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Mackerels in the Moonlight: A Duopoly Model of Political Agency

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Abstract: I study political competition between two candidates who could differ in their ability, popularity, and ethics. In elections, each candidate proposes a flat (income) tax rate and a public good level. A high(er)-ability candidate can produce the public good using less funds. Collected taxes that are not used in public goods production are stolen by the elected politician. The voting decision is probabilistic; it depends on a candidate's fiscal policy and his popularity. I prove that the pure strategy Nash Equilibrium exists and that there are at most two separate equilibria. I also provide a fully solved example.

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1 Introduction

The effectiveness of an economic policy depends on both the objective and the constraints of the policy maker. Illustrating this point, a classical example is the welfare effects of broadening the tax base. When the tax rates are determined by a benevolent dictator, broader tax bases reduce the deadweight loss and increase taxpayers' welfare. When, however, a Leviathan (a policy maker who cares only about his own consumption and who does not face any competition) decides on the tax rates, broader tax bases reduce taxpayers' welfare, (Brennan and Buchanan, 1980; and Wilson, 1989).

Consider a country in which a small group of career politicians repeatedly compete with each other. Assume that in this country (at least some of) the politicians are corrupt, and this is well known by (at least a large fraction of) the voters.[1] How should one model the objectives and the constraints of an elected leader in such a country? Neither the benevolent dictator, nor its exact opposite, the Leviathan, would be an appropriate model. These two models describe two polar cases, similar to the perfect competition and the monopoly in the firm theory. Generalizing earlier work by Polo (1998), I study a "duopoly" model of political agency. Although different factors may contribute to high level political corruption in different countries, the model emphasizes two of them: the limited number of competing politicians and candidate heterogeneity.

When combined with candidate heterogeneity, the limited number of candidates implies that a politician has "market power". In other words, if the candidates are not perfect substitutes from the point of view of voters, then a corrupt politician can steal and still may get re-elected. For instance, a candidate who is known to be more able than his rival can still remain competitive even when he engages in corruption.[2] Ability is not the only characteristics that the voters care about. Their

[1] See, for instance, the section on Elite Cartels in Johnston (2005)'s taxanomy of political corruption.

[2] In 1820s, John Randolph complained that his Congressional colleague, Henry Clay, "... is so brilliant, so capable, and yet so corrupt that like a rotten mackerel in the moonlight, he both shines

decision may be influenced by factors such as the candidate's gender, ethnic origin, family or tribe, religion, personal charisma or ideology. All these factors affect a candidate's popularity. Further, a candidate's popularity may be subject to random shocks: many unforeseeable events (including scandals) that occur during a political campaign affect it. Due to this uncertainty about popularity, even a corrupt candidate who faces an opponent with the same level of ability as well as the same level of *ex ante* popularity has a chance to be re-elected.

To formalize these ideas, Section 2 presents a model of political competition under probabilistic voting. In the model, there is a continuum of voters who differ in their income level. A voter's utility is separable in the private and the public good consumptions. Each of the two expected-rent-maximizing candidates announces a fiscal policy platform: a tax rate and a public good level. Candidates keep their election promises. A candidate can be pathologically honest, that is, he may not steal even if he could receive a net expected monetary benefit by doing so. Such a candidate may still run in the elections because for every winning candidate there are legal rents: ego rents and a salary. But, for those who are not pathologically honest, winning the election provides the opportunity to steal. The amount a candidate steals is implicitly defined by the difference between tax revenues and public good costs where the costs are determined by the candidate's ability.

In the model, there are three types of constraints that would reduce, if not eliminate, the incentives to steal: a candidate may have moral scruples; the voters, other things being equal, prefer a clean candidate to a corrupt one; and finally, a corrupt candidate may get caught and punished. The strength of these constraints, however, vary depending on the political environment and the quality of institutions. So, what happens in equilibrium depends on the parameters of the model.

I show that under all possible parameters, the pure strategy Nash Equilibrium of

and stinks",–quoted in Ehrenhalt (2002). More recently da Silva (2000) notes that Adhemar de Barros, a three-time governor of Sao Paula, has been attributed to say, "I am an embezzler, but I am also an accomplisher".

the model exists. When there are no legal penalties or when the expected penalties are very severe, the equilibrium is unique. Otherwise, there can be at most two distinct equilibria. I identify both the first order conditions that characterize the equilibrium level of corruption, and the relationship between the equilibrium fiscal policy and the equilibrium level of corruption. Since the voters' preferences, too, are part of the parameter space, there is no closed form solution for the general model. Still, the comparative statics from the general model can be used to study several policy questions. For applications that require a closed form solution, a fully solved example for the special case of quasi-linear voter preferences is provided in Appendix.

Political corruption all over the world shows more variation than a simple model can explain. The model here emphasizes the role of limited number of competing candidates as well as (both *ex-ante* and *ex-post*) candidate heterogeneity; other models of political agency emphasize other factors. For instance, in the seminal incumbency model of Ferejohn (1986) and its extension and generalization in Besley and Smart (2007) the source of political corruption is imperfect information.[3] In these models, the voter cannot observe how much, if at all, the incumbent steals; she tries to infer it from his actions.

In countries in which there are sufficiently many able and honest politicians, the discovery (or even the rumor) of a past corrupt behavior would end a politician's career; as there are better alternatives, nobody would vote for him again. The incumbency model in Besley and Smart (2007) would explain policy making in such countries well. In the model I study here the voters may still vote for a politician who is commonly considered as corrupt.[4] This is because they have a limited number

[3]Moral hazard in the former and both moral hazard and adverse selection in the latter.

[4]An earlier example is Mayor Curley of Boston, see Beatty (2000). More recently, Little and Herrera (1996, p. 268) note that in Venezuela, "the election of the second time of Carlos Andres Perez, (first presidency 1974-79) in 1988 suggested that most voters were more than happy with a president who was widely believed to be corrupt, but who promised a return to the old days". In Brazil, following the suspension of the political rights of President Collor and several other politicians after the corruption allegations, Martins (1996, p.196) wrote that "Nonethless, it would not be surprising, if, at the end of the period of suspension of their political rights, they [Ex-president Collor, the congressman and the senators] put themselves forward again as candidates and were

of alternatives (only two), and the other alternative they have could be less able, or, he may not be popular among the voters for other reasons (for instance, he does not have the desirable characteristics such as ethnicity, gender, religion, looks, ideology, etc.).

In the duopoly model, the equilibrium level of corruption is determined through strategic interaction between candidates. This is due to the limited number of competing candidates. Then, a change in a parameter such as salary results in both a direct effect and an indirect (strategic) effect on equilibrium level of corruption. This indirect effect is absent from the models that assume a continuum of competing candidates including the incumbency model.

In the duopoly model, the number of competing candidates is limited. Further, there is no "entry". When both candidates steal in equilibrium, one may wonder why a better person does not run for the office; had this happen, the voters would "throw the rascals out". Caselli and Morelli (2004), and Myerson (1993, 2006), however, show that free entry does not necessarily lead to a significant improvement in the quality of elected politicians. These authors, too, study models of political corruption in which the voters know how corrupt the candidates are. In Caselli and Morelli (2004), low legal rents explain the persistent low quality of political candidates: high quality candidates do not run, since it is not worth it. Further, Caselli and Morelli (2004) note that, once elected, the low quality candidates have incentives to keep the legal rents low to prevent entry.

Myerson (1993, 2006) considers multiple candidates who differ in their exogenous policy platforms (left or right) and exogenous characteristics (honest or corrupt). He shows that under many commonly voting rules (including plurality) the voters may not be able to vote in a coordinated way to elect an honest candidate who adopts a popular policy platform. Thus, the analysis in this paper complements the analysis in Caselli and Morelli (2004), and Myerson (1993, 2006). They explain how corrupt

elected, as has occured in other cases of corruption". Indeed, in 2006, Collor won %44 of the vote and became a senator representing the Brazilian state Alagoas.

politicians may survive in politics. I take it given that some politicians want to (and may have the opportunity to) steal, and study the existence of political equilibrium in such an environment.

In Section 3, I discuss the relation to earlier literature. Before me, both Brennan and Buchanan (1980) and Polo (1998) note that politicians steal in Downsian competition when the vote shares are stochastic. Polo (1998) provides a formal model with micro foundations and quasi-linear preferences. This paper extends and generalizes Polo (1998) in a variety of directions. These extensions allow one to consider some features of political competition that have important policy implications.

Finally, in Section 4, I discuss some of the modelling assumptions and future extensions, then I conclude. An important modelling assumption is that political competition is a one-shot game. The game I study, however, should be considered as the stage game of repeated competition between two career politicians. Such an interpretation justifies the modelling assumption that even a corrupt candidate keeps his election promises instead of stealing everything when elected.[5]

2 The Model

Consider a continuum of voters of measure one. Let Y_i denote the income level of voter i, and $F(Y_i)$ denote the cumulative density of Y_i. Let us normalize the average income, $\int Y_i dF(Y_i)$, to one. Assume that each voter pays an income tax at flat rate t and consumes the rest of his income, $c_i = (1-t)Y_i$. Collected taxes are available to be used by the elected leader to produce a public good, g. For private consumption, c, there is a single good sold an unit price. Each voter i's preferences over goods are represented by the following utility function:

[5]Evrenk (2008b) studies a dynamic but simplified version of this model, and proves that, as long as the equilibrium rents and the candidates' discount factors are not too low, a corrupt candidate has incentives to keep his election promises.

$$U(c_i, g) \ = I(c_i) + \ H(g). \tag{1}$$

In (1), both $I(.)$ and $H(.)$ are strictly increasing, strictly concave, continuous and twice continuously differentiable functions from R_+ to R. I assume that both $I'(0)$ and $H'(0)$ converges to infinity.

There are two competing candidates, $j \in \{1, 2\}$. The timing of the game is as follows: simultaneously each j announces a policy platform, a tax rate, t_j, and a public good level, g_j. Then, the elections will be held. The winner of the election always implements the policy that he announced. The winner produces the public good from the available public funds using a linear technology that depends on his (non-verifiable) ability, α_j. The net public funds used in the production of public good is equal to collected tax revenues minus the salary of the leader, $w > 0$, and an amount that he chooses to steal, s_j,

$$g_j = (t_j - w - s_j)\alpha_j. \tag{2}$$

Each candidate's goal is to maximize his expected rents and each candidate's outside option is normalized to zero. In addition to salary, the winning candidate receives ego rents, η, as well. Further, each candidate j knows that if he steals a dollar from the public budget, a fraction, $(1 - \theta_j) > 0$, is lost (the cost of stealing), and he will appropriate only the rest of it. This assumption known as "leakage" or "deadweight loss of corruption" in the literature reflects the possibility that the leader should share the illegal rents with others or that there is a moral cost of stealing. The second interpretation allows us to use θ_j to model honesty in a utility maximizing setup by setting $\theta_j = 0$, –such politicians are referred as "pathologically honest" in Rose-Ackerman (2001).

In addition to the deadweight loss of corruption, a corrupt politician will get caught and be punished with probability $p \geqslant 0$. Then, he will be deprived of his

position, lose the legal rents w and η, and pay a legal penalty worth $y + vs_j$, where $y \geqslant 0$ and $v \geqslant 0$. Thus, when he is elected, j expects to receive

$$R_j(s_j) = w + \eta + \mathbf{1}_{\{s_j>0\}}[\theta_j s_j - (vs_j + y + w + \eta)p], \tag{3}$$

where $\mathbf{1}_{\{s_j>0\}}$ is equal to 1 if $s_j > 0$, and equal to 0 otherwise.

The voting is probabilistic: i votes for j when $U_i^j > U_i^k$, and flips a coin when $U_i^1 = U_i^2$, where

$$U_i^j = I((1 - t_j)Y_i) + \ H(g_j) + (j - 1)(\beta + \beta_2 + \beta_{i2}). \tag{4}$$

The term $\beta + \beta_2 + \beta_{i2}$ in (4) captures the non–policy issues that affect the voting decision: β is the electorate's average bias in favor of Candidate 2 and it is known *ex ante*.[6] From the candidates' point of view, β_2 and β_{i2} are independent random variables uniformly distributed on $[\frac{-1}{2\sigma}, \frac{1}{2\sigma}]$ and $[\frac{-1}{2\phi}, \frac{1}{2\phi}]$, where both $\frac{1}{2\sigma}$ and $\frac{1}{2\phi}$ are assumed to be sufficiently large but finite. The first term, β_2, reflects a correlated preference shock (such as the candidate's performance on a televised debate just before the elections; a scandal; an unexpected success or failure of a policy that the candidate strongly defended in the past), while β_{i2} reflects an idiosyncratic shock on individual i's preferences. Let $\mathbf{E}[h(Y_i)]$ denote $\int h(Yi)dF(Y_i)$ for any function $h(.)$, and let ρ_j denote the probability that j wins the elections. One can show that[7]

$$\rho_j = \frac{1}{2} + \sigma[\mathbf{E}[U((1 - t_j)Y_i, g_j) - U((1 - t_k)Y_i, g_k)] + 2(j - \frac{3}{2})\beta].$$

Each candidate j chooses his equilibrium policy platform, (t_j^*, g_j^*), to maximize his expected rents, $\rho_j R_j$. There is an agency problem, when $(t_j^*, g_j^*) \neq (t_j^0, g_j^0)$ where

[6] So, a positive (negative) β means Candidate 2 is more (less) popular *ex-ante*.

[7] To derive ρ_1 note that $U_i^1 > U_i^2$ if and only if $\beta_{i2} < U(c_i^1, g_1) - U(c_i^2, g_2) - \beta - \beta_2$. Then the probability that i votes for Candidate 1 is equal to $\frac{1}{2} + \phi[U(c_i^1, g_1) - U(c_i^2, g_2) - \beta - \beta_2]$. Summing over i, we find that Candidate 1's expected vote share is equal to $\frac{1}{2} + \phi[\mathbf{E}[U(c_i^1, g_1) - U(c_i^2, g_2)] - \beta - \beta_2]$. Since β_2 is a random variable, Candidate 1's expected vote share is larger than $\frac{1}{2}$ with probability $\frac{1}{2} + \sigma[\mathbf{E}[U(c_i^1, g_1) - U(c_i^2, g_2)] - \beta]$.

(t_j^0, g_j^0) is the first-best policy platform that maximizes the voters' expected welfare, $\mathbf{E}[\mathbf{W}]$. It is straightforward to show that[8]

$$\mathbf{E}[\mathbf{W}] = \mathbf{E}[U_i((1-t_j)Y_i, g_j)] + (j-1)\beta + \frac{1}{2\sigma}(\rho_k)^2,$$

where $k \neq j$, and that the first-best involves no corruption, $g_j^0 = (t_j^0 - w)\alpha_j$, with $t_j^0 = \arg\max \mathbf{E}[U_i((1-t_j)Y_i, g_j((t_j - w)\alpha_j))]$.

To find when the pure strategy Nash Equilibrium, PSNE, policy platforms and the first-best policy platforms differ, consider the first order conditions (f.o.c.'s) from each candidate's optimization problem. The f.o.c. with respect to tax rate implies that each j sets $\sigma R_j \frac{\partial \mathbf{E}[U_i^j(.)]}{\partial t_j} = 0$. Since $w + \eta > 0$, the candidate's rents, R_j, has to be strictly positive in equilibrium. Thus, $\frac{\partial \mathbf{E}[U_i(.)]}{\partial t_j} = 0$. That is,

Lemma 1 *In equilibrium each candidate chooses a tax rate that maximizes voters' expected welfare given the amount he steals, s_j.*

Lemma 1 implies that there exists an equilibrium tax rate function, $t_j^*(s_j)$, with $t_j^*(0) = t_j^0$. (One can also show that there exists an equilibrium public good level function, $g_j^*(s_j) = a_j(t_j^*(s_j) - w - s_j)$ with $g_j^*(0) = g_j^0$.) Due to our assumptions that (i) candidates are rent-maximizing; (ii) voters are equally influential and equally well informed (β_{i2} has the same support for all i); (iii) there are no special interest lobbies, the agency problem exists, if at all, only when at least one j steals. To be able to see when a candidate steals, below, I reframe the optimization problem: instead of studying the optimal (t_j, g_j), I study the choice of optimal (t_j, s_j). That is to say, I solve the model as if each candidate decides which tax rate to propose and how much to steal. From the point of view of a candidate, there is no difference between these

[8]Let $\mathbf{E}_\chi$ denote expectation taken over the random variable $\chi(\neq Y_i)$. Note that $\mathbf{E}_{\beta_2,\beta_{i2}}[U_i] = \sum_j \rho_j \mathbf{E}_{\beta_2,\beta_{i2}}[U_i^j \mid j \text{ wins}]$. Since $\mathbf{E}_{\beta_{i2}}[\beta_{i2} \mid 2 \text{ wins}] = 0$, we have $\mathbf{E}_{\beta_2,\beta_{i2}}[U_i] = \sum_j \rho_j U_i(c_i^j, g_j) + (1-\rho_1)[\beta + \mathbf{E}_{\beta_2}[\beta_2 \mid \beta_2 < \mathbf{E}[U(c_i^1, g_1) - U(c_i^2, g_2)] - \beta]]$. Note that $(1-\rho_1)\mathbf{E}_{\beta_2}[\beta_2 \mid \beta_2 < \mathbf{E}[U(c_i^1, g_1) - U(c_i^2, g_2)] - \beta]$ is equal to $\frac{1}{2\sigma}[\frac{1}{4} - (\rho_1 - \frac{1}{2})^2]$. Thus, $\mathbf{E}_{\beta_2,\beta_{i2}}[U_i] = \sum_j \rho_j U_i(c_i^j, g_j) + (1-\rho_1)\beta + \frac{1}{2\sigma}[\frac{1}{4} - (\rho_1 - \frac{1}{2})^2]$. Summing over i and using the definition of ρ_j we have the desired result.

two problems: for a given t_j, choosing g_j is the same as choosing s_j (and, vice-versa). This change of variables simplifies the analysis, because, now the relevant strategy space is reduced into a curve, $t_j^*(s_j)$, in $\Sigma_j = \{(t_j, s_j) : t_j \in [w, 1],\ s_j \in [0, t_j - w]\}$ with slope,[9]

$$\frac{dt_j^*(s_j)}{ds_j} = \frac{(a_j)^2 H''((t_j - w - s_j)\alpha_j)}{\mathbf{E}[Y_i^2 I''((1-t_j)Y_i)] + (a_j)^2 H''((t_j - w - s_j)\alpha_j)}. \tag{5}$$

Note that $\frac{dt_j^*(s_j)}{ds_j} \in (0, 1)$, i.e., political corruption is financed by *both* inefficiently high taxes and inefficiently low public good levels.

Taking the derivative of $\rho_j R_j$ with respect to s_j, we obtain the second f.o.c.,

$$\sigma R_j \frac{\partial[H((t_j - w - s_j)\alpha_j)]}{\partial s_j} + (\theta_j - pv)\rho_j \leq 0 \text{ (with equality when } s_j^* > 0). \tag{6}$$

Note that, $\frac{\partial \rho_j R_j}{\partial s_j}$ is equal to a weighted average of two marginal gains: (i) the average marginal disutility of voters from corruption (weighted by σR_j), and (ii) the marginal increase in rents due to corruption (weighted by the probability that j will have the opportunity to receive these rents). Also note that ρ_j (and, thus, $\frac{\partial \rho_j R_j}{\partial s_j}$) depends on s_k. Let $\mathbf{s}_j^p(s_k)$ denote the best response correspondence of candidate j when probability of getting caught is p. Next, I examine whether $\mathbf{s}_j^p(s_k)$'s intersect with each other.

2.1 PSNE when there is no penalty, $p = 0$

Let us first consider the special case with no legal penalty for corruption, $p = 0$. This case is considerably easier to solve; it helps one to see how the electoral competition shapes the equilibrium policy.[10]

Lemma 2 *When $p = 0$, over $(t_j^*(s_j), s_j)$, $\frac{\partial \rho_j R_j}{\partial s_j}$ is (i) continuous and strictly decreas-*

[9] To find the slope, differentiate $\frac{\partial \mathbf{E}[U_i(.)]}{\partial t_j} = 0$ with respect to s_j.

[10] Moreover, the assumption that there is no penalty may not be completely unrealistic: one can think of countries in which effectively there is no legal penalty for corruption, (or, of leaders who behave as if they live in such a country.)

ing (so, the objective function, $\rho_j R_j$, is strictly quasi-concave) in s_j, (ii) continuous and strictly increasing in s_k. Further, stealing everything is never optimal for a corrupt candidate, i.e., $lim_{s_j \to t_j - w}(\frac{\partial \rho_j R_j}{\partial s_j}) = -\infty$

Lemma 2 has three implications about the (shape of the) best response correspondences: parts (i) and (ii), when combined with the Theorem of Maximum, imply that $\mathbf{s}_j^0(s_k)$ is a well defined and continuous function. Parts (i) and (ii) imply that if, for a given s'_k, we have $\frac{\partial \rho_j R_j}{\partial s_j}|_{s_j=0} < 0$, then $\mathbf{s}_j^0(s_k) = 0$ for any $s_k < s'_k$. Third, the last part of Lemma 2 shows that $\mathbf{s}_j^0(s_k)$ is always bounded from above, i.e., $\mathbf{s}_j^0(s_k) < 1 - w$.

The last part of Lemma 2 also implies that *when j steals*, his expected rents as a function of s_j has an inverse-U shape: they first increase and then decrease. An inverse-U shaped revenue curve (the Ibn Khaldun-Keynes-Laffer curve) is used to explain interior equilibrium tax rates in another, Leviathan, model of government. There are, however, some important differences.

First, the source of each curve is different. Although the Leviathan receives a constant fraction of total tax revenue, he does not impose a hundred percent (income) tax. This is because the elasticity of tax base with respect to tax rate (the wage elasticity of labor supply) is considerably high: after a certain point a one percent increase in (income) tax rate reduces the total tax revenue. In contrast, in our model no condition on the elasticity of tax base is required: in our model, a taxpayer's income, Y_i, is perfectly inelastic with respect to tax rate. What derives an interior optimum in the duopoly model is political competition.[11] Second, the relationship between the tax revenue and illegal rents are different. In the duopoly model the illegal rents are not a fixed proportion of the total tax revenue. Thus reducing the total tax revenue (for instance, by imposing constitutional constraints on the size of the public budget) does not always reduce corruption, see Evrenk (2008a, Example 1). Third, the way the curve is determined is different: in Leviathan model, there

[11]The assumption that the marginal utility of private good consumption is very high when the quantity of good consumed is very low also helps: even when k imposes hundred percent taxes (and steals all the tax revenue), by stealing a little bit less than that, j can increase ρ_j significantly.

is only one curve. in our model, when both candidates steal, each candidate has an expected revenue curve. More important, the relevant curve will be determined through the strategic interaction between the candidates. To see why, first note that in the duopoly model the corruption levels of candidates are strategic complements.

Lemma 3 *If candidate j's best response to a certain level of s_k is to steal, $\mathbf{s}_j^0(s_k) > 0$, then j's best response to a larger level of s_k is to steal even more, $\frac{\partial s_j^0(s_k)}{\partial s_k} > 0$.*

The best response function picks the s_j that maximizes $\rho_j R_j$ for a given s_k. Lemma 3 shows that if for a given s_k, candidate j steals (faces an inverse-U shaped expected rents curve), then for any $s_k' > s_k$ he steals more (he faces another such curve, and that the latter curve has a higher peak than the first one has).

When j does not steal, his expected rents are not inverse-U shaped; they decrease in s_j. Then, his best response is not to steal. Thus, if we know the shape of his expected rents curve, we can figure out the shape of his best-response function. There are only three possibilities: (i) the expected rents are always inverse-U shaped ($\frac{\partial \rho_j R_j}{\partial s_j}|_{s_j=0} > 0$ at $s_k = 0$), i.e., $\mathbf{s}_j^0(s_k)$ is strictly positive on all its domain; (ii) the expected rents are always decreasing ($\frac{\partial \rho_j R_j}{\partial s_j}|_{s_j=0} < 0$ at $s_k = 1 - w$), i.e., $\mathbf{s}_j^0(s_k)$ is flat on all its domain; and (iii) the expected rents are decreasing if the rival does not steal much, and they have an inverse-U shape if the rival candidate steals more that a certain amount ($\frac{\partial \rho_j R_j}{\partial s_j}|_{s_j=0} < 0$ at $s_k = 0$, but $\frac{\partial \rho_j R_j}{\partial s_j}|_{s_j=0} > 0$ at $s_k = 1 - w$), i.e., $\mathbf{s}_j^0(s_k) = 0$ up to a certain level of s_k, say $\widetilde{s}_k > 0$, and $\mathbf{s}_j^0(s_k) > 0$ for any $s_k > \widetilde{s}_k$.

Unless $\mathbf{s}_j^0(s_k)$ is flat at least for one candidate, there may be an interior equilibrium. The following property limits the number of interior equilibria.

Lemma 4 *If the best response functions intersect at the interior, $(s_1^*, s_2^*) \in (0, 1-w)^2$, in (s_1, s_2) space, then at the point of intersection $\mathbf{s}_2^0(s_1)$ is flatter than $\mathbf{s}_1^0(s_2)$, i.e., $\frac{\partial s_2^0(s_1^*)}{\partial s_1} < (\frac{\partial s_1^0(s_2^*)}{\partial s_2})^{-1}$.*

Figure 1 helps us to see the implications of Lemma 4 on the number of interior equilibria. In all panels of Figure 1, the darker (lighter) curve is the best response

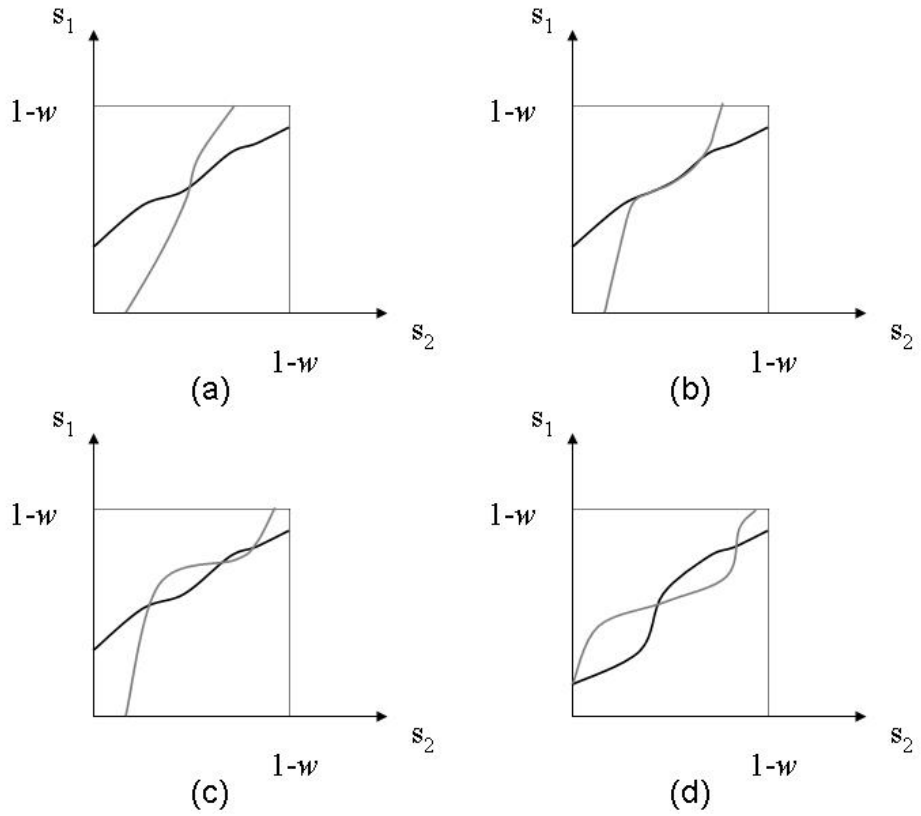

Figure 1: Lemma 4 implies that the equilibria in panels b, c, and d are not possible. (In all graphs, the darker curve is Candidate 1's best-response function.)

function for Candidate 1 (Candidate 2). In panel (a), the condition in Lemma 4 is satisfied at the single intersection point.

Panel (b) helps us to see that we cannot have infinitely many interior equilibria. Because, in that case, the best response functions must be tangent to each other over an interval (they intersect at a continuum of points). As we have $\frac{\partial s_2^0(s_1^*)}{\partial s_1} = (\frac{\partial s_1^0(s_2^*)}{\partial s_2})^{-1}$ in all of these intersection points, they would violate the condition in Lemma 4. Panel (c) helps us to see that in the interior even finitely many multiple equilibria is not possible. In the figure the best response functions intersect finitely many (three) times, and

the condition $\frac{\partial s_2^0(s_1^*)}{\partial s_1} < (\frac{\partial s_1^0(s_2^*)}{\partial s_2})^{-1}$ holds at the first and the third intersections, yet it does not hold at the second intersection in which we have $\frac{\partial s_2^0(s_1^*)}{\partial s_1} > (\frac{\partial s_1^0(s_2^*)}{\partial s_2})^{-1}$. Since the best response functions are continuous and increasing in the interior, between any intersection in which $\frac{\partial s_2^0(s_1^*)}{\partial s_1} < (\frac{\partial s_1^0(s_2^*)}{\partial s_2})^{-1}$, we should have another one in which $\frac{\partial s_2^0(s_1^*)}{\partial s_1} > (\frac{\partial s_1^0(s_2^*)}{\partial s_2})^{-1}$. Thus, as I formally prove in Appendix,

Proposition 1 *When $p = 0$, there can be at most one interior PSNE.*

Since the best response functions are continuous both in the interior and in the boundary, the same idea can be extended to any intersection of the best response functions, see panel (d) in Figure 1. Further, using the Brouwer's Fixed Point Theorem, one can show that the best response functions do intersect at least once. Combining this with Proposition 1, we have the following result.

Proposition 2 *When $p = 0$, the PSNE of the political competition game exists and it is unique.*

2.2 PSNE when there is a penalty, $p > 0$

When $p > 0$ the analysis is more complicated. Because, then, the objective function has an upward jump at $s_j = 0$, that is, $\lim_{s_j \downarrow 0} \rho_j(s_j, s_k)R_j(s_j) < \rho_j(0, s_k)R_j(0)$. When the objective function is discontinuous, the best response function is not necessarily continuous. For this case, let us define,

$$r_j(s_j) = \begin{cases} R_j(s_j) \text{ for } s_j > 0, \\ \lim_{s_j \downarrow 0} R_j(s_j) \text{ at } s_j = 0. \end{cases} \tag{3'}$$

The only difference between $R_j(s_j)$ and $r_j(s_j)$ is that the latter is continuous everywhere where the former is discontinuous at zero. Now, consider a fake objective function: $\rho_j(s_j, s_k)r_j(s_j)$. This function is strictly quasi-concave and continuous in s_j, continuous in s_k, and more important it is equal to $\rho_j(s_j, s_k)R_j(s_j)$ everywhere except at $s_j = 0$.

Next, we derive a *fake* best response function: let $\mathbf{f}_j^p(s_k)$ denote the argument of maximum of $\rho_j(s_j, s_k)r_j(s_j)$. Note that the upward jump in the objective function at $s_j = 0$ implies that the candidate will not steal a trivial amount.[12] It does *not* imply that the candidate will always stay honest. When $p > 0$ stealing a trivial amount is not profitable, but stealing a large amount still could be profitable.[13] Thus,

$$\mathbf{s}_j^p(s_k) = \begin{cases} \mathbf{f}_j^p(s_k) \text{ if } \rho_j(\mathbf{f}_j^p(s_k), s_k)R_j(\mathbf{f}_j^p(s_k)) > \rho_j(0, s_k)R_j(0) \text{ and } \mathbf{f}_j^p(s_k) > 0. \\ 0 \text{ otherwise.} \end{cases}$$

Note that, $\frac{\partial \rho_j R_j}{\partial s_j}|_{(\mathbf{s}_j^p(s_k), s_k)} = 0$ is necessary but not sufficient for $\mathbf{s}_j^p(s_k) > 0$, although it is both necessary and sufficient for $\mathbf{f}_j^p(s_k) > 0$. Also note that, as the following Lemma shows there is no hole in $\mathbf{s}_j^p(s_k)$ when it is equal to $\mathbf{f}_j^p(s_k)$:

Lemma 5 *If $\mathbf{s}_j^p(s_k) = \mathbf{f}_j^p(s_k) > 0$, then for any $s'_k > s_k$, we have $\mathbf{s}_j^p(s'_k) = \mathbf{f}_j^p(s'_k)$.*

When $\mathbf{s}_j^p(s_k)$ is not equal to $\mathbf{f}_j^p(s_k)$, then, by construction, $\mathbf{s}_j^p(s_k)$ is equal to zero. Thus, $\mathbf{s}_j^p(s_k)$ cannot have a discontinuity when it is equal to zero either. Then, the best response function can be written as

$$\mathbf{s}_j^p(s_k) = \begin{cases} \mathbf{f}_j^p(s_k) \text{ if } s_k \geqslant \underline{s}_k \\ 0 \text{ otherwise.} \end{cases}$$

In this formulation $\underline{s}_k$ is the point at which the best response function may be discontinuous, implicitly defined by $\rho_j(\mathbf{f}_j^p(\underline{s}_k), \underline{s}_k)R_j(\mathbf{f}_j^p(\underline{s}_k)) = \rho_j(0, \underline{s}_k)R_j(0)$. Only when $\underline{s}_k \in (0, 1 - w)$, the best response function is discontinuous.

The function $\mathbf{f}_j^p(s_k)$ is similar to $\mathbf{s}_j^0(s_k)$ in the sense that it comes from the maximization of a continuous and strictly quasi-concave objective function over a convex domain. Thus we can apply Lemmas 2, 3, 4 as well as Proposition 1: $\mathbf{f}_j^p(s_k)$'s are single valued, continuous in s_k, strictly increasing in the interior, with at most one

[12] Intuitively, in this case no matter how much he has stolen, a corrupt politician, when caught, will loose rents worth $y + w + \eta$, (the constant penalty and the legal rents). So, stealing any less than $(y + w + \eta)p$ makes no sense.

[13] For instance, when both (y, p, v) and (w, η) are small.

possible intersection in the interior. Thus, when $p > 0$, still, there can be at most one interior equilibrium.

Note that the best response function does not have to be discontinuous even when $p > 0$: it is possible that the penalties are so effective (ineffective) that a candidate never (always) steals no matter how much his rival steals. Then, the structure is isomorphic to that with $p = 0$, and the game has a unique PSNE. When there is a discontinuity in at least one candidate's best response function, the best response functions may intersect both at the boundary and in the interior. In both parts the function is continuous, so the intersection is unique. Thus, in this case we may have two equilibria.

Proposition 3 *When there are legal penalties for corruption, the PSNE always exists. In this case, however, the game may have (at most) two distinct equilibria. In one of these equilibria both candidates steal, and in the other one at most one candidate steals.*

2.3 Equilibrium outcomes and applications

There are three possible equilibrium outcomes: both candidates steal, *CC;* only one candidate steals, *HC;* and no agency problem (none of the candidates steal), *HH*. Using the fact that the best response functions are non-decreasing, we can define the conditions that lead to each type of outcome, see also Appendix 5.2. Since incorporated into our model $I(.)$ and $H(.)$ are also parts of the parameter space, these conditions do not give rise to closed form solutions or explicit conditions on the parameters of the model. For example, it is straightforward to show that when $p = 0$, the unique equilibrium outcome is *HH* if and only if $\mathbf{s}_j^0(0) < 0$ for both candidates; *CC* if and only if (i) $\mathbf{s}_j^0(0) > 0$ for at least one j and (ii) for $k \neq j$, we have $\mathbf{s}_k^0(\mathbf{s}_j^0(0)) > 0$; and *HC (only* j steals) if and only if $\mathbf{s}_j^0(0) > 0$ but $\mathbf{s}_k^0(\mathbf{s}_j^0(0)) = 0$. But, the key condition, $\mathbf{s}_j^0(0) \lesseqgtr 0$ cannot be simplified any more than the following

$$\frac{\theta_j}{2}+(\mathbf{E}[U((1-t_j^0)Y_i,g_j^0)-U((1-t_k^0)Y_i,g_k^0)]+2(j-\frac{3}{2})\beta)\theta_j\sigma \lesseqgtr \sigma\alpha_j H'((t_j^0-w)\alpha_j)(w+\eta).$$

Although we do not have closed form solutions, one can still apply the model to study several fiscal policy issues using the first order conditions.[14] For *HC*, the comparative statics are straightforward: generically when there is an infinitesimal change in one of the parameters of the model, only the corrupt candidate's policy platform change, and this change can easily be calculated by applying the Implicit Function Theorem on the first order conditions for this candidate,–both before and after the change, the other candidate proposes (t_j^0, g_j^0).

To calculate the effect of an infinitesimal change in a parameter, say κ, on s_j^*'s when both candidates steal, one needs to differentiate the first order conditions, $\frac{\partial \rho_j R_j}{\partial s_j}=0$, for both candidates with respect to κ. This, yields the following set of equations.

$$\begin{bmatrix} \frac{\partial^2(\rho_1^* R_1^*)}{(\partial s_1)^2} & \frac{\partial^2(\rho_1^* R_1^*)}{\partial s_1 \partial s_2} \\ \frac{\partial^2(\rho_2^* R_2^*)}{\partial s_1 \partial s_2} & \frac{\partial^2(\rho_2^* R_2^*)}{(\partial s_2)^2} \end{bmatrix} \begin{bmatrix} \frac{ds_1^*}{d\kappa} \\ \frac{ds_2^*}{d\kappa} \end{bmatrix} = \begin{bmatrix} -\frac{\partial^2(\rho_1^* R_1^*)}{\partial s_1 \partial \kappa} \\ -\frac{\partial^2(\rho_2^* R_2^*)}{\partial s_2 \partial \kappa} \end{bmatrix}$$

Using equation (7) from the proof of Lemma 4 in the Appendix, Lemma 4 can be rewritten as,

Corollary 1 *Evaluated at an interior equilibrium,* $\frac{\partial^2(\rho_j R_j)}{(\partial s_j)^2}\frac{\partial^2(\rho_k R_k)}{(\partial s_k)^2} - \frac{\partial^2(\rho_j R_j)}{\partial s_j \partial s_k}\frac{\partial^2(\rho_k R_k)}{\partial s_k \partial s_j}$ *is less than zero.*

Since it shows that the determinant of the coefficient matrix above is always negative, Corollary 1 considerably simplifies calculations for the comparative statics and it is very useful for applications.

[14]For instance, Evrenk (2008a) studies the (in)effectiveness of three commonly discussed anti-corruption policies (constitutional constraints, wage reform, and higher penalties). To calculate the effects of each policy, I first fix the type of the equilibrium outcome. Then, I calculate the effect of a change in the parameter that will be affected by each policy on the equilibrium corruption levels s_j^*'s, and (using $t_j^*(s_j^*)$ and $g_j^*(s_j^*)$) on voters welfare, $\mathbf{E}[\mathbf{W}]$.

To calculate the comparative statics in CC one needs to use the f.o.c.'s for both candidates because when both candidates steal, a change in a given parameter results in both a direct effect and an indirect effect (on equilibrium level of corruption and on fiscal policy). The indirect effect is due to strategic interaction between the candidates, and, thus, it cannot be captured by most of the other commonly used agency models which assume a continuum of competing candidates implying no strategic interaction between them.[15] To see the difference between these two effects, let us calculate the effect of a marginal increase in salary on equilibrium level of corruption in both HC and CC (which I denote below by s_2^{HC} and s_2^{CC}). To simplify the calculations, assume that the candidates are identical in both cases, except in the former, Candidate 1 is pathologically honest, $\theta_1 = 0$. Following the steps described above, one can show that

$$\frac{ds_2^{HC}}{dw} = \frac{(\theta_2 - pv)[H'(g^{HC}) - H'(g^0)] + (1 - pv)H'(g^{HC}) - R_2^{HC}H''(g^{HC})\alpha}{-(\theta_2 - pv)[H'(g^{HC}) - H'(g^0)] - (\theta_2 - pv)[H'(g^{HC}) + R_2^{HC}H''(g^{HC})\alpha}$$

$$\frac{ds_2^{CC}}{dw} = \frac{R_2^{CC}H''(g_2^{CC})\alpha}{(\theta_2 - pv)H'(g_2^{CC}) - R_2^{CC}H''(g_2^{CC})\alpha}$$

where $g_2^{HC} = (t_2^*(s_2^{HC}) - w - s_2^{HC})\alpha$, $g_2^{CC} = (t_2^*(s_2^{CC}) - w - s_2^{CC})\alpha$, and g^0 is the first-best public good level. To be able to compare the effects, let us assume that the size of the aggregate uncertainty, σ, differ in both cases so that $s_2^{HC} = s_2^{CC}$ (which implies $R_2^{HC} = R_2^{CC}$ and $g_2^{HC} = g_2^{CC}$).[16] Then, one can show that $\frac{ds_2^{CC}}{dw} > \frac{ds_2^{HC}}{dw}$, that is, the wage increase is more effective in reducing Candidate 2's equilibrium level of corruption when both candidates steal.[17] In HC, the wage increase has only a direct effect: when the legal rents increase, the office becomes more attractive. Then, to

[15] Such as Barro (1973), Ferejohn (1986), Besley and Smart (2007), and Caselli and Morelli (2006).

[16] More precisely, let us assume that $\frac{\sigma_{CC}}{\sigma_{HC}} = \frac{1}{2\rho_2^{HC}}$ where ρ_2^{HC}, the probability that the corrupt candidate wins in HC, is equal to $\frac{1}{2} + \sigma_{HC}(\mathbf{E}[I((1 - t_2^*(s_2^{HC})Y_i) - I((1 - t_2^0)Y_i)] + H((t_2^*(s_2^{HC}) - w - s_2^{HC})\alpha) - H((t_2^0 - w)\alpha))$.

[17] More formally, $\frac{ds_2^{CC}}{dw} = \frac{ds_2^{HC}}{dw} + \Delta$, where

increase the probability that he wins, the candidate proposes a better policy platform (he steals less). In CC, however, there is an indirect effect as well. The office becomes equally more attractive, yet, this is true for Candidate 1 as well: the wage increase reduces s_1^* too. Thus, to increase the probability that he wins the election, Candidate 2 needs to reduce s_2^* further. Note that the indirect effect is possible only when there is strategic interaction among candidates; when each candidate takes into account the other's level of corruption when deciding how much to steal.

In the general model, it is not possible to calculate the relative size of each effect. Using examples, one can show that the indirect effect can be large and that it can have important policy implications, see Evrenk (2008a). It is also worth noting that these two effects do not need to have the same sign, (consider for instance an increase in the candidate's popularity).

In some applications one may need to compare two distinct equilibria. Then, comparative statics are not useful.[18] For such applications, a fully solved example for $U(c,g) = c + 2\gamma\sqrt{g}$ is provided in Appendix. Although studying quasi-linear preferences allows one to obtain closed form solutions, as I discuss in the next section, these preferences have strong implications on equilibrium outcome.

3 Relation to previous literature

Using models of two candidate competition, Brennan and Buchanan (1980), Polo (1998), and Persson and Tabellini (2000) show that when there is (i) uncertainty

$$\Delta = \frac{(\theta_2 - pv)H'(g^*)[H'(g^*)((\theta_2 + 1 - 2pv) - (\theta_2 - pv)H'(g^0)] - (1 - pv)H'(g^*)R_2^*H''(g_2^*)\alpha}{[(\theta_2 - pv)(2H'(g^*) - H'(g^0)) - R_2^*H''(g^*)\alpha][(\theta_2 - pv)H'(g_2^*) - R_2^*H''(g_2^*)\alpha]}$$

is positive as both the nominator and denominator are positive.

[18] For instance, Evrenk (2008b) examines under which conditions (both corrupt and honest) politicians oppose anti-corruption reforms. When a politician decides whether to support an anti-corruption reform or not, he compares his gain (more votes in the current election) and his loss (lower rents in future) due to reform. So, to determine when a candidate supports the reform, one needs to calculate equilibrium rents before the reform (in HC or CC) and after the reform in (HH).

about the voter preferences, (ii) candidate heterogeneity, and (iii) low legal rents, politicians will steal despite repeated elections. They emphasize the ineffectiveness of repeated elections in constraining politicians. The purpose of this paper is to provide a model for policy analysis when repeated elections are not effective. In this section, I first show that the findings of the earlier studies can be considered as applications of this model in special environments. Then, I discuss what one gains by considering the more general model in this paper.

Lemma 6 *Consider an s_k to which j's best response is to steal, $\mathbf{s}_j^p(s_k) > 0$. Any of the following would increase $\mathbf{s}_j^p(s_k)$: (i) an increase in the uncertainty about popularity, $\frac{1}{\sigma}$, (ii) an increase in the expected popularity of candidate, $2(j-\frac{3}{2})\beta$, (iii) a decrease in the ability of the rival candidate, α_k, and, (iv) a decrease in ego rents, η.*

Proof. When $\mathbf{s}_j^p(s_k) > 0$, we have $\frac{\partial \rho_j R_j}{\partial s_j} = 0$. Applying the Implicit Function Theorem to this equality, the above results are obtained. ■

To my knowledge, Geoffrey Brennan and James Buchanan are the first ones to note that when there is aggregate uncertainty about vote shares, each of the two Downsian candidates have incentives to steal. Brennan and Buchanan (1980, p.27) provides an example: consider two politicians and three voters where each politician simultaneously proposes a policy on how to distribute \$300 among the three voters (if the total money allocated to the voters is less than \$300, then, he pockets the difference). Each voter and each politician cares only about how much money he will receive. The policy that receives two (out of the three) votes from voters will be implemented. Brennan and Buchanan (1980) note that a PSNE for this game does not exist: each candidate will have to propose a probabilistic policy. They do not calculate the mixed strategy equilibrium,[19] but rather they note that when each candidate's vote share is a stochastic function of his policy platform (as in a mixed

[19] Although the example is simple, to calculate the mixed strategy equilibrium is quite difficult. Recently, Szentes and Rosenthal (2003) study an isomorphic game and show that each player's equilibrium mixed strategy is characterized by the uniform density on the surface of a regular tetrahedra.

strategy equilibrium) "each party would rationally appropriate some of the $300." (p. 27).[20]

The analysis in Section 2 generalizes Polo (1998) who provides a formal agency model that allows one to study the relationship between the aggregate uncertainty about the vote shares and the incentives to steal. The differences are that in Polo (1998) there is no punishment for stealing, no ability differences between candidates, no deadweight loss of corruption (all candidates are fully corrupt, $\theta_j = 1$) and the voters' preferences are quasilinear, $I(c) = c$. As Brennan and Buchanan (1980), Polo (1998), too, assumes that there is no legal rents. He, too, finds that both candidates always steal in equilibrium.

Proposition 4 *(**Brennan and Buchanan (1980), Polo (1998)**) Suppose that candidates are identical, ($\alpha_1 = \alpha_2$, $\beta = 0$), are not pathologically honest, ($\theta > 0$), that there are no legal rents, ($w = \eta = 0$) and no punishment, $p = 0$. If there is aggregate uncertainty about vote shares, ($\frac{1}{\sigma} > 0$), then both candidates steal in the equilibrium.*

The intuition behind this result is that when there are no wages or ego rents, the only source of rents is corruption. Then, a candidate wants to win, only if he can steal after winning. Thus, a candidate who does not face any other (legal, or moral) constraints, steals. Note that if there are no legal rents, then, even the severe penalties cannot eliminate the agency problem: severe penalties guarantee that the candidate will not steal, but they do not guarantee that the candidate will choose the first-best policy.[21]

To my knowledge, Polo (1998) is also the first one to study how candidate heterogeneity affects a candidate's incentives to steal. Polo (1998, Lemma 2) shows that the agency problem may stem from popularity differences even when there is no aggregate uncertainty about vote shares. There is a technical problem with the existence

[20]Brennan and Buchanan (1980) does not pursue this example further. After noting that the Downsian competition is not always enough to restrain politicians, they model the state as a monolithic entity, Leviathan, and discuss the effectiveness of several fiscal policies using the monopoly model of government.

[21]That is, when R_j cannot exceed zero, Lemma 1 does not hold.

of the equilibrium in this case, so assume that (i) each i votes for the more popular candidate when $U_i^2 = U_i^1$, and (ii) there are N voters, where N is a very large odd number, for the following example.[22]

Example 1: Assume that $\alpha_1 = \alpha_2$, $\theta_1 = \theta_2$, $p = 0$, $\frac{1}{\sigma} = 0$, and $\beta > 0$ but very small. Then in equilibrium, the popular candidate always steals. To see why, note that since both candidates have the same ability, the first-best policy is the same for them. So, when Candidate 2 proposes the first-best policy, he wins for sure. Yet, Candidate 2 *can afford* to steal; if he steals the amount that is implicitly defined by $\mathbf{E}[U_i^2(t_2, g_2)] + \beta = \mathbf{E}[U_i^1(t^0, g^0)]$, then he wins certainly. Thus, greater popularity allows a candidate to steal.

Polo's observation helps explain the paradox that some corrupt politicians are also quite popular: politicians are not popular because they are corrupt, but rather that popular politicians can afford to be corrupt. This result can be extended to the other type of comparative advantages: such incentives still exist when the politicians differ not in terms of their popularity but in their ability or both.

In their survey of agency models, Persson and Tabellini (2000, p. 71) discuss a model based on Polo (1998), but they consider ego rents as well.[23] They show that the (identical) candidates steal in equilibrium only when the ego rents are low, $\eta < \frac{\theta}{2\sigma}$. Below, Proposition 5 shows that Persson and Tabellini (2000)'s conclusion on the effects of legal rents still holds in the more general version.[24]

Proposition 5 *(**Persson and Tabellini (2000, p.73)**) When the candidates are identical, they steal if and only if* $(w+\eta)(1-p) < py + (\theta - pv)(\frac{1}{2\sigma\alpha H'(\alpha(t(\underline{s})-w-\underline{s}))} - \underline{s})$.

[22] Technically, there is no equilibrium in pure strategies (neither in the model of Polo (1998) nor in our model) when $\frac{1}{\sigma} = 0$ and $\beta \neq 0$. Yet, these two assumptions restore the existence of equilibrium. (Polo (1998) notes the same problem. The solution he suggests is to discretize the strategy space.)

[23] Another difference is that in Polo (1998) all voters have the same income, where Persson and Tabellini (2000) consider an electorate composed of three different income groups.

[24] When $p = 0$, we have $\underline{s} = 0$. If in addition, $w = 0$, then the condition in Proposition 5 is reduced to $\eta < \frac{\theta}{2\sigma}$.

Uncertainty, candidate heterogeneity, and legal rents all affect the incentives for political corruption. However, their interaction is not always straightforward. For instance, the conclusion about the role of the uncertainty in Persson and Tabellini (2000, p.73), "...the crux of generating positive rents is thus the uncertainty about the electoral competition...," should not be interpreted as whenever one adds uncertainty into the model, the level of political corruption increases. Quite the opposite, with heterogenous candidates, aggregate uncertainty is sometimes *necessary* to stop corruption. To see why, consider again the setup in Example 1, but this time specifically assume that the legal rents are very high. Note that as long as there is no uncertainty about voter loyalty, Candidate 2 has incentives to steal no matter how high the legal rents are. Because, still, greater popularity permits a candidate to steal more without making himself inferior to the other candidate. Yet, in this case, if there exists some (but, not too much) uncertainty about Candidate 2's popularity,[25] then Candidate 2 cannot guarantee a victory with the policy in Example 1. Further, if the size of the aggregate uncertainty is large enough he cannot guarantee winning the election even when he adopts the first-best policy. Then, he proposes the first-best policy platform to increase the probability that he gets elected (and thus receives the high legal rents).

I consider a more general framework because the setup used in earlier models would give rise to some unrealistic policy recommendations when used for policy analysis.[26] For instance both Polo (1998), and Persson and Tabellini (2000) assume quasi-linear preferences. When voter preferences are quasi-linear, the best response functions are linear: we have $\frac{ds_j^0(s_k)}{ds_k} = \frac{1}{2}$ in the interior. Then, the existence and uniqueness of equilibrium can be shown easily. Yet, when $I(.)$ is linear, $\frac{dt_j^*(s_j)}{ds_j} = 1$: the only effect of corruption is excessive tax rates; the equilibrium public good levels

[25] More formally, when $p = 0$, what we need is $\mathbf{s}_2^0(0) \leq 0$ (and when $p > 0$, the condition $\mathbf{f}_2^p(0) \leq 0$ would be sufficient). This condition is equivalent to $((w + \eta)\alpha H'((t^0 - w)\alpha) - \beta\theta)\sigma < \frac{\theta}{2}$.

[26] Note, once again, that these earlier studies do not claim that they present models for policy analysis. Their emphasis is on the result that under certain conditions repeated elections are not enough to deter corruption.

are always optimal. As I note following (5), when both $I(.)$ and $H(.)$ are strictly concave, political corruption affects both components of the fiscal policy.[27]

As I discuss in Section 3, when one considers legal penalties, there may be two PSNE. The legal penalties have implications on the effectiveness of other policies as well. Evrenk (2008a) finds that when there are no legal penalties, higher salaries are always effective when both candidates steal. In a setup with legal penalties, however, this is not always true.

Another dimension that this paper differs from the earlier ones is that I consider candidates who may differ not only in their popularity but also in their ability. The assumption that the candidates have the same level of ability, too, has strong policy implications. Under this assumption, the differences in observed policy platforms has to come from corruption. That is, in equilibrium a candidate proposes a higher tax rate or a lower public good then his rival does only because he steals the difference. Then, punishing the candidate who proposes a smaller public good level, or a larger tax rate, would always be welfare increasing.

Finally I consider candidates who may face different costs of corruption. This difference allows one to study the effectiveness of policies when one of the candidates is (pathologically) honest, (as well as when it is relatively easier for one candidate to steal). Evrenk (2008a) shows that such differences, too, have policy implications: a salary reform that would be welfare-increasing when both candidates are corrupt may reduce voters' welfare when only one candidate is corrupt.

[27]Polo (1998, Proposition 6) notes that the model he studies has this unrealistic prediction. He also notes that the equilibrium public good level is not optimal when one assumes non-separable preferences. However, to study the model with general non-separable preferences is quite difficult. He, for instance, does not discuss the issues of existence and the uniqueness for this case. As Proposition 2 shows, with separable, but not quasi-linear voter preferences, the PSNE still exists and it is still unique for the case Polo (1998) studies.

4 Discussion and Conclusion

I study a duopoly model of political agency, describing competition among a small group of career politicians who may differ from each other in ability, popularity and honesty. Voters care about a candidate's ability in producing the public good; because, it affects the cost of the public good. But, they also care about some candidate characteristics that are orthogonal to fiscal policy. Then, from the point of view of voters, the candidates are not perfect substitutes. This gives candidates some type of a "market power". Then, depending on the candidate's comparative advantage, his morals, the extend of the uncertainty about the voters' preferences, and the effectiveness of legal penalties, a candidate may steal. Although the model includes several relevant features of political competition, the pure strategy Nash Equilibrium exists and the game may have at most two distinct equilibria.

I made some simplifying assumption. For instance, in the model, the probability that a corrupt politician will be punished, p, is independent of the amount he stole, s_j. The idea is that a corrupt leader may get caught as a result of an official audit (although, in countries with widespread corruption this is not very likely) or as a result of a scandal. In general, the probability that either of these will occur may depend on s_j. It is not clear, however, whether the probability that he will be *punished* increase in s_j: as s_j increases, j becomes more powerful, and he can afford to buy more allies both in judiciary and in press. Then, the probability that he will be punished may *decrease* in s_j. Since it is not clear how p would change in s_j, and since a constant p simplifies the analysis considerably, I simplify the model by assuming that p does not change in the level of corruption.

I assume that when he wins, a corrupt candidate keeps his election promises. Given that the election occurs only once in our model, one may wonder, why a corrupt candidate does not steal all he can when he can. The one period game studied here should be considered as the stage game of a dynamic model with reputation. Evrenk (2008b) studies a simplified but infinitely repeated version of this game and proves

that as long as the present value of the future rents of a corrupt candidate is not too low, he has incentives to keep his election promises.

Finally, I note that a corrupt candidate may need to share his illegal rents with others, $\theta_j < 1$, but I do not model the complicated multi-person bargaining that would occur between the politician and the other actors (the businessman, the middleman, the members of judiciary) involved in political corruption. Without modelling this complicated bargaining part, one may still consider a model in which j decides how many public contracts to award to his friends. Then, j knows that these friends charge the government the competitive price plus a "mark-up", and to thank this profitable opportunity they transfer a fraction of their profit to j's account in a foreign bank that. This version of the model may seem closer to the actual corruption in several countries, but (unless one models the interaction between the politician and the other actors) the structure, and thus the results, would be identical to the model studied here.[28]

Both the fiscal policy and equilibrium level of corruption are determined endogenously in the model, so it can be used to study several policy issues.[29] Evrenk (2008a and 2008b) provide some applications of this model. It can also be considered as a model of candidate effort, where s_j denotes shirking. Then, it can be used to study the supervision of a utility maximizing bureaucracy by politicians as in Svensson (2000).

In this paper I assume that the voters are equally influential and equally well informed, that there are no special interest lobbies, and that candidates do not have any policy preferences. Under these assumptions, a candidate does not adopt the first-best policy only when he steals. It is well known that political corruption is not the only reason for inefficient policies. By removing some of these assumptions, one may study the equilibrium when there several reasons for inefficient policies coexist.

[28]Except, in the alternative model there would be more parameters.

[29]Besley (2006) provides several examples of policy issues that one can study using an agency model.

Such extensions seems especially feasible as these issues, too, has been studied using the same framework that I use here: two-candidate simultaneous move competition with probabilistic voting.[30] These extensions are left for future research.

5 Appendix

5.1 Proofs

Proof of Lemma 2. For (i), note that $\frac{\partial \mathbf{E}[U(c_i^j,g_j)]}{\partial g_j}$ is continuous in both t_j and s_j. When $p=0$, $R_j(s_j)$ is continuous in s_j as well. Also note that when s_j increases, ρ_j decreases, $R_j(.)$ increases, and, since $\frac{\partial t_j^*(s_j)}{\partial s_j} < 1$, $\frac{\partial \mathbf{E}[U(c_i^j,g_j)]}{\partial g_j}$ increases, thus the objective function is quasi-concave.

For (ii), simply note that $\mathbf{E}[U(c_i^k,g_k)]$ and thus ρ_j is continuous in s_k with $\frac{\partial \rho_j}{\partial s_k} = -H'((t_k-w-s_k)\alpha_k)\sigma\alpha_k < 0$.

Finally, note that $\frac{\partial [H((t_j-w-s_j)\alpha_j)]}{\partial s_j} = -H'((t_j-w-s_j)\alpha_j)$. Thus, $\lim_{s_j \to t_j-w}(\frac{\partial \rho_j R_j}{\partial s_j}) = -\infty$ directly follows from our assumption that $H'(0)$ converges to infinity. ■

Proof of Lemma 3. Fix s_k. If $\mathbf{s}_j^0(s_k) > 0$, then, by definition, $\frac{\partial \rho_j R_j}{\partial s_j}|_{(\mathbf{s}_j^0(s_k),s_k)} = 0$. Applying the Implicit Function Theorem, we find

$$\frac{\partial \mathbf{s}_j^0(s_k)}{\partial s_k} = \frac{-\frac{\partial^2 \rho_j R_j}{\partial s_j \partial s_k}}{\frac{\partial^2 \rho_j R_j}{(\partial s_j)^2}} = \frac{z_{jk}}{2z_{jj} + \alpha_j R_j \frac{\partial^2 \mathbf{E}[U(c_i^j,g_j)]}{(\partial g_j)^2}(\frac{\partial t_j^*(s_j)}{\partial s_j} - 1)}. \tag{7}$$

where $z_{jk} = \theta_j \alpha_k \frac{\partial \mathbf{E}[U(c_i^k,g_k)]}{\partial g}$ and $z_{jj} = \theta_j \alpha_j \frac{\partial \mathbf{E}[U(c_i^j,g_j)]}{\partial g}$. Since $H(.)$ is strictly concave, we have $\frac{\partial^2 \mathbf{E}[U(c_i^j,g_j)]}{(\partial g)^2} < 0$. Finally, (5) implies that $\frac{\partial t_j^*(s_j)}{\partial s_j} < 1$. Thus, $\frac{\partial \mathbf{s}_j^0(s_k)}{\partial s_k} > 0$. ■

Proof of Lemma 4. Assume that $\frac{\partial s_j^0(s_k^*)}{\partial s_k} > (\frac{\partial s_k^0(s_j^*)}{\partial s_j})^{-1}$. Then by (7), we should have $\frac{z_{jk}z_{kj}}{4z_{jj}z_{kk}+Z} \geq 1$ where $z_{jk}z_{kj} = z_{jj}z_{kk}$ and $Z \geq 0$. Contradiction. ■

Proof of Proposition 1. First, note that by Implicit Function Theorem $\frac{\partial \mathbf{s}_j^0(s_k)}{\partial s_k}$ is well

[30] Such studies include policy formation when there are lobbies (Baron, 1994; Grossman and Helpman 1994, 2001); equilibrium fiscal policy when voters differ in their influence and the elasticity of taxable income, (Warskett, Hettich, and Winer 1998); and fiscal policy when policymakers have (partisan) preferences over the fiscal policy (Roemer, 2001).

defined everywhere in the interior. Second, note that for each j, $\mathbf{s}_j^0(s_k)$ is a continuous function. Assume that $\mathbf{s}_j^0(s_k)$'s, which are increasing in the interior, intersect more than once in the interior. Then, by continuity, we should have $\frac{\partial s_j^0(s_k^*)}{\partial s_k}\frac{\partial s_k^0(s_j^*)}{\partial s_j} \geq 1$ in one of these intersections. Contradiction. ■

Proof of Proposition 2. Each $\mathbf{s}_j^0(s_k)$ is continuous and maps $[0, 1-w]$ to itself. Thus, by Brouwer's Fixed Point Theorem, an equilibrium in pure strategies exists.

For uniqueness first note that by Proposition 1, we know that there is at most one interior equilibrium. The idea behind Proposition 1 can be extended to intersections at the boundary, but we first need to show that $\mathbf{s}_j^0(s_k)$ is differentiable at the boundary. When $\mathbf{s}_j^0(s_k) > 0$ everywhere, or when $\mathbf{s}_j^0(s_k) = 0$ everywhere, it is differentiable everywhere, (in the first case this follows from the Implicit Function Theorem, and in the second case it is simply because $\frac{\partial s_j^0(s_k)}{\partial s_k} = 0$ everywhere. But if $\widetilde{s_k} \in (0, 1-w)$, then $\mathbf{s}_j^0(s_k)$ may have a kink at $\widetilde{s_k}$ (we can use the Implicit Function Theorem for $s_k > \widetilde{s_k}$, and we know that $\mathbf{s}_j^0(s_k) = 0$ for $s_k < \widetilde{s_k}$, but at at $\widetilde{s_k}$ nothing guarantees that the directional (one-sided) derivatives are equal to each other). Nevertheless, we can still sign the directional derivatives at $\widetilde{s_k}$: the right-sided derivative (derived from $\frac{\partial \rho_j R_j}{\partial s_j} = 0$) is strictly positive, and the left-sided derivative (when $\frac{\partial \rho_j R_j}{\partial s_j} < 0$) is zero.

To establish uniqueness, we first note that there cannot be more than one corner equilibria. Since the best response functions are bounded from above, if a corner equilibrium exists, then this should be an equilibrium in which at least one candidate does not steal. If neither candidates steal, the slope of each best response function is zero with respect to *different* axes, so they can intersect at most once. And if only one candidate, say j, steals, then at the equilibrium $\mathbf{s}_j^0(s_k) > 0$. Then, Lemma 3 implies that $\mathbf{s}_j^0(s_k)$ does not go back to the boundary. Thus, we cannot have more than one corner equilibrium.

Lastly, I claim that the game cannot have both a corner equilibrium and a strictly interior equilibrium. To see why, suppose that there exist one corner equilibrium and one interior equilibrium. Note that in a corner equilibrium generically

$\frac{\partial s_j(s_k^*)}{\partial s_k}\frac{\partial s_k(s_j^*)}{\partial s_j} = 0$. In the non-generic case, where both reaction functions have non-zero slope, Lemma 4 applies, thus $\frac{\partial s_j(s_k^*)}{\partial s_k}\frac{\partial s_k(s_j^*)}{\partial s_j} < 1$ (where I consider the right sided derivatives). However, also by Lemma 4, in the interior equilibrium we have $\frac{\partial s_j(s_k^*)}{\partial s_k}.\frac{\partial s_k(s_j^*)}{\partial s_j} < 1$. In the non-generic case, both reaction functions are differentiable between the two equilibria, thus the intuition behind Proposition 1 applies. That is, for two such equilibria to exist, there should be a second interior equilibrium between the corner equilibrium and the interior equilibrium, *and* at that second interior equilibrium we should have $\frac{\partial s_j(s_k^*)}{\partial s_k}\frac{\partial s_k(s_j^*)}{\partial s_j} \geq 1$. This, however, contradicts Lemma 4. In the generic case, as we discuss above $\frac{\partial s_j(s_k)}{\partial s_k}$ may not be defined at $\widetilde{s_k}$. However, since this is a boundary point and since we have shown that there cannot be two corner equilibria, whether the derivative exists at this point or not does not matter. As long as the reaction function is continuous, one can apply the same argument that we provided for the non-generic case. Thus, when $p = 0$, there is a unique equilibrium. ■

Proof of Lemma 5. We need to show that $\mathbf{s}_j^p(s_k) = \mathbf{f}_j^p(s_k)$ for some s_k with $\mathbf{f}_j^p(s_k) > 0$ implies that $\rho_j(\mathbf{f}_j^p(s_k'), s_k)R_j(\mathbf{f}_j^p(s_k')) > \rho_j(0, s_k')R_j(0)$ for any $s_k' > s_k$. Take any s_k where $\rho_j(\mathbf{f}_j^p(s_k), s_k)R_j(\mathbf{f}_j^p(s_k)) \geq \rho_j(0, s_k)R_j(0)$. Let us note that both sides are continuously differentiable in s_k and consider an infinitesimal increase. The increase in l.h.s. is equal to $l = ds_k([\frac{\partial \mathbf{E}[U_i^j]}{\partial s_j}\frac{\partial s_j^f(s_k)}{\partial s_k} - \frac{\partial \mathbf{E}[U_i^k]}{\partial s_k}]\sigma R_j(\mathbf{f}_j^p(s_k)) + (\theta_j - pv)\frac{ds_j^f(s_k)}{ds_k}\rho_j(\mathbf{f}_j^p(s_k), s_k)) > 0$. The increase in r.h.s. is equal to $r = ds_k\frac{\partial \mathbf{E}[U_i^k]}{\partial s_k}\sigma R_j(0) > 0$. Thus, we need to show that $l - r > 0$. Note that $\mathbf{f}_j^p(s_k) > 0$, implies that $\frac{\partial \mathbf{E}[U_i^j]}{\partial s_k}\sigma R_j(\mathbf{f}_j^p(s_k)) + (\theta_j - pv)\rho_j(\mathbf{f}_j^p(s_k), s_k) = 0$. Thus $l - r = ds_k[\frac{\partial \mathbf{E}[U_i^k]}{\partial s_k}\sigma R_j(0) - \frac{\partial \mathbf{E}[U_i^k]}{\partial s_k}\sigma R_j(\mathbf{f}_j^p(s_k), s_k)]$. Staying honest would increase the probability of winning the election, i.e., $\rho_j(\mathbf{f}_j^p(s_k), s_k) < \rho_j(0, s_k)$. Then, $\rho_j(\mathbf{f}_j^p(s_k), s_k)R_j(\mathbf{f}_j^p(s_k)) \geq \rho_j(0, s_k)R_j(0)$ implies that $R_j(\mathbf{f}_j^p(s_k)) > R_j(0)$. Hence $l - r > 0$. ■

Proof of Proposition 3. As we discuss in Section 3.2, $\mathbf{s}_j^p(s_k)$'s can intersect at most once in the interior. Similarly, one can show that there can be at most one corner equilibrium, (and, by definition, in this corner equilibrium at most one candidate

steals). The only difference occurs when the best response function is discontinuous. In this case, there can be both a corner and an interior equilibria: following a corner equilibrium in which, say, $\mathbf{s}_2^p(s_1)$ is steeper than $\mathbf{s}_1^p(s_2)$, the game may have an interior equilibrium in which again $\mathbf{s}_2^p(s_1)$ is steeper than $\mathbf{s}_1^p(s_2)$. This is because at the point of discontinuity $\mathbf{s}_1^p(s_2)$ may fall below $\mathbf{s}_2^p(s_1)$, –or $\mathbf{s}_1^p(s_2)$ may jump above $\mathbf{s}_2^p(s_1)$. Thus, at the equilibrium we still have $\frac{\partial s_j^p(s_k^*)}{\partial s_k} < (\frac{\partial s_k^p(s_j^*)}{\partial s_j})^{-1}$ ■

Proof of Proposition 4. Under the above conditions, $R_j = \theta s_j$. Then, the marginal expected rents from stealing is positive even when the other candidate does not steal, $\frac{\partial \rho_j R_j}{\partial s_j}|_{s_j=0,s_k=0} = \frac{\theta}{2} > 0$. Thus, in the (unique) equilibrium both candidates steal. ■

Proof of Proposition 5. Note that in symmetric case, both candidates steal in equilibrium ($s^* > 0$) if and only if $s^p(\underline{s}) > \underline{s}$. Since (6) holds with equality at $s^* > 0$, this condition can be written as $(w+\eta)(1-p) < py + (\theta - pv)(\frac{1}{2\sigma\alpha H'(\alpha(t(\underline{s})-w-\underline{s})} - \underline{s})$. ■

5.2 A fully solved example with quasi-linear preferences

Assume that $U(c,g) = c + 2\gamma\sqrt{g}$ where $\gamma > (\min\{\alpha_1, \alpha_2\})^{-\frac{3}{2}}$. Let $\Delta_j = \gamma^2(\alpha_j - \alpha_k) + 2(j - \frac{3}{2})\beta$ denote the relative advantage of Candidate j, and let λ_j^p denote the amount of illegal rents that are payoff equivalent to Candidate j's legal rents when probability of getting caught is p, i.e., $\lambda_j^p = \frac{(1-p)(w+\eta)-py}{\theta_j - pv}$. Since quasi-linear preferences do not satisfy our assumption that $I'(0)$ converges to infinity, stealing everything could be a best response, –the last part of the Lemma 2 does not need to apply. To rule out an equilibrium outcome with hundred percent taxes, I assume that neither the overall uncertainty nor one candidate's relative advantage is too high. More formally, for each $j \in \{1,2\}$, we have $\frac{3}{4}\sigma + 2\Delta_j + \gamma^2(\alpha_j + \alpha_k) - (w+\eta)(\frac{1}{\theta_j} + \frac{1}{2\theta_k}) < \frac{3}{2}$. To save some space, below, I report only the Nash Equilibrium corruption levels. From these levels, one can easily calculate equilibrium fiscal policy platforms as $t_j^* = \gamma^2 a_j + w + s_j^*$ and $g_j^* = (\gamma a_j)^2$

When $p = 0$, it is straightforward to show that $\mathbf{s}_j^0(s_k) = \max\{0, \frac{1}{4\sigma} + \frac{s_k}{2} + \frac{\Delta_j}{2} - \frac{\lambda_j^0}{2}\}$.

Further, $\mathbf{s}_j^0(0) > 0$ if and only if

$$w + \eta < \frac{\theta_j(1 + 2\Delta_j\sigma)}{2\sigma}, \tag{8}$$

and $\mathbf{s}_k^0(\mathbf{s}_j^0(0)) > 0$ if and only if

$$w + \eta < \frac{\theta_k\theta_j}{2\sigma(\theta_k + 2\theta_j)}(3 + 2\sigma\Delta_k). \tag{9}$$

Thus,

(i) each $j \in \{1, 2\}$ steals $\frac{1}{2\sigma} + \frac{\Delta_j}{3} - \frac{1}{3}(2\lambda_j^0 + \lambda_k^0)$ if and only if (8) holds for at least one j, and (9) holds for $k \neq j$.

(ii) candidate j steals $\frac{1}{4\sigma} + \frac{\Delta_j}{2} - \frac{\lambda_j^0}{2}$, and k does not steal if and only if (8) holds for $j \in \{1, 2\}$, and (9) does not hold for $k \neq j$.

(iii) neither candidate steals if and only if (8) does not hold for any $j \in \{1, 2\}$.

When $p > 0$, one can show that $\mathbf{s}_j^p(s_k) = \begin{cases} \mathbf{f}_j^p(s_k) \text{ if } s_k \geqslant \underline{s}_k \\ 0 \text{ otherwise.} \end{cases}$, where, $\mathbf{f}_j^p(s_k) = \max\{0, \frac{1}{4\sigma} + \frac{s_k + \Delta_j - \lambda_j^p}{2}\}$ and $\underline{s}_k$ is equal to

$$\frac{-1}{2\sigma} - \Delta_j + \lambda_j^p + \frac{2}{\theta_j - pv}[p(w + \eta + y) + \sqrt{(w + \eta)p(w + \eta + y)}]. \tag{10}$$

Note that $\mathbf{f}_j^p(0) > 0$ if and only if

$$(w + \eta)(1 - p) - py < \frac{(\theta_j - pv)(1 + 2\Delta_j\sigma)}{2\sigma}, \tag{11}$$

and $\mathbf{f}_j^p(.)$'s have an interior intersection only if (i) (11) holds for one j, *and* (ii) for $k \neq j$ we have $\mathbf{s}_k^f(\mathbf{f}_j^p(0)) > 0$, that is,

$$(w + \eta)(1 - p) - py < \frac{(\theta_j - pv)(\theta_k - pv)}{2\sigma((\theta_k - pv) + 2(\theta_j - pv))}(3 + 2\sigma\Delta_k) \text{ for } k \neq j \tag{12}$$

The game has a unique equilibrium either when (11) does not hold for any j (in

which case both candidates stay honest), or when $\underline{s}_k < 0$ for both $k \in \{1,2\}$ in which case each j steals[31]

$$\frac{1}{2\sigma} + \frac{\Delta_j}{3} - \frac{1}{3}(2\lambda_j^p + \lambda_k^p). \tag{13}$$

The game may have multiple equilibria when $\underline{s}_k > 0$ for at least one candidate, i.e., when there is a discontinuity in at least one candidate's best response function. When this is the case for both candidates, i.e. when (10) is larger than zero for both $j \in \{1,2\}$, there are two possibilities:

(i) If (11) holds for some $j \in \{1,2\}$ and (12) holds for $k \neq j$, then the number of equilibria depends on whether (10) is less than (13) or not. There is a single equilibrium (neither candidate steals) when (10) is larger than (13) for at least one j. There are two equilibria (in one of the equilibria neither candidate steals, and in the other each j steals the quantity given at (13)) when (10) is less than (13) for both j.

(ii) If (11) holds for some $j \in \{1,2\}$, but (12) does not hold for $k \neq j$, then in the unique equilibrium none of the candidates steal.

The last possibility is that $\underline{s}_k > 0$ only for one $k \in \{1,2\}$. To make the presentation clearer assume, without loss of generality, that $\underline{s}_1 > 0$ and $\underline{s}_2 \leqslant 0$ (the analysis for $\underline{s}_2 > 0$ and $\underline{s}_1 \leqslant 0$ is fully symmetric). Below, I write $(13)_j$ to mean (13) evaluated for candidate j. First, note that if $\underline{s}_2 < 0$, then we have $\mathbf{s}_1^f(0) > 0$. Second, we need to check whether (12) holds for $j = 2$ or not:

(i) If (12) does not hold for $j = 2$, then, as we are studying the case in which $\underline{s}_1 > 0$, in the unique equilibrium $s_1^* = \frac{1}{4\sigma} + \frac{\Delta_1}{2} - \frac{\lambda_1^p}{2}$ and $s_2^* = 0$.

(ii) If (12) holds for $j = 2$, then the $\mathbf{f}_j^p(s_k)$'s have interior intersection. Then, we need to check whether $\underline{s}_1 \leq s_1^f(0)$ or not. The game has a unique interior equilibrium in which each j steals $\frac{1}{2\sigma} + \frac{\Delta_j}{3} - \frac{1}{3}(2\lambda_j^p + \lambda_k^p)$ if and only if $\underline{s}_1 \leq s_1^f(0)$. When $\underline{s}_1 > s_1^f(0)$ there are two possibilities:

(a) $s_1^* = \frac{1}{4\sigma} + \frac{\Delta_1}{2} - \frac{\lambda_1^p}{2}$ with $s_2^* = 0$, and $s_j^* = \frac{1}{2\sigma} + \frac{\Delta_j}{3} - \frac{1}{3}(2\lambda_j^p + \lambda_k^p)$ for $j \in \{1,2\}$

[31]Note that $\underline{s}_k < 0$ implies that $s_j^p(0) > 0$

are both PSNE if and only if $(13)_2 \geq \underline{s}_1$,

(b) there is a unique equilibrium in which $s_1^* = \frac{1}{4\sigma} + \frac{\Delta_1}{2} - \frac{\lambda_1^p}{2}$ and $s_2^* = 0$ if and only if $(13)_2 < \underline{s}_1$.

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