigma_c^2-2\sigma_{ac}}}\right)$.

Therefore, the likelihood for an arbitrary candidate i in municipality j is given by:

$$L_{ij} = \begin{cases} f\left(\frac{s_{ij}Y_j}{x_{ij}}, \frac{s_{ij}(1-s_{ij})}{x_{ij}}\right) & \text{if } i \text{ is not binding in municipality } j, \\ \int_0^{s_{ij}(1-s_{ij})/\bar{x}} f\left(\frac{s_{ij}Y_j}{\bar{x}}, c\right)\,\mathrm{d}c. & \text{if } i \text{ is binding in municipality } j, \\ \Phi\left(\frac{\log(Y_j)-\mu_a+\mu_c}{\sqrt{\sigma_a^2+\sigma_c^2-2\sigma_{ac}}}\right) & \text{if } i \text{ is a non-entrant in municipality j.} \end{cases} \tag{12}$$

The likelihood for all candidates in municipality j is then $\prod_{i=1}^n L_{ij}$. Finally, given data on municipalities $j=1,\ldots,J$, the log-likelihood is $\sum_{j=1}^J \sum_{i=1}^I \log L_{ij}$.

We maximize the log-likelihood with respect to $\mu^{\text{Inc}}, \Sigma^{\text{Inc}}, \mu^{\text{Cha}}, \Sigma^{\text{Cha}}$ using a standard numerical procedure. To verify that the maximization was successful, we re-estimated the parameters for a sequence of starting points and found that the estimates are not sensitive to the starting point. Furthermore, we performed simulations of the data $\mathbf{y}$ using known parameters $\mu^{\text{Inc}}, \Sigma^{\text{Inc}}, \mu^{\text{Cha}}, \Sigma^{\text{Cha}}$ and spending limits $\mathbf{x}$ and found that the MLE estimates returned very similar parameters.

In order to compute standard errors, we numerically evaluate the inverse of the Hessian at the maximum. When considering transformations of the estimated parameters, we compute the standard errors using the Delta method.

A.3 Additional Tables and Figures

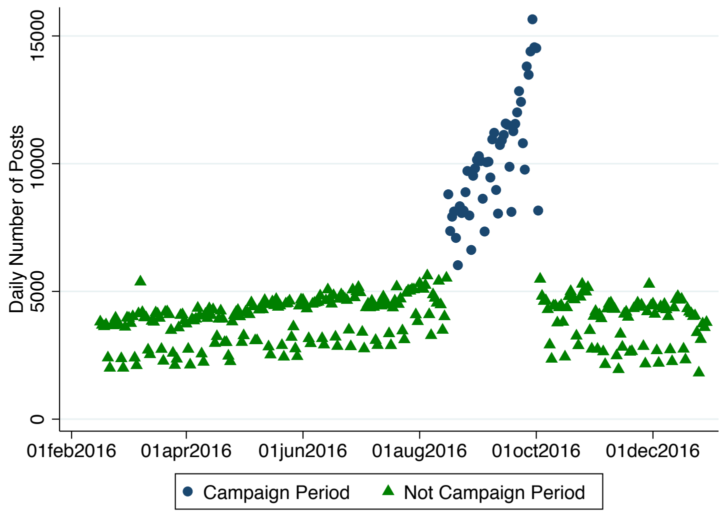


Figure A.1: Daily Number of Facebook Posts

Notes: Each point on the plot represents the total number of Facebook posts posted by all mayoral candidates in a given day. Blue circles are campaign period days: from august 16 (official start of campaign period) to october 2 (election day)

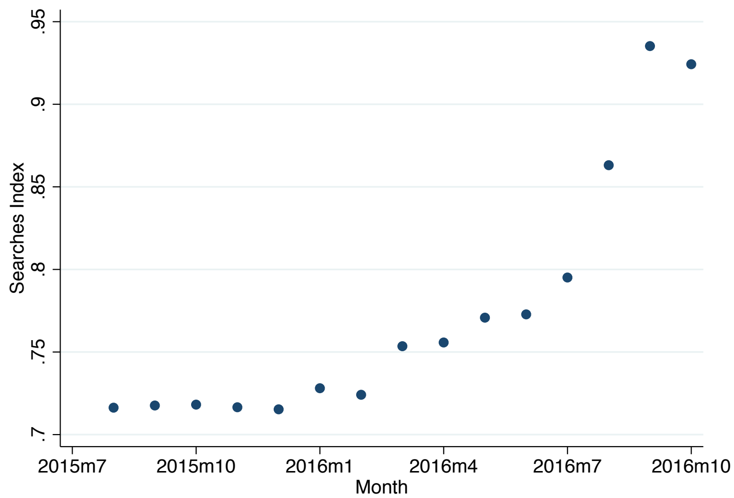


Figure A.2: Google Searches Index

Notes: Each dot on the plot represents the average Google Searches Index across all mayoral candidates in a given month

Table A.1: Probability of Winning the Election

	(1) Winner of the Election
Age	-0.0167***
	(0.00298)
Age Squared	0.0000161***
	(0.00000339)
Female	-0.235***
	(0.0878)
White	-0.254
	(0.388)
Black	-0.623
	(0.437)
Brown	-0.398
	(0.392)
High School	-0.119
	(0.0828)
College	-0.0494
	(0.0625)
Log Assets	0.0435***
	(0.00902)
Incumbent	0.612***
	(0.0732)
Political Experience	0.0560**
	(0.0262)
Party Fixed Effects	Yes
Observations	6438

Notes: Robust standard errors are in parentheses. The sample is restricted to observations that are excluded from the RD regressions. The dependent variable is equal to one if the candidate wins the election and zero otherwise. The regression also controls for party fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.2: Effects of Spending Limits on Facebook Campaign Activity of Incumbents and Challengers

	Mean	Obs	(1)	(2)	(3)	(4)
Panel A: Incumbents						
Has Facebook Page	0.324	1457	-0.050	-0.060	-0.035	-0.054
	(0.040)		(0.048)	(0.054)	(0.044)	(0.060)
Number of Posts (log)	1.156	1545	-0.055	-0.079	-0.035	-0.020
	(0.162)		(0.187)	(0.214)	(0.171)	(0.219)
Number of Reactions (log)	2.002	1745	0.045	-0.019	0.031	0.028
	(0.264)		(0.327)	(0.367)	(0.297)	(0.460)
Panel B: Challengers						
Has Facebook Page	0.340	2148	-0.038	-0.069*	-0.026	-0.065*
	(0.027)		(0.032)	(0.037)	(0.029)	(0.041)
Number of Posts (log)	1.190	1987	-0.173	-0.215	-0.117	-0.189
	(0.103)		(0.129)	(0.149)	(0.117)	(0.151)
Number of Reactions (log)	2.332	1858	-0.399	-0.466	-0.292	-0.444
	(0.204)		(0.252)	(0.290)	(0.227)	(0.293)
Bandwidth	CCT	CCT	CCT	75% CCT	125% CCT	CCT
Polynomial Order	One	One	One	One	One	Two

Notes: Each figure in columns (1)-(4) reports the estimate and standard error of a separate regression. Standard errors are in parentheses. The mean is the estimated value, based on specification (1), of the dependent variable for a municipality at the cutoff point whose spending limit is $R108,039. The dependent variables are respectively the proportion of candidates with a Facebook Page, the log plus one of the average number of candidates' posts and the log plus one of the average number of reactions candidates' posts got computed at the municipality-level between the beginning of the campaign period and election day. Panel A presents the results using only incumbent candidates and panel B using the average across challengers in closed seat municipalities. The CCT bandwidth is selected with the optimal procedure by Calonico et al. (2014) , and the number of observations under this bandwidth is reported in the table. State fixed effects and municipal controls (income per capita, illiteracy, share urban, population, gini coefficient) are included in all regressions. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.3: Distribution of Candidates' Number of Searches in September 2016

Number of Searches	Index Value	Number of Candidates
0 -10	0	5,806
11 - 100	1	5,540
101 - 1,000	2	2,800
1,001 - 10,000	3	834
10,001 - 100,000	4	116
100,001 - 1,000,000	5	3
Total		15,099

Notes: This table displays the distribution of Candidates' Google searches in September 2016.

Table A.4: Correlation Between September Google Search and Candidates' Ad Time Share

VARIABLES	(1) September Google Search
Ad Share	0.17**
	(0.08)
Ln(Campaign Spending)	0.09***
	(0.01)
Incumbent	0.09***
	0.03
Female	0.033
	(0.03)
Political Experience	0.06***
	(0.02)
Age	0.00
	(0.00)
College	0.02
	(0.02)
Race Fixed Effect	y
Party Fixed Effect	y
City Fixed Effect	y
Observations	14,612

Notes: Robust standard errors are in parentheses. The dependent variable is the September Google Search Index for the mayoral candidate. Ad Share is the advertisement time share of the mayoral candidate in the municipality. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.