Auctioning Public Office*

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Abstract

Campaign promises and campaign spending are modelled as integral parts of a signaling mechanism that transmits information about candidates' abilities and proposed policies to the voters. We suggest that viewing promises and spending as inseparable parts of the same mechanism is essential in moving towards providing a microfoundation framework of political campaigns. Political competition in spending and promising is modeled as an auction which enables us to derive results about the laws governing political campaigns. The degree of commitment is crucial to the mixture of signaling used by candidates.

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-Jack-Don't spend a dime more than is necessary. I'll be damned if I am going to pay for a landslide.

J.F.KENNEDY, quoting a telegram from his father¹

-[Politicians] are the same all over. They promise to build a bridge even where there is no river.

NIKITA S. KHRUSHCHEV, Belgrade, Yugoslavia, August 21, 1963²

1 Introduction

The first of the two quotations from two politicians who dominated the cold-war-era world politics might not be proof that public seats can be bought with enough money, while the second is probably a warning that campaign promises should not always be taken at face value. However, taken together they are an indication that the two aspects of the electoral process, namely campaign spending and campaign promises, deserve much attention if we are to understand better the micro-mechanics of elections. Bundling these two integral parts of political campaigns and representing them in a way that can be of use for derivation of predictions is a challenging but promising endeavor.

Many theoretical and practical questions arise when examining the role of elections. Why do candidates take up costly actions such as committing to produce difficult work? Why do they engage in, sometimes excessive, spending? Why do rational voters attach value to these actions? How much cost would a candidate be willing to incur in order to prove worthiness to the electorate? Does a strong candidate make promises or does she spend? Or both? How about a weak one? Does it depend on the electoral environment? How does, for example, uncertainty or the closeness of a political race affect the candidates behavior? Does increasing political competition affect the candidates' electoral strategies?

These are the questions we set out to answer by attempting a first step towards a unifying theory of campaign promises and campaign spending. We propose a novel way of modeling political campaigns as auctions, in which candidates engage in two-dimensional bidding for office. Our argument is simple: If political campaigns are to influence electoral outcomes, they must bear informational value for the voters. Candidates who spend more must be preferred to ones who spend less or don't spend. And candidates who promise

¹Source: [10], p. 10.

²as reported by the New York Herald Tribune, August 22, 1963, p. 16 and cited in [3] and [21].

more must be preferred to ones who don't engage in promising. This rests upon the simple condition, that office holds greater value to more competent candidates.

There is a variety of reasons why this might be the case. One might be that more competent candidates are more effective in fundraising. Alternatively, they might have to deviate less from preferred policies in order to accommodate their contributors' demands. Or they might simply find the task at hand easier and hence be able to engage in more campaign spending. In the model proposed, the cost of coming to office is higher, in terms of effort, for lower ability candidates. Our setup would be suitable for analyzing electoral competition in any circumstances in which preferred candidates value holding office more. If ability is a wanted commodity for the voters and increases the value of being in office for a candidate, able candidates will be willing to pay (or promise) more to come to office and rational voters will indeed vote for big spenders (and/or promisors).

Candidates have two ways of signaling their types: promising and spending. Both are costly for them and the candidate who suffers the highest cost must be the most capable one and is hence elected. Both campaign promises and spending are modeled as auctions. This allows us to borrow tools from auction theory's rich toolbar, reproduce theoretically the mechanics of political campaigns and make predictions about the intensity and form of political competition.

Auctions are a natural way to model political competition. Although the latter is common wisdom³, no formal attempt has been made to model political competition as an auction. We do so by assuming that candidates engage in a bidding war in the space of campaign promises and campaign spending. Although they can both serve as signals of ability, as they are costly, promises are shown to be superior to spending as a signal, because apart from signaling candidates' types, they affect the voters' utility directly. Our first result establishes just that and merits some separate mention. If both promises and spending can be used as signaling instruments, promises must be preferred to spending as they directly increase the voter's welfare.

The key to determining which instrument will be used hence, is commitment: under commitment, or what we call contractual completeness, all signaling will occur through campaign promises. This is an important result, as it simplifies multi-dimensional signaling and might have applications

³One, for example, reads in the Sydney Morning Herald, December 6th 2007, in an article headed "Tax-cut bidding war worried central bank's board", that "The Reserve Bank has revealed that the tax-cut auction by the major parties featured prominently at its November board meeting, after which it took the unprecedented step of raising interest rates during a federal election campaign"

in different areas of economics. Consider for example the dilemma facing a car manufacturer. Should she signal quality through traditional advertising or should she do so by offering more after sales service? If both are costly and after sales service directly affects the buyers' utility, whereas advertising is money-burning serving only as a signal, our prediction is that signaling of quality will take place through after sales service, something in line with many firms' practice in recent era. Or consider a job market signaling situation à la Spence [20]. The applicant can signal her ability by attending any school, a sort of "effort-burning", or she can attend a school that relates to the job she is applying for. Both signal ability but a trained-for-the-job candidate is more useful for the employer and our first result, applied in a suitable setup, would predict that she will indeed be preferred.

Lifting the assumption of commitment in the one shot model, changes the scenery. If, for example, a contract for after-sales service is not enforceable, quality will have to be signaled through advertising. Similarly, in our setup, as spending occurs before the elections and promising is delivered after the elections, no candidate can find it in his interest to deliver on his promises once elected. Promises cease to be informative and only spending is used as a means of signaling ability. Proposition 3 states that the highest spender will be chosen and calculates the campaign spending strategies under no commitment in one-shot election games. We then proceed to examine how campaign expenditures are affected by political competition, uncertainty and asymmetries in candidates' abilities in Propositions 4, 5 and 6 respectively.

Reputation can restore commitment in games of repeated elections. In this, a level of promises is sustainable and campaign promising and spending are shown to co-exist. Proposition 7 shows that the set of credible promises is non-empty in repeated games and that promises will be preferred as a means of signaling, as was the case in the one-shot game. Then Proposition 8 describes the bidding strategies, that is the levels of spending and promising, candidates will choose and Proposition 9 establishes that there exists indeed an equilibrium. We do not require a folk-theorem-type setup for this as we show that an equilibrium involving strictly positive campaign promises exists, irrespective of the candidates' time discounting (as long as candidates do not fully discount the future). Finally, Proposition 10 examines how political campaigns are affected by changes in the exogenous parameters, namely the horizon of punishment of deviating candidates, time patience and rents for being in office.

The paper is organized as follows: Section 2 places this paper within the existing literature, section 3 presents our model, section 4 examines elections as a static game under both complete and incomplete contracts, section 5 presents the repeated game and section 6 concludes.

2 Related literature

The two strands of the literature that we attempt to bring together are models of campaign promises and models of campaign spending. Early literature recognizes the effect of campaign spending on electoral outcomes without providing sound theoretical microfoundation for this. For example [5], [9] and [19] take as given the positive effect spending has on the probability of elections. But it wasn't until [14] and [15] that a theoretical microeconomic model, explaining how campaign advertising may affect the electorate's vote, appeared for the first time. Both papers argue that informed lobbies fund competent candidates only and voters can infer the candidates' types from observing campaign spending. Similarly, in [11], entry occurs only for candidates of high ability who signal their competence in the pre-entry stage by engaging in campaign spending.

In [6] and [13], citizen-candidates spend in order to enter the electoral race and as in [11], [14] and [15] when there are split contributions, no difference in spending is observed. Candidates spend the same amount and spending does not allow the electorate to distinguish between them. The costs are sunk entry costs that affect only political competition but not the outcome of elections, as both models assume full information and full commitment to proposed policies. However, although full commitment is a useful assumption when modeling political competition, as it abstracts from issues of credibility, assuming it, needs justification and it has been argued that it cannot be assumed in models of electoral competition. Signaling models such as [17] and [16], use a policy platform to signal their types. To do so, serial correlation of the type in time is required and only the incumbent can signal. They provide useful insight about political policy cycles but do not explain promises or spending by potential entrants. For example [17] argue that "Any promises the two parties might make before an election have no impact on the voters in our model, since neither party has any incentive to be honest" and then proceed to model information transmission by the incumbent through distortion of tax policy. Unless something forces politicians to live up to their promises, proposing a policy is cheap talk, or to put it in [8]'s words "(if)... the sender, an incumbent up for re-election, cares only about staying in office and not at all about social welfare, campaign promises will be 'meaningless cheap talk' in both the technical and everyday sense".

It has been demonstrated that in situations of affiliation between the sender's and receiver's interests, cheap talk can be informative (see for example [7]). In most elections however, candidates and voters have, at least in part, non-aligned interests. In order to sustain policy promises then, some kind of reputation argument has to be assumed. In [2], ideological presi-

dents have an incentive to deviate to their preferred policies after election as they cannot be re-elected. Commitment is ensured by side-payments made to them by the party “heir” who compensates them for losses incurred from following a policy they do not endorse. In [1], existence of convergence of policy to the voter’s most preferred policy is proven, in a repeated game, even though parties have different bliss points. The result rests upon the assumption of infinite horizon and low discounting.

Low discounting can ensure compliance in repeated games but has to be justified. In [18], it is the role of campaign expenditure to ensure that only candidates with low discounting will enter the race. Campaign promises and spending are interpreted as complements in the sense that promises cannot be credible without spending, as the latter guarantees that only candidates who intend to stay in the game for a long time will be considered for office. In this paper, promises and spending are considered as complements.

In the present setup, campaign promises and spending are substitutes and can be used interchangeably as means of signaling. The exact mixture of the two will be determined by the rules of the game, particularly commitment and the time horizon.

3 An integrated framework for two dimensional bidding in elections

In what follows, we present a simple model of elections that accounts for both campaign promises and campaign spending as means of signaling candidates’ competence. Since there is no reason to *a priori* exclude one of the two as a means of signaling, we examine how the choice of instruments for signaling vary as we vary the environment in which elections take place.

Specifically, two crucial factors determine the exact mix of instruments a candidate will use to signal his ability and proposed policy. Firstly, the time horizon determines whether one of the two or both means, that is campaign promises and campaign spending, will be used to signal ability and policy. Then, what we call contractual completeness will determine which means will be used, when only one means of signaling is available, and the mix of the two when both are allowed. As time is of importance, we distinguish between two cases: the single-period game and the infinite horizon game that gives different results as far as two dimensional bidding is concerned.

Consider a representative voter, V and n candidates running for public office. The n candidates differ in ability and have three ways of signaling their competence and proposed policy: either by campaign promises about

the level of public good they will deliver if elected, or by engaging in wasteful campaign spending, a sort of money-burning, or both. Campaign promises can be informative about their ability because delivering a given level of public good requires a minimum effort and ability. Money-burning, or campaign spending is informative in exactly the same way advertising is informative about quality in signaling models of advertising. If holding office is of greater value to more competent candidates, more competent candidates can afford to waste more money to signal their ability.

The voters after observing the candidates' political campaigns which in general will consist of *both* campaign promises and campaign spending, vote for the candidate that maximises their welfare.

3.1 The actors of the election game

The candidates: Let each of n candidates differ in ability $\theta \sim F(\cdot)$ with support Θ , where Θ is a compact subset of $\mathbb{R}$ and $F'(\cdot) = f(\cdot) > 0$ be the density function of θ . Ability is redistributed in each period. This reflects changes in the suitability of each candidate to deal with changing political or economic environment or changes in candidates' characteristics that come with time, such as experience or saturation etc. Assume that each candidate enjoys the following rents in each period:

$$V_i^C = \begin{cases} W - \psi(e_i) - t_i \equiv U(e_i) - t_i & \text{if } i \text{ is elected} \\ -t_i & \text{if not} \end{cases} \quad (1)$$

where W denotes some exogenous rents or wages for being in office, which for simplicity are assumed constant across candidates but could be considered varying without altering our results, e_i is effort required by candidate i for the production of public good g if elected, $\psi(\cdot)$ is a function capturing the disutility of effort in monetary terms with $\psi', \psi'' > 0$, and t_i is candidate i 's campaign spending.

The voters: We assume a representative voter, V . Her utility stems from consumption of the public good, g and from the elected candidate's ability: $U^V = U(g, \theta)$. U is continuous and differentiable, with $U_g, U_\theta > 0$.

We assume that a candidate's ability is appreciated by the voter independently of its role in the production of the public good. This could be the case, for example, if voters prefer a leader who is eloquent or good in public relations to a leader who could produce the same level of public good but lacks in charisma. All candidates and voters discount future by the common discount factor $\delta \in (0, 1)$.

The public good: The production function of the public good is given by $g = g(\theta, e)$, $g_\theta, g_e > 0$ and $g_{\theta\theta}, g_{ee} \leq 0, g_{\theta e} > 0$. This is a standard production function with decreasing marginal returns and some substitutability between factor of production. Assume that there is a minimum amount g^{min} that has to be produced (in order to keep things running). The production function gives the production technology for each level of effort and ability. Inverting $g(\cdot)$ allows us to calculate the level of ability required for the production of public good g given effort e denoted $\theta(g, e)$ and/or the level of effort required for production of public good g by a candidate of ability θ , denoted $e(g, \theta)$.

3.2 The players' strategies and the equilibrium notion

In each period, each candidate observes his ability only and decides on the level of his campaign spending $t_i \in T \subseteq \mathbb{R}_+$ and the public good he will deliver if elected, $g_i \in G \subseteq \mathbb{R}_+$. Candidate i 's strategy space in each period is $T \times G \subseteq \mathbb{R}_+^2$. A candidate's strategy is a rule $(t_i(\theta_i), g_i(\theta_i)) : \Theta \rightarrow (T \times G)$ that assigns to each type a level of spending and promises in period s .

In the one-period game, the voters observe the candidates' bids and vote for the bid that will maximize their welfare. In the repeated game however, punishing deviating candidates can ensure that a higher level of welfare is achieved. If M denotes the set of candidates, the voters' strategy space in each period is M and their (pure) strategy in each period is a map $R : (T \times G)^n \rightarrow 2^M$, 2^M denoting the powerset of M , assigning a subset of M (henceforth called winner) to each profile of candidates' strategies. In the infinitely repeated game, with t periods of history, $R_t : [(T \times G)^{nt} \rightarrow 2^M \times 2^M \dots$

All equilibria discussed will be Bayesian equilibria and we will refer to them as the equilibrium. In multiple period games equilibria will also be subgame perfect.

3.3 The timing of events

Time is discrete and indexed in the multi-period game by $s = 1, \dots$. In the beginning of each period, Nature assigns to candidates a level of ability which is identically and independently distributed among candidates from F . Each candidate observes his ability only and voters cannot observe the candidates' abilities. Then all candidates engage in political competition, consisting of campaign promises about the public good each will deliver if elected and campaign spending.

The voters observe the candidates' strategies $(t, g) = \left(\begin{bmatrix} t_1 \\ \vdots \\ t_n \end{bmatrix}, \begin{bmatrix} g_1 \\ \vdots \\ g_n \end{bmatrix} \right)$ and

vote for the candidate whose pair of bids (t_i, g_i) maximises EU^V .

This auction is a hybrid auction consisting of bidding in two dimensions, (t, g) for a single prize (office). Bidding in the level of public good is assumed to be in the form of first price auction. Campaign spending bidding is modelled as an all-pay auction. This means that campaign spending takes place regardless of whether a candidate is elected or not.

This is the natural way to model political campaigns for two reasons: Firstly, this is what is observed in elections. Although only the winner is called upon to implement his proposed policy, all candidates engage in campaign spending. Secondly, campaign spending can be informative only for as long as candidates are forced to engage in it. But if competing in campaign spending is modelled as a standard form auction, there cannot be an incentive compatible mechanism that will make the candidates spend once they have won (especially in the single period model): Once a candidate has won, the voters gain nothing from making him pay, since campaign spending is just a signal of competence and does not increase their welfare directly. But if the voters have no incentive to force a candidate to pay, the incentive scheme of the candidates collapses and campaign spending ceases to be informative.

We can now proceed with stating our main results. As was mentioned, the time horizon is crucial in determining whether signaling will take place in a single or double dimensional space. Hence the first case we examine is the one shot game under the assumptions of 1) full and 2) no commitment to campaign promises.

4 Political campaigns in the one-shot game

4.1 Elections as a complete contract

Consider a single-period version of the game described. And assume that the candidates can fully commit to live up to their promises once they have been elected. Elections are hence seen as a complete contract between the candidates and the voters. Its terms and outcomes are observable, verifiable and enforceable. Under such circumstances the voters can force a candidate to deliver on his promises after being elected.

Our first results establishes that all signaling then will take place in one dimension, through campaign promises only. This is a result that can have useful implications in other areas where there is potential of multi-dimensional

signaling and where signaling in some dimensions directly affects the receivers' welfare whereas signaling in other directions is a waste and bears only informational value.

Proposition 1. *Consider the one period game with full commitment and let $(\hat{t}_i, \hat{g}_i)$ be a strategy for candidate i with $\hat{t}_i > 0$. Then there exists a strategy (t'_i, g'_i) for i , with $t'_i < \hat{t}_i$ and $g'_i > \hat{g}_i$ that strictly dominates $(\hat{t}_i, \hat{g}_i)$. Hence the only possible equilibrium strategy for i will be of the form $(0, g_i)$.*

Proof. A formal proof is given in the Appendix. ■

The intuition behind this result is simple. If the terms of a contract can be enforced, all bidding will take place in the dimension that directly affects the receiver's utility. That is because a candidate can substitute signaling through "money burning" with a higher level of promises that signals the same level of competence. This cannot decrease his utility when elected but will decrease his spending when not. Furthermore, as the same ability is signaled through a higher level of public good, the voters will vote for him at least as often as they would have if he followed $(\hat{t}_i, \hat{g}_i)$ and hence his probability of being elected cannot decrease. Overall he will be strictly better off.

The result is important as it can simplify a class of multidimensional bidding mechanisms by reducing them to lower dimensional bidding for as long as the result of the mechanism is enforceable *ex post*. It can also possibly explain, if applied to a suitable context, the turn that companies are often observed to take away from advertising as a signal of quality and towards more after the sales support. If promising after-sales support is indeed enforceable by the buyers after the purchase, signaling quality through it is preferred to simple money burning that has no direct effect on the buyers' utility. In our context, it can render the role of campaign spending clearer. Note that this result is quite strong. It does not rely on the functional form of the candidates' utility as long as it is separable in the cost of spending and implementing a promise. This is because the candidates' utility is linear in t and concave in g . As g increases, substituting g for t "saves" the candidate constant marginal utility from less expenditure but burdens him with increasing marginal disutility from effort required to produce more public good. As the result holds for general functional forms, one can think of very convex disutility functions $\psi(\cdot)$ and the results would still hold. Hence the result is not due to the fact that "he saves more money by reducing expenditure, than it costs him to produce more public good", but rather to the fact that no matter how little a candidate increases public good, it is a signal

that is of use to the receiver (the voter) and will be preferred as such to a wasteful signal.

Since signaling competence through campaign promises is superior to non-productive signaling, the fact that other means of political campaigns are observed is an indication that there is less than full commitment on the part of the candidates as will be clearer in what follows.

Having established that under contractual completeness, in the single period game, political campaigns will assume the form of campaign promises only, we can proceed to show that the voters will gain by assigning office to the highest bidder.

Proposition 2. *In the single period game with commitment and $n \geq 2$ candidates, suppose there exists a candidate with ability θ^0 , who is indifferent between providing $g^{\min}$ and not getting elected. Then, there exists a unique symmetric equilibrium promises function $g(\theta_i)$ for candidate i . The highest ability candidate will win the election. Candidate i 's campaign promise will be the solution to the following differential equation:*

$$\begin{cases} g'(\theta) = \frac{(n-1)[F(\theta)]^{n-2}f(\theta)}{[F(\theta)]^{n-1}} \frac{W - \psi(e(g(\theta), \theta))}{\psi'(e(g(\theta), \theta))e_g(g(\theta), \theta)} \\ g(\theta^0) = g^{\min} \end{cases} \quad (2)$$

Proof. As $U_\theta = -\psi'(e(g, \theta))e_\theta(g, \theta) > 0$ and $U_{\theta\theta} = -\psi''(e(g, \theta))[e_\theta(e(g, \theta))]^2 - \psi'(e(g, \theta))e_{\theta\theta}(e(g, \theta)) < 0$ and since $\frac{\partial}{\partial \theta} \left(-\frac{U_g}{U} \right) < 0$ (by lemma 1), all the assumptions of Theorem 2 of [12] are met and hence there exists a unique bid function $g(\theta)$ for a candidate with ability θ . Moreover, as [12] show, $g(\cdot)$ is increasing (and differentiable) and hence the highest ability candidate will make the highest bid and will be elected. ■

We have established that if promises are binding, all signaling will take place through them in the one shot game and the most competent candidate will come to office. The voters' welfare is maximized since the highest bidder is elected and he is also the highest ability candidate.

Our results so far rely on contractual completeness. This assumption is useful as it clarifies under which circumstances campaign promises are more than just cheap talk, however it is difficult to justify. It is difficult to imagine situations in which an electorate can drag a lying candidate to courts and have him punished for not living up to his electoral promises. Once contractual completeness is lifted, the scenery changes dramatically and bidding through promises is no longer credible in single period games.

4.2 Elections as an incomplete contract

Consider now the single period version of the model described above, however commitment is not assumed. Assume instead that once elected, a candidate cannot be forced to deliver the level of public good promised in his political campaign. There is clearly a time inconsistency problem in such a game: once elected, a candidate has a strong incentive to renege on his promises and deliver the minimum level of public good, since producing more public good is costly in terms of effort for the elected candidate. No promise to deliver any level of public good higher than $g^{\min}$ is credible and the only possible equilibrium level of public good will be $g^{\min}$. All signaling in this framework will take place through campaign spending, t . Assume that $W - \psi[e(\theta^{\min}, g^{\min})] \geq 0$. This is an assumption that simply ensures that the lowest ability candidate will participate in the elections and makes discussion about the lowest ability candidate meaningful. Without it, we could define as the candidate for whom the above holds with equality to be the infimum of Θ . Now since $g = g^{\min}$, regardless of who is elected, the winner's utility will be

$$U^W = W - \psi[e(\theta^W, g^{\min})] - t^W$$

Define $w_i \equiv W - \psi[e(\theta_i, g^{\min})]$. Then w_i is candidate i 's value of being in office. Let $\Phi(w)$ denote w 's distribution function⁴. Equation (1), giving candidates' utility can then be written as

$$V_i^C = \begin{cases} w_i - t_i & \text{if } i \text{ is elected} \\ -t_i & \text{if not} \end{cases} \quad (3)$$

It is clear that the candidates engage in an all-pay auction type of campaign expenditure competition.

Proposition 3. *In the single period game without commitment, the most competent candidate comes to office. Candidate i 's level of campaign expenditure is given by $t(w_i) = [\Phi(w_i)]^{n-1}w_i - \int_{x=w_{\min}}^{w_i} [\Phi(x)]^{n-1}dx$.*

Proof. Calculating the candidates' level of campaign expenditure is a direct application of the *Revenue Equivalence Theorem (R.E.T)*: Since this is an all-pay auction, with risk-neutral bidders, a candidate will always pay his bid, hence his bid must equal the expected payment of a candidate with the same type in an ascending auction. The latter is his probability of winning $[\Phi(w_i)]^{n-1}$, times the expected second highest value given that i wins,

⁴Applying the change of variable formula we get $\Phi(w) = \int_{-\infty}^w f(\theta[g^{\min}, \psi^{-1}(W - z)]) |\theta_e(g^{\min}, \psi^{-1}(W - z)) \psi^{-1}(W - z)| dz$

$w_i - \frac{\int_{x=w_{\min}}^{w_i} [\Phi(x)]^{n-1} dx}{[\Phi(w_i)]^{n-1}}$. That the most competent candidate is elected, stems from the fact that $t(w_i)$ is increasing in w_i , which is easily derived with a differentiation of t w.r.t. w_i and w_i is clearly increasing in θ_i . ■

4.2.1 Political competition and aggressiveness of political campaigns

Proposition 3 gives the candidates' campaign expenditure as a function of their types and the political competition they face. It would be of interest to to examine two aspects of political competition. Firstly, what happens candidates' campaigns, as political competition increases. Would we expect candidates to bid more or less aggressively? Secondly, it would be interesting to examine what happens to the overall waste as political competition increases.

Proposition 4. *As political competition (n) increases the following happens to campaign expenditures:*

- i. Individual campaign expenditures rise only for candidates of a threshold of ability and above. That is, there exists a level of $\hat{w}(n)$ such that $t(w)$ rises (falls) with n for $w > (<) \hat{w}(n)$*
- ii. The overall level of campaign expenditures rises with n .*

Proof. See appendix. ■

Proposition 4 states that high ability candidates become more aggressive as competition increases, whereas low ability candidates become less aggressive. Figure 1 captures this result. The derivative of spending w.r.t. the number of candidates, $\frac{\partial t}{\partial n}$ is calculated in the appendix. We can see that for $w > \hat{w}$, candidates become more aggressive as political competition rises.

4.2.2 Electoral uncertainty and political expenditures

Applying Proposition 3 to a model of n candidates whose valuation of office, w_i is uniformly distributed on $[\mu - h, \mu + h] \subset \mathbb{R}^+$ gives us insight about how increasing h , a parameter that captures uncertainty, as it is a multiple of the variance of the distribution, affects campaign spending.

Proposition 5. *Suppose that there are n candidates competing for office with valuations $w_i \sim U[\mu - h, \mu + h]$. Then*

Figure 1: As political competition increases only candidates with valuations above $\hat{w}$ will bid more aggressively. For less competent candidates the level of campaign expenditure will fall.

- i. As uncertainty (h) increases, strong candidates, that is candidates with valuations above the mean, μ , bid less aggressively and*
- ii. The effect of an increase in h on weak candidates' bids, that is bids of candidates with valuations less than μ is ambiguous.*

Proof. From Proposition 3 we get candidate i 's bid, as a function of his valuation for office :

$$t(w_i) = \left(\frac{w_i - \mu + h}{2h} \right)^{n-1} \left(\frac{(n-1)w_i + \mu - h}{n} \right) \quad (4)$$

Differentiating with respect to h we get

$$\frac{\partial t(w_i)}{\partial h} = -\frac{2^{1-n} \left(\frac{w_i - \mu + h}{h} \right)^{n-2}}{nh} \left[(w_i - \mu + h) + (n-1) \frac{w_i - \mu}{h} [(n-1)w_i + \mu - h] \right]$$

It is clear that for $w_i \geq \mu$ or even for $w_i = \mu - \epsilon$, $\frac{\partial t(w_i)}{\partial h} < 0$, which proves the first part. Now consider, for example, the case where $w_i \sim U[40, 60]$ and $n = 5$. For a candidate with valuation $w_i = 46$, it is $\frac{\partial t(w_i)}{\partial h} = 0.095148$ and hence such a candidate would become more aggressive if uncertainty rose. ■

The derivative of spending $t(w_i)$ with respect to the uncertainty measuring parameter, h , is plotted against w_i for two distributions of w_i , namely $w_i \sim U[40, 60]$, with $n = 5$ and $w_i \sim U[0, 1]$ and $n = 3$, in figure 2.

Figure 2: Political expenditure and uncertainty

The intuition behind this result is simple. Consider a strong candidate. He has a small mass of the distribution to his right. As the distribution spreads, the mass of more able candidates will increase for a given level of ability and he will run a higher risk of losing the election and forfeiting his bid. Hence he becomes less aggressive. The opposite is true for low ability candidates. The fact that a candidate with mean valuation ($w_i = \mu$) becomes less aggressive as uncertainty rises, should be clear after observation of (4). In this, i 's bid is given by the probability of winning when there are $n - 1$ opponents (the first factor) times the the expected second highest bid from the $n - 1$ losing opponents (second factor). The second factor in (4) always falls with h while the first increases if and only if a candidate has valuation below μ and falls if his valuation is above μ . At $w_i = \mu$ the probability of winning remains constant as h rises but the expected second highest bid falls as its distribution is stretched to the left. Hence a candidate with mean valuation will tend to become less aggressive with uncertainty.

4.2.3 Closeness of race and political expenditures

The simplicity of our model allows us to apply our setup to a variety of different electoral environments to make predictions and/or interpret various, often puzzling and diverging phenomena. For example, in the most recent United States presidential primaries, March 2008 saw Senator John McCain winning the Republican nomination having raised (and spent) around one third the amount Senators Hilary Clinton and Barack Obama raised and spent (see figure 3). As all polls⁵ suggested that both McCain vs Clinton and McCain vs Obama would result in a close race, it is reasonable to assume that

⁵See for example <http://www.realclearpolitics.com/polls>

in our setup all three candidates are perceived as being of comparable ability or having comparable valuations for office. Yet their campaign expenditures for their parties primary elections varied significantly.

The key difference between Senator McCain and Senators Clinton and Obama is that the former faced weak competition, whereas the latter two competed in a tight race, predicted to continue long after the Republican nomination was determined. Assuming that all three Senators would be strong candidates for the presidential nomination, in our setup, we could model this situation by allowing a (strong) candidate to face a weaker opponent and examine how his campaign expenditure varies as the opponent becomes stronger. To do so we need to introduce asymmetry in the distributions of ability of the candidates. Modelling such an election as a one-shot game seems only fitting as one can argue that both winning and losing presidential primaries candidates are unlikely to stand for a presidential nomination again. For tractability of results we assume again uniformly distributed abilities with asymmetric supports. Our model then reproduces the observed behavior of the three presidential candidates, described above.

Proposition 6. *Suppose there is a two-candidate race and suppose candidate A's valuation for office, $w_A \sim U[0, 1]$ and candidate B's valuation, $w_B \sim U[0, \rho]$, with $\rho \in (0, 1]$. Then as the race becomes tighter (that is as ρ increases),*

- i. There exists a threshold level of valuation $\tilde{w}_A(\rho) \leq e^{-1/2}$ with $\tilde{w}'_A(\rho) > 0$ such that the strong candidate (A) becomes more aggressive (that is $t(w_A)$ increases) for any valuation $w_A \geq \tilde{w}_A(\rho)$ and*
- ii. The weak candidate (B) becomes less aggressive (that is $t(w_B)$ falls) for any given level of w_B .*

Proof. See Appendix A.3 ■

5 Multi-period game. The effects of reputation

As in the single period game, we distinguish between complete and incomplete contracting. Under complete contracting one sees that the results of the one-shot game generalize to several periods. In each period, all signaling will take place through campaign promises and the highest candidate will come to office. That is because, in each period, candidates can commit to

(Totals include only itemized contributions, which typically exceed \$200.)

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Figure 3: U.S.A. 2008 presidential primaries spending. Source <http://www.opensecrets.org>

their promises since contracts are enforceable and verifiable. Voters maximize their utility by choosing the highest bidder in each period. We have a repetition of the 1-stage game in which the most competent candidate is allocated the office.

The situation becomes somewhat more interesting when we consider an infinitely repeated game without commitment. This allows the voters to implement more complex stick and carrot strategies that will support some level of credible promises about the level of the public good. Consider the game in each one of the infinite periods. This consists of three stages. In stage one, each of the n candidates makes his bid (political campaign) which as before consists of a pair (t_i, g_i) of spending and promises. The voters observe all bids and in stage two they vote for the candidate that maximises their welfare. In stage three, the elected candidate comes to office and implements policy. Since the game has now an infinite horizon, the voters' strategy space is $M \times M \times \dots$. If a candidate fails to deliver on his promise, candidates can punish him by not voting for him in subsequent periods.

Since delivering a level of public good $g > g^{\min}$ in the subgame beginning at after the election of a candidate, reduces the elected candidate's utility, a candidate will have an incentive to "cheat", that is to renege on his promises and deliver $g^{\min}$. The voter's strategy space now allows her to engage in punishing strategies and make cheating costly for elected candidates. This can result in a level of sustainable promises, that is promises that all candidates will live up to if elected.

Definition 1. *A level of promises g^S is said to be sustainable or credible if there exists a strategy $R^V \in 2^M \times 2^M \times \dots$ for the voter, such that in the subgame starting upon election of a candidate i ,*

1. *Delivering $g(\theta)$ is optimal for candidate i with ability θ , given R^V , for all $g(\theta) \leq g^S$ and for all candidates.*
2. *$R^V, g(\theta)$ are equilibrium strategies for the voter and the candidate respectively.*

Definition 1 just states that a level of public good is sustainable if there exists a voter strategy that makes it unprofitable for a candidate to cheat once elected. An additional requirement states that the voter and candidates strategies that can implement this level of public good are reasonable strategies, that is equilibrium strategies. Let G^S denote the set of all sustainable promises, that is $G^S = \{g^S : g^S \in \mathbb{R}^+\}$.

Proposition 7. *The following hold:*

Figure 4: Political Campaigns

- i. G^S is non empty and furthermore $\bar{g}^S \equiv \sup G^S$ exists.
- ii. Let $(\hat{t}_i, \hat{g}_i)$ be a strategy for candidate i with $\hat{t}_i > 0$ and $\hat{g}_i < \bar{g}^S$. There exists a strategy (t'_i, g'_i) for i , with $t'_i < \hat{t}_i$ and $g'_i > \hat{g}_i$ that strictly dominates $(\hat{t}_i, \hat{g}_i)$.
- iii. There cannot be an equilibrium strategy $(\hat{t}_i, \hat{g}_i)$ with $\hat{g}_i > \bar{g}^S$.

Proof. See appendix. ■

What Proposition 7 establishes, is that there exists some sustainable, bounded level of promises in the repeated game. We haven't established that this is not trivial, that is $\bar{g}^S > g^{\min}$. However we know what an equilibrium campaign will be like if it exists and is non-trivial. All bidding will take place through campaign promises until $\bar{g}^S$ is reached and those candidates who wish to further signal their ability will do so by engaging in campaign spending. The campaign bidding process is depicted in figure 4. In figure 4 (a) political campaigns are shown to take place hierarchically through promising first and when the supremum of credible promises is reached, through campaign spending. Figure (b) depicts signaling of ability which takes place through promising at first and when the possibility of signaling through promising is exhausted, further signaling takes place through spending.

What remains is to characterize the candidates' bidding behavior and establish conditions under which a non-trivial level of sustainable campaigns exists.

Proposition 8. *Suppose that there exists a non-trivial set (that is a set of non-zero Lebesgue measure) of sustainable campaign promises. Then there exists a unique symmetric equilibrium campaign promises and campaign spending functions for a candidate of ability θ . Campaign promises and campaign spending are increasing and differentiable.*

Proof. The proof follows closely [12], Theorem 2. For the existence part, since we are dealing with two dimensional bidding see appendix A.5. The rest of the proof is identical to [12], adjusted for two dimensional bidding in our context. ■

Corollary 1. *i. Low ability candidates, that is candidates of ability $\theta_i \leq \bar{\theta}$ engage only in campaign promises, whereas high ability candidates (of ability $\theta_i > \bar{\theta}$) engage in both promises and spending.*

ii. The level of promises of low ability candidates differs depending on their level of ability θ . High ability candidates engage in the same level of campaign promises, $\bar{g}^S$ but differ in their level of campaign spending ($t(\theta)$).

Having examined what form the political campaigns will take, if there exists a level of sustainable campaign promises, it remains to see whether such a level of promises exists and how it is determined. We have mentioned that in the repeated game, the voters can punish elected candidates who do not deliver on their promises by not voting for them for a number of periods. We examine how the time-horizon of the punishing strategy affects political campaigns in the last section. An equilibrium level of sustainable promises is a level of promises that is sustainable, i.e. no candidate can ever find it profitable to deviate and renege on his promises. Assuming that the set of sustainable promises is non-empty and of non-zero Lebesgue measure, it is reasonable to focus on its supremum as this ensures the highest level of sustainable promises and hence maximizes the voters' welfare.

But even though the voter prefers high public output to low one, it is not guaranteed that she will find it profitable to force candidates to live up to their promises by punishing cheating candidates. The reason is that by punishing a candidate she reduces competition and hence on average will have a lower ability candidate elected during the punishment period. If the loss in her utility due to this is offset by the gain of enjoying more public good, then she will find it optimal to punish. Otherwise, she won't and campaign promises cannot be sustained, hence all signaling will take place through campaign spending only, as in the one-shot game with no commitment. The condition on her welfare and the candidates' distribution

of ability that guarantees that the voter will find it profitable to enforce compliance with electoral promises is the following:

$$\int_{\theta^{\min}}^{\theta^{\max}} (n-2)U^V(g(x), x)[F(x)]^{n-3}f(x)dx > \int_{\theta^{\min}}^{\theta^{\max}} (n-1)U^V(g(x), x)[F(x)]^{n-2}f(x)dx \quad (\text{AC})$$

Proposition 9. *The set of sustainable campaign promises is non-trivial (it has positive Lebesgue measure), that is $\bar{g}^S > g^{\min}$. If furthermore, condition (AC) holds, then the voter will find it optimal to enforce compliance with promises and hence a level of campaign promises strictly greater than $g^{\min}$ will emerge in equilibrium.*

Proof. See Appendix A.6 ■

This closes the multi-period game.

5.1 Some comparative statics

It would be of interest to see how the exogenous parameters in our model, namely the agents' patience, δ , the time horizon of the punishment, T and the rents from coming to office, W affect political campaigns.

Proposition 10. *i. The equilibrium level of campaign promises is a non-decreasing function of δ, T and W .*

ii. The equilibrium level of campaign spending is a non-increasing function of δ, T and W .

Proof. See Appendix A.7 ■

Corollary 2. *Optimal punishment should last for ever ($T^* = \infty$).*

This follows directly from the fact that the equilibrium level of campaign promises is a non-decreasing function of T . Hence the voter welfare will be non-decreasing in T and the voters can only do better by extending the punishment length.

We see that, contrary to many signaling games of elections (for example [16], [17] and [18]), where rents for being in office are detrimental to voter welfare as they increase incentives to distort policy or cheat, here, rents increase the level of campaign promising and hence voter welfare. This is due to the moral hazard feature of our model. Higher rents lead candidates to exert higher effort with beneficial effects for voters.

Figure 5: Comparative Statics. A change in the above parameters shifts $\Pi(g, T)$ upwards.

6 Conclusion

“It is fitting that bonanza is a Spanish word, as Spain’s voters are experiencing one, in an orgy of tax-cutting promises. Curiously, it coincides with the election on March 9th”⁶, “I hear all these folks talking about who is or isn’t electable. Well, they said the same thing about me when I started running in New York. ... You know, nobody would vote for me, good grief. *I was wasting my time and my money*, Clinton recently said. But I trust the voters, and frankly that’s who matters”⁷. Evidence that political competition assumes the form of intensive bidding or that political campaigning is costly for candidates in terms of time and money is abundant.

Standard auction theory was employed to analyze political campaigns. In doing so, we derived a useful result concerning multi-dimensional signaling and testable results about the ways the political environment affects campaign promises and spending. A number of questions about political campaigns, raised in the Introduction, can now be answered by our model: candidates commit time, effort and resources to political campaigns and to delivering on their promises in order to signal that they are best suited for the job. Both promises and spending can be viewed in our setup as signals. If holding office is of greater value to better suited candidates, as is the case in our model, rational voters will vote for the candidate(s) who outbid the rest.

In electoral environments with short horizon, where no reputation effect can be sustained (for example when candidates can only serve for a limited

⁶The Economist, February 16th 2008

⁷Obama tops new national polls, <http://www.cnn.com>, February 26, 2008, emphasis added.

number of terms), the electoral environment was shown to affect political campaigns. Specifically, political competition was shown to make strong candidates more and weak candidates less aggressive. Uncertainty seemed to have the opposite effect. The closeness of the race was shown to make the strong candidate aggressive and the weak one less aggressive. We showed that when a level of promises is sustainable, weak candidates tend to rely more on promises in order to signal, while stronger ones will engage in campaign spending as well (Corollary 1).

This can only be a first step in applying techniques and results from auction theory to analyze models in politics. For example, different electoral systems might be better represented by different auction mechanisms. We modeled individual candidates, but modeling parties as bidding in multiple object (seats) auctions can be of interest. Incumbency advantages can be incorporated via signaling through a policy dimension. Auction theory can provide a rigorous, yet clear and applicable framework for representing and analyzing elections that could potentially produce rich theoretical and empirical results.

Appendix A

Lemma 1. *Consider the inverse function of public good described in section 3.1, $e(g, \theta)$ and the candidate utility function $U(e(g, \theta))$, defined in equation (1). The following hold:*

i. $e_\theta(g, \theta) < 0, e_g(g, \theta) > 0$.

ii. $e_{g\theta} < 0$.

iii. $e_{\theta\theta} > 0$.

iv. $e_{\theta\theta} + e_{g\theta}g_\theta + e_g g_{\theta\theta} < 0$.

v. $\frac{\partial}{\partial \theta} \left(-\frac{U_g}{U} \right) < 0$

Proof. i. Taking the total differential of the production function $g(\theta, e)$, we solve for changes in θ and e that leave the level of public good constant: $dg = g_\theta d\theta + g_e de = 0 \Leftrightarrow \frac{de}{d\theta} = -\frac{g_\theta}{g_e}$. But

$$e_\theta \equiv \left. \frac{de}{d\theta} \right|_{g=\text{constant}} = -\frac{g_\theta}{g_e} < 0$$

That $e_g(g, \theta) > 0$ follows directly from $g_e > 0$.

ii. Since $e(g, \theta)$ is the inverse function of $g(\theta, e)$, it will be the case that $e_g = \frac{1}{g_e}$. But then

$$e_{g\theta} = \frac{\partial \frac{1}{g_e}}{\partial \theta} = -\frac{g_{e\theta}}{g_e^2} < 0$$

iii.

$$e_{\theta\theta} = \frac{\partial e_\theta}{\partial \theta} = -\frac{\partial \frac{g_\theta}{g_e}}{\partial \theta} = -\frac{g_{\theta\theta}g_e - g_{e\theta}g_\theta}{g_e^2} > 0$$

iv.

$$\begin{aligned} e_{\theta\theta} + e_{g\theta}g_\theta + e_g g_{\theta\theta} &= -\frac{g_{\theta\theta}g_e - g_{e\theta}g_\theta}{g_e^2} + e_{g\theta}g_\theta + e_g g_{\theta\theta} < 0 \Leftrightarrow \\ &2e_{g\theta}g_\theta^2 < 0 \end{aligned}$$

which is clearly true. The last inequality is derived after some algebra and using the facts that $g_e = \frac{1}{e_g}$ and $g_{e\theta} = \frac{\partial \frac{1}{e_g}}{\partial \theta} = -e_{g\theta}g_e^2$.

v.

$$\begin{aligned}\frac{\partial}{\partial \theta} \left(-\frac{U_g}{U} \right) &= -\frac{U_{g\theta}U - U_gU_\theta}{U^2} \\ &= -\frac{-\psi''e_g e_\theta U - \psi' e_{g\theta} U + \psi'^2 e_g e_\theta}{U^2} < 0\end{aligned}$$

■

A.1 Proof of Proposition 1

Proof. We break the proof in five steps.

Step I: For every strategy $(\hat{t}_i, \hat{g}_i)$ with $\hat{t}_i > 0$, there exists a strategy (t'_i, g'_i) with $t'_i < \hat{t}_i$ and $g'_i > \hat{g}_i$ that signals the same minimum level of ability: Let $(\hat{t}_i, \hat{g}_i)$ such a strategy for candidate i . His individual rationality constraint implies that

$$\begin{aligned}W - \hat{t}_i &\geq \psi(e(\hat{g}_i, \theta_i)) \Leftrightarrow \\ \psi^{-1}(W - \hat{t}_i) &\geq e(\hat{g}_i, \theta_i) \Leftrightarrow\end{aligned}\tag{A.1}$$

$$\theta_i \geq \theta(\hat{g}_i, \psi^{-1}(W - \hat{t}_i)) \equiv \theta^{\min}\tag{A.2}$$

Reduce $\hat{t}_i$ by dt and increase $\hat{g}_i$ by dg such that

$$dg = \frac{\theta_e(\hat{g}_i, \psi^{-1}(W - \hat{t}_i))}{\theta_g(\hat{g}_i, \psi^{-1}(W - \hat{t}_i))} \psi^{-1'}(W - \hat{t}_i) dt$$

where θ_j denotes partial derivative of θ with respect to j .

But then, the change in the minimum ability signaled will be:

$$d\theta^{\min} = \theta_g(\hat{g}_i, \psi^{-1}(W - \hat{t}_i)) dg + \theta_e(\hat{g}_i, \psi^{-1}(W - \hat{t}_i)) \psi^{-1'}(W - \hat{t}_i) d(-t) = 0$$

(We have used the fact that $de = \psi^{-1'}(W - t)(-1)dt$).

Step II: Consider the alteration in i 's strategy described in Step I. The least competent candidate that would bid in both cases $((\hat{t}_i, \hat{g}_i)$ and (t', g')), would have ability $\theta^{\min}$ and zero utility if elected:

The least able candidate that would bid in the first case will be a candidate for whom

$$W - \hat{t}_i = \psi(e(\hat{t}_i, \theta^{\min}))$$

For any candidate with $\theta < \theta^{\min}$, it will be the case that $\psi(e(\hat{t}_i, \theta)) > W - \hat{t}_i$ and hence he will not bid $(\hat{t}_i, \hat{g}_i)$ since his individual rationality constraint

would be violated otherwise. This is because $e(g, \theta)$ is strictly decreasing in θ (lemma 1).

By exactly the same line of argument one can show that the least able candidate that will bid (t', g') will be of ability $\theta^{\min}$. For him, as well, the individual rationality constraint must be binding: $W - t' = \psi(g', \theta^{\min})$. It follows that for the least competent candidate willing to play both strategies $(\theta^{\min})$, it will be the case that $dV^C = W - \hat{t}_i - \psi(e(\hat{g}_i, \theta^{\min})) - [W - t'_i - \psi(e(g'_i, \theta^{\min}))] = 0 - 0 = 0$.

Step III: Any candidate willing to play both $(\hat{t}_i, \hat{g}_i)$ and (t', g') will be strictly better off *when elected* by playing (t', g') .

First note that by equation (A.1), there must be a level of effort $\tilde{e} \equiv \psi^{-1}(W - \hat{t}_i) \geq e(\hat{g}_i, \theta_i)$ with $\psi^{-1'}(W - \hat{t}_i) = \frac{1}{\psi'(\tilde{e})}$. But then

$$\psi'(e(\hat{g}_i, \theta_i))\psi^{-1'}(W - \hat{t}_i) \leq \psi'(\tilde{e})\psi^{-1'}(W - \hat{t}_i) = 1 \quad (\text{A.3})$$

Now, consider an elected candidate's utility when $(\hat{t}_i, \hat{g}_i)$ was his winning bid:

$$V^C = W - t_i - \psi(e(\hat{g}_i, \theta_i))$$

and the deviation (from $(\hat{t}_i, \hat{g}_i)$ to (t', g')) described in Step I that signals the same minimum level of ability. The change in his utility caused by that deviation will be:

$$\begin{aligned} dV^C &= -dt_i - \psi'(e(\hat{g}_i, \theta_i)) e_g(\hat{g}_i, \theta_i) dg \\ &= - \left[\frac{\theta_g}{\theta_e} \frac{1}{\psi^{-1'}(W - \hat{t}_i)} + \psi'(e(\hat{g}_i, \theta_i)) e_g(\hat{g}_i, \hat{t}_i) \right] dg \end{aligned} \quad (\text{A.4})$$

As $dg > 0$, we can see that dV^C will be positive if and only iff the terms in the brackets are negative. Hence

$$\begin{aligned} dV^C \geq 0 &\Leftrightarrow - \left[\frac{\theta_g}{\theta_e} \frac{1}{\psi^{-1'}(W - \hat{t}_i)} + \psi'(e(\hat{g}_i, \theta_i)) e_g(\hat{g}_i, \theta_i) \right] \geq 0 \\ &\Leftrightarrow \frac{e_\theta}{g_\theta} + \psi^{-1'}(W - \hat{t}_i) \psi'(e(\hat{g}_i, \theta_i)) e_g \leq 0 \\ &\Leftrightarrow e_\theta + \psi^{-1'}(W - \hat{t}_i) \psi'(e(\hat{g}_i, \theta_i)) e_g g_\theta \leq 0 \end{aligned} \quad (\text{A.5})$$

Now since $dV^C|_{\theta=\theta_{\min}} = 0$, it must be

$$\left\{ e_\theta + \psi^{-1'}(W - \hat{t}_i) \psi'(e(\hat{g}_i, \theta_i)) e_g g_\theta \right\} \Big|_{\theta=\theta_{\min}} = 0 \quad (\text{A.6})$$

But for any candidate with $\theta > \theta^{\min}$ it will be the case that

$$\left\{ e_\theta + \psi^{-1'}(W - \hat{t}_i) \psi'(e(\hat{g}_i, \theta_i)) e_g g_\theta \right\} \Big|_{\theta > \theta_{\min}} < 0$$

This is because

$$\begin{aligned} & \frac{\partial}{\partial \theta} \left[e_\theta + \psi^{-1'}(W - \hat{t}_i) \psi'(e(\hat{g}_i, \theta_i)) e_g g_\theta \right] = \\ &= e_{\theta\theta} + \psi^{-1'}(W - \hat{t}_i) \frac{\partial}{\partial \theta} [\psi'(e(\hat{g}_i, \theta_i)) e_g g_\theta] \\ &= e_{\theta\theta} + \psi^{-1'}(W - \hat{t}_i) \{ \psi''(e(\hat{g}_i, \theta_i)) e_\theta e_g g_\theta + \psi'(e(\hat{g}_i, \theta_i)) [e_{g\theta} g_\theta + e_g g_{\theta\theta}] \} \\ &\leq \psi^{-1'}(W - \hat{t}_i) \psi'(e(\hat{g}_i, \theta_i)) \left[\underbrace{[e_{\theta\theta} + e_{g\theta} g_\theta + e_g g_{\theta\theta}]}_{-ve} + \underbrace{\frac{\psi''(e(\hat{g}_i, \theta_i))}{\psi'(e(\hat{g}_i, \theta_i))} e_\theta e_g g_\theta}_{-ve(e_\theta < 0)} \right] \\ &< 0 \end{aligned}$$

Here we have used the fact that $\psi'(e(\hat{g}_i, \theta_i)) \psi^{-1'}(W - \hat{t}_i) \leq 1$ by (A.3) and $e_{\theta\theta} + e_{g\theta} g_\theta + e_g g_{\theta\theta} < 0$ by Lemma 1. Hence for any candidate that enters, that is any candidate with $\theta > \theta_{\min}$, it must be that $dV^C > 0$ and his utility will increase if he deviates from $(\hat{t}, \hat{g})$ to (t', g') .

Step IV: Let $P(t, g)$ denote i 's probability of election as a function of the vectors of campaign promises and spending t and g . Then i 's probability of winning the election cannot decrease by the deviation described above:

$$P[(t^{i'}, t^{-i})', (g^{i'}, g^{-i})'] \geq P[(\hat{t}_i, t^{-i})', (\hat{g}_i, g^{-i})']$$

This is because in both cases he signals the same minimum level of ability but by deviating he promises more public good. But the voters' expected utility function is increasing in the level of public good ceteris paribus:

$$\begin{aligned} EU^V &= \int_{\theta_{\min}}^{\theta_{\max}} \frac{f(x)}{F(\theta_{\max}) - F(\theta_{\min})} U^V(g, \theta) d\theta \\ \Rightarrow \frac{\partial EU^V}{\partial g} &= \int_{\theta_{\min}}^{\theta_{\max}} \frac{f(x)}{F(\theta_{\max}) - F(\theta_{\min})} \frac{\partial}{\partial g} U^V(g, \theta) d\theta > 0 \end{aligned}$$

as the integrand is positive everywhere. Since the voters' expected welfare from choosing i is higher, i will win the elections in all those cases, in which he won before the deviation plus in the cases where the highest bid among the other $n - 1$ bids is higher than i 's bid before the deviation but lower

than his new bid. His probability of election hence, cannot decrease from the deviation.

Step V: Strategy $(\hat{t}_i, \hat{g}_i)$ is strictly dominated by (t'_i, g'_i) :

$$\begin{aligned}
EU_i^C(\hat{t}_i, \hat{g}_i) &= P[(\hat{t}_i, t_{-i})', (\hat{g}_i, g_{-i})'] [W - \psi(e(\theta_i, \hat{g}_i)) - \hat{t}_i] - \\
&\quad [1 - P[(\hat{t}_i, t_{-i})', (\hat{g}_i, g_{-i})']] \hat{t}_i \\
&\leq P[(\hat{t}_i, t_{-i})', (\hat{g}_i, g_{-i})'] [W - \psi(e(\theta_i, g'_i)) - t'_i] - \\
&\quad [1 - P[(\hat{t}_i, t_{-i})', (\hat{g}_i, g_{-i})']] \hat{t}_i \\
&\leq P[(t'_i, t_{-i})', (g'_i, g_{-i})'] [W - \psi(e(\theta_i, g'_i)) - t'_i] - \\
&\quad [1 - P[(t'_i, t_{-i})', (g'_i, g_{-i})']] \hat{t}_i \\
&< P[(t'_i, t_{-i})', (g'_i, g_{-i})'] [W - \psi(e(\theta_i, g'_i)) - t'_i] - \\
&\quad [1 - P[(t'_i, t_{-i})', (g'_i, g_{-i})']] t'_i \\
&= EU_i^C(t', g')
\end{aligned}$$

The first inequality stems from the fact that $dU \geq 0$ (Step III), the second from $P[(t'^i, t^{-i})', (g'^i, g^{-i})'] \geq P[(\hat{t}_i, t^{-i})', (\hat{g}_i, g^{-i})']$ (Step IV) and the third from $t'_i < \hat{t}_i$. ■

A.2 Proof of Proposition 4

Proof. i. Differentiating i 's level of campaign spending w.r.t. the number of candidates, we get

$$\frac{\partial t}{\partial n} = w [\Phi(w)]^{n-1} \ln[\Phi(w)] - \int_{x=w_{\min}}^w [\Phi(x)]^{n-1} \ln[\Phi(x)] dx$$

the first term on the right hand side of the equation is negative and the second positive, so there is no uniform effect of political competition on campaign expenditure. Now, using De l'Hopital's rule, we get that

$$\lim_{w \downarrow w_{\min}} \frac{\partial t_i}{\partial n} = 0 \quad (\text{A.7})$$

$$\lim_{w \uparrow w_{\max}} \frac{\partial t_i}{\partial n} = - \int_{x=w_{\min}}^{w_{\max}} [\Phi(x)]^{n-1} \ln[\Phi(x)] dx > 0 \quad (\text{A.8})$$

Also, differentiating $\frac{\partial t}{\partial n}$ with respect to valuation w (which as mentioned

is an increasing function of ability), we get

$$\begin{aligned} \frac{\partial^2 t}{\partial n \partial w} &= w(n-1)[\Phi(w)]^{n-2} \phi(w) \ln[\Phi(w)] \\ &\quad + w[\Phi(w)]^{n-2} \phi(w) > 0 \Leftrightarrow \\ \Phi(w) &> \exp \left[-\frac{1}{n-1} \right] \end{aligned} \tag{A.9}$$

Let $\tilde{w}$ denote the solution to $\Phi(w) = \exp[-\frac{1}{n-1}]$. Since for $w < \tilde{w}$, $\frac{\partial^2 t}{\partial n \partial w} < 0$ and $\lim_{w \rightarrow w_{\min}^+} \frac{\partial t_i}{\partial n} = 0$, it must be $\tilde{w} \leq 0$. Since $\frac{\partial t}{\partial n}$ is continuous in w , it follows there exists a $\hat{w}(n) \in [\tilde{w}, w^{\max}]$ with $\frac{\partial t}{\partial n}|_{\hat{w}(n)} = 0$. Although we cannot determine whether $\hat{w}$ is increasing in the level of political competition, we know that $\tilde{w}(n)$ is (Figure 1).

- ii. This is a standard result in auctions with private independent values: By the *R.E.T.*, the overall expected campaign expenditure in this all-pay auction should yield the same level of expenditure as a second-price auction. But the expected payment in a second price auction is equal to the the second highest value among n bidders. The distribution function of the second highest among n independent draws with distribution $F(x)$ is $n[F(x)]^{n-1}[1 - F(x)] + [F(x)]^n$ which is easily shown to be lower than the distribution function of the second highest value among $n + 1$ independent draws. Hence the distribution of the second highest value with $n + 1$ draws, stochastically dominates that with n draws and $E(\text{Second highest bid}|n \text{ bidders}) < E(\text{Second highest bid}|n + 1 \text{ bidders})$. ■

A.3 Proof of Proposition 6

Proof. Let α denote the bidding function of player A and β denote the bidding function of player B:

$$\begin{aligned} \alpha &: [0, 1] \rightarrow \mathbb{R} \text{ with } \alpha(w_A) = x \\ \beta &: [0, \rho] \rightarrow \mathbb{R} \text{ with } \beta(w_B) = y \end{aligned}$$

Define the distributions functions of x, y as follows: $F(x) \equiv U(\alpha^{-1}(x))$, $G(y) \equiv U(\beta^{-1}(y))$, where U is the distribution function of w_A and w_B . Following [4], the equilibrium conditions for x, y are

$$F(x) = \frac{1}{G'(x)} \quad \text{and} \quad G(y) = \frac{1}{\rho F'(y)}$$

with boundary conditions $G(0) = 0, F(0) = 0$. The general solution to the above system of differential equations is

$$\begin{aligned} F(x) &= C_0[x(1+\rho) - C_1]^{\frac{1}{1+\rho}} \\ G(y) &= C'_0[y(1+\rho) - C'_1]^{\frac{\rho}{1+\rho}} \end{aligned} \quad (\text{A.10})$$

where C_i, C'_i integration constants. Using the boundary conditions and the fact that by the common support Lemma in [4], $\alpha(1) = \beta(\rho)$ and inverting $F(x)$ and $G(x)$, we get

$$\alpha(w_A) = \frac{\rho}{1+\rho} w_A^{1+\rho} \quad (\text{A.11})$$

$$\beta(w_B) = \frac{w_B^{\frac{1+\rho}{\rho}}}{\rho^{\frac{1}{\rho}}(1+\rho)} \quad (\text{A.12})$$

The derivatives of the bidding functions w.r.t. ρ are then

$$\begin{aligned} \frac{\partial \alpha(w_A)}{\partial \rho} &= \frac{w_A^{1+\rho}}{1+\rho} \left[\frac{1}{1+\rho} + \ln w_A \right] \gtrless 0 \\ \Leftrightarrow w_A &\gtrless e^{-\frac{1}{1+\rho}} \equiv \tilde{w}_A(\rho) \end{aligned} \quad (\text{A.13})$$

and

$$\frac{\partial \beta(w_B)}{\partial \rho} = \frac{w_B^{\frac{1+\rho}{\rho}} \ln w_B \rho^{\frac{1}{\rho}}(1+\rho) - w_B^{\frac{1+\rho}{\rho}} \left[\rho^{\frac{1}{\rho}} + \frac{(1+\rho)^{\frac{1}{\rho}}}{\rho^2} (1 - \ln \rho) \right]}{\rho^{\frac{2}{\rho}}(1+\rho)^2} < 0 \quad (\text{A.14})$$

■

A.4 Proof of Proposition 7

Proof. i. That G^S is non-empty follows from the fact that, trivially, $g^{\min} \in G^S$. That $\bar{g}^S$ exists, follows from the fact that G^S is bounded, since by the candidates' participation constraint, no candidate can ever find it profitable to promise more than $g(\theta^{\max}, \psi^{-1}(W))$.

ii. The proof is identical to the proof of Proposition 1. A candidate can always signal a competence by increasing promises and decreasing spending in such a way that he will be better off if elected and strictly better off when not elected.

iii. By the revelation principle, we can restrict attention to mechanisms that ensure truthful revelation of types. Let $\Pi(\bar{g}^S)$ denote the expected rents for candidate i from playing the game indefinitely. These expected rents are calculated below. When a candidate is caught cheating, the voters can punish him by not voting for him for a (possibly infinite) number of periods. Hence the voters can deprive him of a portion $\kappa \in (0, 1]$ of his expected future earnings. Consider a candidate who comes to office after having promised a level of public good $g(\theta)$. By cheating he earns $\psi(e(g(\theta), \theta)) - \psi(e(g^{\min}, \theta))$ and forgoes $\kappa\Pi(\bar{g}^S)$. Now, suppose that there exists an equilibrium strategy involving a level of promising $\hat{g}_i > \bar{g}^S$ for some candidate i . That means that the voters allow promises of up to at least $\hat{g}_i > \bar{g}^S$. Suppose that all other candidates report truthfully (otherwise this cannot be a truth revealing equilibrium). By the definition of $\bar{g}^S$, there will exist a type of candidate j with $\bar{g}^S < g(\theta_j) < \hat{g}_i$, for whom it will be optimal to cheat if he is elected, that is

$$\psi(e(g(\theta_j), \theta_j)) - \psi(e(g^{\min}, \theta_j)) > \kappa\Pi(\bar{g}^S) \quad (\text{A.15})$$

But then, it will be the case that

$$P(g(\theta_j)) [\psi(e(g(\theta_j), \theta_j)) - \psi(e(g^{\min}, \theta_j)) - \kappa\Pi(\bar{g}^S)] > 0 \quad (\text{A.16})$$

where, $P(g(\theta_j))$ is candidate j 's probability of election when he promises $g(\theta_j)$, given that others report truthfully. But the left hand side in (A.16) is j 's net expected utility from cheating, that is, his expected utility from promising $g(\theta_j)$ and then cheating minus his expected utility from promising $g(\theta_j)$ and living up to his promise if elected.

Candidate j 's expected utility from cheating will be

$$P(g) [W - \psi(e(g^{\min}, \theta_j)) + (1 - \kappa)\Pi(\bar{g}^S)] + [1 - P(g)]\Pi(\bar{g}^S)$$

Candidate j 's probability of election $P(\cdot)$ cannot be decreasing, so by reporting a little more, his expected utility from cheating rises:

$$\begin{aligned} \frac{\partial}{\partial g} [E(U_j^C(\text{Cheating}))] &= P'(g) [W - \psi(e(g^{\min}, \theta_j)) - \kappa\Pi(\bar{g}^S)] \geq \\ &P'(g) [\psi(e(g(\theta_j), \theta_j)) - \psi(e(g^{\min}, \theta_j)) - \kappa\Pi(\bar{g}^S)] > 0 \end{aligned}$$

Hence j has an incentive to promise at least $\hat{g}_i$ and mis-report his type and hence $\hat{g}_i$ cannot be an equilibrium level of promises. ■

A.5 Proof of Proposition 8

Let $H(\theta)$ denote the probability of election for a candidate of ability θ . H is the distribution of the n^{th} order statistic of θ . If $(g(\theta), t(\theta))$ are the equilibrium promises and spending of a candidate of ability θ then $x = \theta$ must maximize for each θ a candidate's expected utility

$$EV^C = H(x)U(g(x), \theta) - t(x) \quad (\text{A.17})$$

If we differentiate,

$$\begin{aligned} \frac{\partial}{\partial x} EV^C = & \\ & H(x)U_g[g(x), \theta] \left[g'(x) + \frac{H'(x)}{H(x)} \frac{U[g(x), \theta]}{U_g[g(x), \theta]} - \frac{t'(x)}{H(x)U_g[g(x), \theta]} \right] \end{aligned} \quad (\text{A.18})$$

By Proposition 7, it follows that since all bidding takes place through campaign promises only until $\bar{g}^S$ is reached and then through spending only, it must be the case that $g'(x) = 0$ for $g(x) = \bar{g}^S$ and $t'(x) = 0$ for $g(x) < \bar{g}^S$. Thus (A.18) becomes:

$$\begin{aligned} \frac{\partial}{\partial x} EV^C = & \\ & H(x)U_g[g(x), \theta] \left[\mathbb{I}_{g < \bar{g}^S} g'(x) + \frac{H'(x)}{H(x)} \frac{U[g(x), \theta]}{U_g[g(x), \theta]} - \frac{[1 - \mathbb{I}_{g < \bar{g}^S}]t'(x)}{H(x)U_g[g(x), \theta]} \right] \end{aligned} \quad (\text{A.19})$$

and hence,

$$\frac{\partial}{\partial x} EV^C = \begin{cases} H(x)U_g[g(x), \theta] \left[g'(x) + \frac{H'(x)}{H(x)} \frac{U[g(x), \theta]}{U_g[g(x), \theta]} \right] & \text{if } g(x) < \bar{g}^S \\ H'(x)U[g(x), \theta] - t'(x) & \text{if } g(x) = \bar{g}^S \end{cases} \quad (\text{A.20})$$

Since by Lemma 1 $\frac{\partial}{\partial \theta} \frac{U^C}{U_g^C} < 0$, we conclude that for $g(x) < \bar{g}^S$,

$$\frac{\partial}{\partial x} EV^C \gtrless H(x)U_g[g(x), \theta] \left[g'(x) + \frac{H'(x)}{H(x)} \frac{U[g(x), x]}{U_g[g(x), x]} \right]$$

iff $\theta \gtrless x$.

Also, if $g(x) = \bar{g}^S$, it will obviously be the case that

$$\frac{\partial}{\partial x} EV^C \gtrless H'(x)U[g(x), x] - t'(x)$$

iff $\theta \gtrless x$.

Therefore, if we define campaign promises and spending by the follow differential equations,

$$\begin{cases} g'(\theta) = -\frac{H'(\theta)}{H(\theta)} \frac{U[g(\theta), \theta]}{U_g[g(\theta), \theta]}, & g(\theta^0) = g^{\min}, \text{ and } \theta \leq \bar{\theta} \\ t'(\theta) = H'(\theta)U[g(\theta), \theta], & t(\bar{\theta}) = 0, \text{ and } \theta > \bar{\theta} \end{cases} \quad (\text{A.21})$$

where $U^C(g^{\min}, \theta^0) = 0$ and $g(\bar{\theta}) = \bar{g}^S$, it follows directly that

$$\frac{\partial}{\partial x} EV^C \gtrless \frac{\partial}{\partial x} EV^C \Big|_{x=\theta} = 0 \quad \text{as } \theta \gtrless x$$

and hence (A.17) is maximized at $x = \theta$. Uniqueness, monotonicity and differentiability of $g(\cdot), t(\cdot)$, follow the proof of [12]'s Theorem 2 and are omitted.

A.6 Proof of Proposition 9

Proof. To show that the level of sustainable promises is strictly greater than $g^{\min}$, we need to calculate both the cost of breaking a promise, i.e. the cost of punishment and the gain from cheating. The cost to a candidate of not delivering on a promise is $\frac{1-\delta^T}{1-\delta}$ times his expected period utility of playing the game, where T is the length of punishment. The expected utility of a candidate of ability x is $[F(x)]^{n-1}U^C(x, g(x)) - t(x)$. Hence the expected utility of a candidate staying in the electoral process for the next T periods is

$$\begin{aligned} \Pi(\bar{g}^S, T) = \frac{1-\delta^T}{1-\delta} & \left[\int_{\theta^{\min}}^{\bar{\theta}(\bar{g}^S)} [F(x)]^{n-1} U^C(x, g(x)) f(x) dx + \right. \\ & \left. \int_{\bar{\theta}(\bar{g}^S)}^{\theta^{\max}} [[F(x)]^{n-1} U^C(x, \bar{g}^S) - t(x)] f(x) dx \right] \quad (\text{A.22}) \end{aligned}$$

The gain to candidate of ability θ from not delivering on his promise and producing the minimum level of public good is $\psi(e(\theta, g(\theta))) - \psi(e(\theta, g^{\min}))$. Let $\theta^* \equiv \operatorname{argmax}_{\theta} [\psi(e(\theta, g(\theta))) - \psi(e(\theta, g^{\min}))]$. That θ^* exists follows from the fact that $\psi(\cdot)$ is continuous in θ and the set of ability is a compact set

and hence by the Bolzano-Weierstrass Theorem ψ must have a maximum. Then

$$\Psi(g^S) \equiv \psi(e(\theta^*, g(\theta^*))) - \psi(e(\theta^*, g^{\min}))$$

is the maximum gain any candidate can get from cheating. Now define

$$\tilde{\Psi}(\bar{g}^S) \equiv \Psi(g^S) - \Pi(\bar{g}^S, \infty)$$

to be the maximum gain from cheating net of punishment. Clearly $\tilde{\Psi}$ is continuous in $\bar{g}^S$. Now suppose, contrary to our claim that $\bar{g}^S = g^{\min}$. Then

$$\tilde{\Psi}(g^{\min}) = -\Pi(g^{\min}, \infty) < 0$$

But by the continuity of $\tilde{\Psi}$, there must exist $g > g^{\min}$ with $\tilde{\Psi}(g) < 0$ and hence g will be sustainable, which means that $g^{\min}$ cannot be the supremum of G^S , a contradiction. Hence there exists a level of sustainable promises that the voters will find it optimal to hold on to rather than cheat and deliver $g^{\min}$. That the voter will find it optimal to punish deviating candidates, follows by condition (AC), since by punishing she enjoys in each period more utility from the highest ability candidate (among $n - 1$ candidates) who will produce a higher level of public good, than by not punishing and have n candidates who produce $g^{\min}$. ■

A.7 Proof of Proposition 10

- i. Note that $\bar{g}^S$ is the first point of intersection between $\Psi(g)$ and $\Pi(g, T)$ if the two intersect as in Figure 5 (a) or the maximum level of public good that any candidate might be willing to produce, i.e. $g(\theta^{\max}, \psi^{-1}(W))$ if the two do not intersect as in Figure 5 (b). In other words, $\bar{g}^S = \min\{g^{*T}, g(\theta^{\max}, \psi^{-1}(W))\}$, where g^* is the (vector of) solutions to $\tilde{\Psi}(g) = 0$. We can distinguish two cases:

- (a) $\bar{g}^S < g(\theta^{\max}, \psi^{-1}(W))$ Then since $\tilde{\Psi}$ is continuous and $\tilde{\Psi}(g^{\min}) < 0$, it follows that $\Psi_g(\bar{g}^S) > \Pi_g(\bar{g}^S, T)$. But then by use of the Implicit Function Theorem, we conclude that

$$\frac{d\bar{g}^S}{dz} = -\frac{\frac{\partial \tilde{\Psi}(\bar{g}^S)}{\partial z}}{\frac{\partial \tilde{\Psi}(\bar{g}^S)}{\partial g}} = -\frac{-\Pi_z}{\Psi_g(\bar{g}^S) - \Pi_g(\bar{g}^S)} > 0 \quad (\text{A.23})$$

for $z = \delta, T, W$. The expected level of campaign promises is the

expected level of promises of the highest among n candidates:

$$E(g) = \int_0^{\theta(\bar{g}^S)} (n-1)g(x)[F(x)]^{n-2}f(x)dx + \int_{\theta(\bar{g}^S)}^{\theta^{\max}} (n-1)\bar{g}^S[F(x)]^{n-2}f(x)dx \quad (\text{A.24})$$

But then, $\frac{\partial}{\partial \bar{g}^S} E(g) = \int_{\theta(\bar{g}^S)}^{\theta^{\max}} (n-1)[F(x)]^{n-2}f(x)dx > 0$ as the integrand positive everywhere. Hence $\frac{\partial E(g)}{\partial z} = \frac{\partial E(g)}{\partial \bar{g}^S} \frac{d\bar{g}^S}{dz} > 0$, where $z = \delta, T, W$.

(b) If $\bar{g}^S = g(\theta^{\max}, \psi^{-1}(W))$, it is clear that $\frac{d\bar{g}^S}{dz} = 0$.

Overall $\frac{\partial E(g)}{\partial z} \geq 0$.

- ii. The equilibrium bidding function $t(\theta)$, is solved by integration of the differential equation (A.21), taking into account the boundary condition. Hence the equilibrium bidding function $t(\theta)$ can be written as $t(\theta) = \int_{\theta(\bar{g}^S)}^{\theta} t'(y)dy = \int_{\theta(\bar{g}^S)}^{\theta} H'(y)U[g(y), y]dy$.

$$\begin{aligned} \frac{\partial E(t)}{\partial \bar{g}^S} &= \frac{\partial}{\partial \bar{g}^S} \int_{\theta(\bar{g}^S)}^{\theta^{\max}} (n-1)t(x)[F(x)]^{n-2}f(x)dx \\ &= -\theta'(\bar{g}^S)t(\theta(\bar{g}^S))(n-1)[F(\theta(\bar{g}^S))]^{n-2}f(\theta(\bar{g}^S)) + \\ &\quad \int_{\theta(\bar{g}^S)}^{\theta^{\max}} (n-1)\frac{\partial}{\partial \bar{g}^S} \left[\int_{\theta(\bar{g}^S)}^x H'(y)U[g(y), y]dy \right] [F(x)]^{n-2}f(x)dx \\ &= 0 + \\ &\quad \int_{\theta(\bar{g}^S)}^{\theta^{\max}} (n-1)[- \theta'(\bar{g}^S)H'(\theta(\bar{g}^S))U[g(\theta(\bar{g}^S)), \theta(\bar{g}^S)]] [F(x)]^{n-2}f(x)dx \\ &< 0 \end{aligned}$$

since $t(\theta(\bar{g}^S)) = 0$ by (A.21) and the integrand is negative everywhere.

Hence, depending on whether we are in an internal ($\bar{g}^S < g(\theta^{\max}, \psi^{-1}(W))$) or corner ($\bar{g}^S = g(\theta^{\max}, \psi^{-1}(W))$) solution, we can conclude that $\frac{\partial E(t)}{\partial \bar{g}^S} \leq 0$.

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