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By

Sugato Dasgupta

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ABSTRACT

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This dissertation analyzes the efficiency of the electoral mechanism. Two distinct-but-related topics are addressed in the three chapters.

Chapters one and two investigate the issue of electoral accountability. In the presence of informational advantages for candidates, we investigate whether the threat of electoral sanction provides sufficient incentive for candidates to comply with voter demands. Using formal principal-agent models that combine adverse selection and moral hazard elements, the theoretical possibility of candidate accountability is demonstrated. The theoretical conclusions are buttressed with evidence from a series of laboratory experiments.

In chapters one and two, rules governing all social interactions are exogenous; that is, they are taken as given. In contrast, chapter three constructs a formal model that endogenizes rules. In brief, we posit that political parties in power establish rules so as to confer benefits upon their constituents. We ask the following questions: What determines the nature of the rules in place? When are they flexible and what makes them rigid? We adopt, furthermore, a comparative perspective and contrast polities in a parliamentary system with those in a separation-of-powers system. A surprising mathematical result is proved -- rules generated in the parliamentary system are more flexible than those produced by the separation-of-powers system.

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Finally, I want to thank my family -- Baba, Ma, Sona, Dola and Padmanabh -- for years of love and support. Despite the physical separation, my mental world has always been filled with their laughter and their tears.

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1. CHAPTER 1: EFFICIENCY IN A MODEL OF ELECTIONS WITH MORAL HAZARD – SOME EXPERIMENTAL EVIDENCE

1.1. Introduction

In a well-functioning representative democracy, elected public officials serve to implement some notion of the "collective will." Periodic elections are the mechanism by which the electorate disciplines these public officials. In essence, irrespective of the extent of divergence between the innate interests of the public and the elected officials, the threat of electoral defeat provides sufficient incentive for the latter to comply with popular demands. Nevertheless, the degree to which electoral incentives constrain the behavior of public officials is debatable.

As Austen-Smith and Banks (1989) observe, in an ideal world of complete information, effective accountability can be easily achieved. The presence of incomplete information on the part of voters substantially weakens the power of electoral control. Informational asymmetries arise for at least two reasons. First, since public officials specialize in the day-to-day tasks of government, they are g to

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privy to more information than the voters. Second, even if all pertinent information is readily available, rational voters acquire information only if the incremental benefit exceeds the resource cost of its acquisition. Since each voter is a small percentage of the population, the probability of casting a decisive vote is miniscule. Thus, the value of information is close to zero and voters choose to remain rationally ignorant (e.g., Downs (1957) and Ferejohn (1990)).[1] If informational asymmetries characterize all real-world democracies, then the appropriate policy question becomes: how does the quality of available information affect a representative democracy?

Researchers have examined this question by constructing abstract election models that acknowledge, in varying detail, the presence of informational frictions between voters and potential candidates. Theoretical discussions subdivide into two camps: Barro (1973), Ferejohn (1986), and Austen-Smith and Banks (1989) consider informational problems from a moral hazard (hidden action) perspective; Rogoff and Sibert (1988), Alesina and Cukierman (1990), Reed (1990), Rogoff (1990), Harrington (1993), and Banks and Sundaram (1993) consider informational problems from an adverse selection (hidden types) point of view. By

[1] We should note, however, that within a rational choice framework, Ledyard (1986) and Palfrey and Rosenthal (1985) demonstrate that a single vote may be more relevant than is generally believed.

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computing a model's equilibrium, the theoretical exercises investigate the effect of information in an election environment.

The theoretical literature provides intuition regarding the performance of democratic systems when information is of poor quality but the predictive validity of such models is difficult to ascertain. In fact, electoral outcomes are without exception dependent on variables such as information structure, utility function characteristics, and the values of rewards and punishments. Yet, data seldom provide even error-laden measures of these variables.[2] Therefore, we adopt a different stance. First, we construct a model of elections that incorporates informational frictions between the elected public officials and the electorate. Second, we evaluate the theoretical model using experimental techniques. Within the structured environment of a laboratory, it is relatively simple to both induce and systematically control the values of the parameters of interest. This capacity for variation allows for a thorough consistency-check of the theory.[3]

The theoretical setup involves an infinite horizon model of elections comprised

[2]A large empirical literature tests the reduced form comparative static predictions of theoretical political-agency models. Examples include Kalt and Zupan (1990), Lott and Davis (1992), Lott and Bronars (1993), and Besley and Case (1995a, and 1995b).

[3]We are not arguing that experimental methods are intrinsically superior to non-experimental methods. Rather, they are a valid tool for testing theory when naturally occuring data is of dubious quality. The close relationship between experimental evidence and innovative field studies is explored in Roth (1991).

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of two candidates and an electorate of homogeneous voters. In each period, the incumbent candidate for that period selects an effort level from a choice set. Effort, for example, can take the form of time spent drafting legislation, casework solicitation and accessibility to constituents. One feature of effort is that only a fraction of the electorate will be cognizant of how much effort the incumbent expends (e.g., Stokes and Miller (1962) and Abramowitz (1980)). In sum, there is a significant moral hazard component to effort.[4]

In our model, voters estimate the effort level of the incumbent by examining the realized output (i.e., what projects or policies the incumbent has actually produced). We model output as being probabilistically dependent on the effort expended. Consistent with the principal-agent literature, larger effort levels produce better output realizations on average.[5] We emphasize that when interpreting the performance of the incumbent, the electorate never directly observes the effort level. Rather, since effort level and realized output are correlated, ex post performance conveys some information to voters about the incumbent's diligence in office.

The root of the principal-agent problem is as follows. Effort undertaken by

[4]For an exposition of moral hazard models, the reader is referred to Holmstrom (1979) and Grossman and Hart (1983).

[5]The need to model "good" output realizations as likely signals of "high" effort is explicitly recognized by Milgrom (1981).

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the incumbent is privately costly in terms of resources expended (e.g., time). Therefore, output levels preferrable to the voter impose higher costs on the incumbent candidate. How, then, can the incumbent be induced to expend costly and unobservable effort? Electoral control is partially accomplished by using the office-holder's ambition to discipline her. Specifically, since the incumbent derives private benefit from holding office, expending effort becomes rational should voters reward "good" performance by reelecting the incumbent and punish "poor" performance by electing the opposing candidate. In sum, the institutional structure of repeated elections provides the electorate with an incentive device with which to mitigate the informational advantages of the elected public official.[6]

For the model sketched above, we provide some theoretical guidance regarding likely electoral outcomes. Given our multi-player, repeated-interactions environment, there exists an abundance of sequential equilibria. For the purposes of sharper predictions, we focus on the set of symmetric and stationary sequential equilibria. Our theoretical predictions fall into two categories. First, we prove the existence of a continuum of symmetric, stationary sequential equilibria and we explicitly compute an upper bound on the amount of effort that can be elicited from

[6]Our formal model is similar to that of Ferejohn (1986). Voters in Ferejohn's model confront a moral hazard problem: they observe incumbent candidates' actions with some noise. However, unlike our setup, incumbent candidates in Ferejohn's model know the consequences of their actions with certainty: they observe the realizations of noise prior to action choices.

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candidates. We interpret the "effort upper bound" as representing the maximal feasible efficiency of the elections model. Second, holding constant the behavior of voters, we find that a candidate's effort level is an increasing function of 1) the private benefit of holding office, 2) the rate of time discounting, and 3) the productivity of candidate effort.[7]

To test the predictions of the model, we conducted a series of laboratory experiments. The experimental sessions were of two sorts. In one-shot sessions, with the composition of the electorate held fixed, each pair of candidates participated in only a single election. By contrast, in the repeated-interactions sessions, the same two candidates participated in a series of structurally identical elections. Across both session-types, we varied two parameters of interest: 1) the private benefit of holding office; and 2) the productivity of candidate effort.

The data are consistent with the theoretical predictions of the baseline model. Our principal findings are twofold. First, given the absence of reelection pressure, candidates in one-shot sessions were unwilling to expend nonnegligible levels of effort. Second, in repeated-interactions sessions, average candidate effort was increasing with respect to both the private benefit of office and the productivity

[7]Productivity of candidate effort is defined as follows. We exogenously increase candidate effort at the margin and we let productivity be the associated increase in the probability with which "better" electoral outcomes obtain.

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of effort. In sum, candidates exhibited behavioral patterns that were sharply responsive to incentives implicit in the theoretical setup.[8]

The remainder of this chapter is organized as follows. In section 1.2 we describe the experimental model. Section 1.3 provides the analytical solution to the experimental model. The experimental design for our empirical tests is in section 1.4 and the results are described in section 1.5. Section 1.6 concludes the chapter from a substantive perspective. All theoretical proofs are relegated to section 1.7 while tables presenting the empirical results are gathered in Appendix A.

1.2. The Experimental Model

The model explores the interaction between two candidates, denoted by $K \equiv \{A, B\}$, and an electorate of n voters, denoted by $N \equiv \{1, 2, ..., n\}$. The interaction spans an infinite sequence of structurally identical periods. Each period consists of three phases. In phase one, the incumbent candidate for that period selects an effort level from a choice set. In phase two, voters and the two candidates receive payoffs. In phase three, an election determines whether the incumbent candidate is reelected. A description of the three phases follows.

[8] Several researchers in experimental economics have investigated the impact of repeated interactions in ameliorating various enforcement problems implicit in one-shot games. Examples include Palfrey and Rosenthal (1992), Feinberg and Husted (1993), and Davis and Holt (1994).

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1.2.1. Phase One — Incumbent Candidate's Effort Choice

Each period, $t \in Z_{+}$, begins with a candidate already in office. We refer to the current office-holder as the period-t incumbent candidate and we term the remaining candidate as the period-t challenger. Unobserved by either the electorate or her challenger, the period-t incumbent candidate selects an effort level, denoted e_t, from the set $E \equiv [0, 1)$.

Once e_t is chosen, an output, denoted y_t, is stochastically generated from the two-point set $Y \equiv \{y_L, y_H\}$, where $y_H > y_L > 0$. The following three assumptions are imposed on the output generation process.

[A.1] Probability$\{y_t = y_H \mid e_t\} = \pi_L + e_t \times (\pi_H - \pi_L)$.

[A.2] Probability$\{y_t = y_L \mid e_t\} = (1 - \pi_L) - e_t \times (\pi_H - \pi_L)$.

[A.3] $\pi_H \geq \pi_L$ and $\pi_i \in [0, 1]$, $i \in \{L, H\}$.

In the above notation, "Probability$\{y_t = y_i | e_t\}$" represents the probability that the period-t output is y_i ($y_i \in \{y_L, y_H\}$) when the period-t effort is e_t. π_H, π_L are two arbitrarily chosen numbers from the unit interval such that π_H weakly exceeds π_L. Assumptions [A.1] and [A.2] jointly ensure that: Probability$\{y_t = y_H \mid e_t\}+$ Probability$\{y_t = y_L \mid e_t\} = 1$. Thus, subsequent to the choice of e_t, the ensuing output must equal either y_L or y_H.

The three assumptions assert that, as the effort level rises, there is a corre-mi

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sponding increase in the probability that the realized output is the superior outcome (y_H). Specifically, observe that: ∂ [Probability$\{y_t = y_H \mid e_t\}]/\partial\, e_t = (\pi_H - \pi_L) \geq 0$.

In unambiguous terms, [A.1] - [A.3] define the productivity of candidate effort. We measure productivity by the increase in the probability of generating y_H corresponding to an exogenous unit increase in the effort level (i.e., ∂ [Probability$\{y_t = y_H \mid e_t\}]/\partial\, e_t$). Since ∂ [Probability$\{y_t = y_H \mid e_t\}]/\partial\, e_t$ equals $(\pi_H - \pi_L)$, note that candidate effort is more productive as $(\pi_H - \pi_L)$ is raised.

1.2.2. Phase Two — Payoffs of Players

We now describe the period-t payoffs of the players in the model. The period-t payoff of each voter $i \in N$ is set to y_t. By endowing voters with identical preferences, all aspects of preference heterogeneity are abstracted away.[9] The period-t payoff of the period-t challenger is set to 0. Since the period-t challenger undertakes no task, the normalization is without loss of generality. Finally, the period-t payoff of the period-t incumbent candidate is given by $(B - k \times [\frac{e_t^2}{2}])$, where $B > 0$ and $k > 0$. The incumbent candidate's payoff is comprised of two components: the private benefit of office, summarized by B, and the private cost

[9]For a general discussion of the effects of preference heterogeneity, the reader is referred to Ferejohn (1986).

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of choosing effort e_t (i.e., $k \times [\frac{e_t^2}{2}]$).

The chosen payoff functions highlight the principal-agent problem. As the effort level, e_t, is raised, both the probability of generating y_H and the private cost borne by the period-t incumbent candidate increase. Therefore, the electorate and the period-t incumbent candidate have diametrically opposed preferences over the set E. The electorate's (incumbent candidate's) current payoff is maximized when e_t is chosen to be the largest (smallest) value in E.

1.2.3. Phase Three — Election Outcome

Once voters receive their period-t payoffs, they cast their ballots and decide whether to retain the period-t incumbent candidate. Following the vote, period t concludes.

The majority winner of the period-t election is assigned to be the period-$(t+1)$ incumbent candidate. The sequence of events in period $(t+1)$ replicates that of period t.

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1.3. Experimental Predictions

In this section, we develop the predictions which logically follow from the model.[10] The section is organized as follows: First, we formally define a sequential equilibrium of the model. Second, we refine the sequential equilibrium by imposing stationarity and symmetry conditions. Third, we state and briefly discuss the principal predictions that follow from the model's solution.

1.3.1. Definition of Sequential Equilibrium for the Model

To define a sequential equilibrium, we introduce the following notation.[11] A history of length t, denoted h^t, specifies all public events through period t: namely, the identity of the incumbent candidate in each period, the output generated in each period and the distribution of votes in the end-of-period election. H^t denotes the set of all possible histories of length t and $H^0 \equiv \phi$. For each $h^t \in H^t$, a partial history, denoted h_p^t, is a specification that includes all the component elements of h^t except the distribution of votes realized in the period-t election. H_p^t denotes the set of all possible partial histories of length t and $H_p^0 \equiv \phi$.

[10]For readers uninterested in the details of computing equilibria of the model, much of section 1.3 can be skimmed. The principal implications of the model's solution are presented in section 1.3.3.

[11]A general description of sequential equilibrium for finite games is given in Kreps and Wilson (1982). In defining a sequential equilibrium for the model, much of the notation is adapted from Banks and Sundaram (1993).

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Voter i's strategy is represented as a sequence of functions $v_i = (v_i^t)_{t=1}^{\infty}$ where, for each t, $v_i^t : H_p^t \to [0,1]$ is a measurable map that specifies the probability with which voter i casts her ballot in favor of the period-t incumbent candidate as a function of the partial history h_p^t. V_i denotes the set of all possible strategies for voter i and $V \equiv \prod_{i=1}^{n} V_i$.

For each $(v_1, ..., v_n) \equiv v \in V$, $r(v) \equiv (r(v)^t)_{t=1}^{\infty}$ is a sequence of functions where, for each t, $r(v)^t$: $H_p^t \to [0,1]$ is a measurable map that specifies the probability with which the period-t incumbent candidate is retained in office as a function of the partial history h_p^t and voting strategy v.

Given the effort space of candidates $(E \equiv [0,1))$, $\Im_E$ denotes the Borel sets of E and $\Delta(E)$ denotes the space of probability measures on the measurable space $(E, \Im_E)$. The strategy for candidate $i \in K$ is represented as a sequence of functions $c_i \equiv (c_i^t)_{t=1}^{\infty}$where, for each t, c_i^t: $H^{t-1} \to \Delta(E)$ is a measurable map that specifies the probability measure in $\Delta(E)$ chosen by candidate i if after history h^{t-1} she is the period-t incumbent candidate. C_i denotes the set of all possible strategies for candidate i and $C \equiv C_A \times C_B$.

For partial history $h_p^t \in H_p^t$ and fixed strategy profile $(c, v) \in C \times V$, $\lambda_V(h_p^t;$ $c, v)$ denotes each voter's expected discounted sum of payoffs over the infinite horizon, conditional on being at h_p^t. Similarly, for history $h^t \in H^t$ and fixed

strategy profile $(c, v) \in C \times V$, $\{\lambda_i(h^t; c, v)\}_{i \in K}$ denotes candidate $i's$ expected discounted sum of payoffs over the infinite horizon, conditional on being at h^t. (c, v) is called a sequential equilibrium if and only if after every $h_p^t \in H_p^t$ ($h^t \in H^t$), the voting (effort) strategy of each voter (candidate) is privately optimal. Specifically, we require the following two inequalities to hold:

$[C.1]\lambda_V(h_p^t; c, v) \geq \lambda_V(h_p^t; c, v_{-i}, \widetilde{v}_i); \forall \widetilde{v}_i \in V_i$ and $\forall i \in N$.

$[C.2]$ $\lambda_i(h^t; c, v) \geq \lambda_i(h^t; c_{-i}, \widetilde{c}_i, v)$; $\forall \widetilde{c}_i \in C_i$ and $\forall i \in K$.

Consider condition [C.1]. $\lambda_V(h_p^t; c, v_{-i}, \widetilde{v}_i)$ denotes each voter's expected discounted sum of payoffs over the infinite horizon conditional on being at h_p^t when: 1) candidates adopt strategy c; 2) voters, except for voter i, adopt strategy v_{-i}; and 3) voter i deviates from strategy v_i by selecting $\widetilde{v}_i$ instead. If strategy profile (c, v) is a sequential equilibrium, condition [C.1] requires that a unilateral deviation by voter i be unprofitable.

Consider condition [C.2]. $\lambda_i(h^t; c_{-i}, \widetilde{c}_i, v)$ denotes candidate $i's$ expected discounted sum of payoffs over the infinite horizon conditional on being at h^t when: 1) the other candidate adopts strategy c_{-i}; 2) candidate i deviates from strategy c_i by selecting $\widetilde{c}_i$ instead; and 3) voters adopt strategy v. If strategy profile (c, v) is a sequential equilibrium, condition [C.2] requires that a unilateral deviation by candidate i be unprofitable.

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1.3.2. Refining the Sequential Equilibrium for the Model

Given the multi-player, repeated-interactions design, there exists multiple sequential equilibria. For the purposes of sharper predictions, we focus on symmetric and stationary sequential equilibria in which both candidates play pure strategies. We impose the following four restrictions on admissible strategy profiles (c, v):

[*A*.4] For $i \in K$, $t \in Z_+$ and $h^{t-1} \in H^{t-1}$, $c_i^t(h^{t-1})$ assigns a probability mass of one to some point in E.

[*A*.5] Let h^t and $h^{\tilde{t}}$ be any two histories following which candidate $i \in K$ is in office. Then, $c_i(h^t) = c_i(h^{\tilde{t}})$. Hereafter, $\bar{e}_i \in E$ denotes the effort level chosen by candidate i when she is the incumbent.

[*A*.6] $\bar{e}_A = \bar{e}_B$ $(\equiv \bar{e})$.

[*A*.7] For each t and $h_p^t \in H_p^t$, v is such that $r(v)^t(h_p^t)$ depends only on the realized output in period t, y_t. Hereafter, $r_L(r_H)$ denotes the probability with which the incumbent candidate is reelected when output equals $y_L(y_H)$.

We explain the four restrictions ([A.4] - [A.7]). Assumption [A.4] forbids the two candidates from randomizing over the effort space, E. If after histories h^t and $h^{\tilde{t}}$, candidate $i \in K$ is reelected, the subgames following h^t and $h^{\tilde{t}}$ are structurally identical. Assumption [A.5] requires candidate i to expend equal effort in the two situations. Assumption [A.6] is a symmetry statement. Since the two candidates

possess identical preferences, we consider equilibria in which they expend equal effort. Finally, assumption [A.7] is a necessary imposition if candidate strategies are to obey assumptions [A.4] - [A.6]. Note that if reelection of the period-t incumbent candidate involves considerations other than the current realized output, y_t, then optimal period-t effort will depend on the details of history h^{t-1}, thereby violating assumption [A.5].

Given assumptions [A.4] - [A.7], we can define an equilibrium in a more compact manner. $S \equiv \{s_A, s_B\}$ is the state space of the model and $s_A(s_B)$ is a subgame in which candidate $A(B)$ is the incumbent. $Q : S \times E \rightarrow S$ is a transition map that specifies, as a function of the current state and effort expended, the probability of the two states in the next period. The following two conditions regarding Q can be readily established:[12]

$$Q(s_i|s_i, e) = \text{Probability}\{y = y_H|e\} \times r_H + \text{Probability}\{y = y_L|e\} \times r_L$$

$$Q(s_{-i}|s_i, e) = \text{Probability}\{y = y_H|e\} \times (1 - r_H) + \text{Probability}\{y = y_L|e\} \times (1 - r_L)$$

[12] In our notation, s_{-i} is a shorthand for the element of S not equal to s_i

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Starting from a node of the game tree in which candidate i is the incumbent, $Q(s_i|s_i, e)$ denotes the probability of reelection when effort expended is equal to e. Given assumption [A.7], candidate i is reelected with probability $r_H(r_L)$ when realized output is $y_H(y_L)$. Furthermore, since effort is fixed at e, the probability of $y_H(y_L)$ is Probability$\{y = y_H|e\}$ (Probability$\{y = y_L|e\}$). The expression for $Q(s_i|s_i, e)$ now follows from a standard conditioning argument. Analogous interpretations apply for $Q(s_{-i}|s_i, e)$.[13]

$\{V_i(s_j; e)\}_{i,j\in K}$ is the discounted sum of payoffs (value function) for candidate $i \in K$ when: 1) the current state is $s_j \in S$ and 2) each candidate, when in office, expends effort equal to e. Standard recursion arguments yield the following two conditions:

$$V_i(s_i; e) = (B - k \times [\frac{e^2}{2}]) + \delta \times [Q(s_i|s_i, e) \times V_i(s_i; e) + Q(s_{-i}|s_i, e) \times V_i(s_{-i}; e)]$$

$$V_i(s_{-i}; e) = \delta \times [Q(s_{-i}|s_{-i}, e) \times V_i(s_{-i}; e) + Q(s_i|s_{-i}, e) \times V_i(s_i; e)]$$

[13]Starting from a node of the game tree in which candidate $i \in K$ is the incumbent, $Q(s_{-i} | s_i, e)$ denotes the probability of electoral defeat when effort expended is equal to e. Thus, $Q(s_i|s_i, e) + Q(s_{-i}|s_i, e) = 1$.

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Starting from a node of the game tree in which candidate i is the incumbent, $V_i(s_i; e)$ denotes her total discounted sum of payoffs. When candidate i expends effort e, her current period payoff is $(B - k \times [\frac{e^2}{2}])$. Thereafter, with probability $Q(s_i|s_i, e)(Q(s_{-i}|s_i, e))$ she is reelected (rejected) and obtains, over the remainder of the game, a discounted sum of payoffs equal to $\delta \times V_i(s_i; e)$ $(\delta \times V_i(s_{-i}; e))$.[14] $V_i(s_i; e)$ is computed as the sum of her current and expected future payoffs. Analogous interpretations apply for $V_i(s_{-i}; e)$.

Using the unimprovability criterion from dynamic programming, it follows that $(\overline{e}_A, \overline{e}_B) \equiv (\overline{e}, \overline{e})$ can be supported as the effort level of a sequential equilibrium satisfying assumptions $[A.4] - [A.7]$ if and only if for $i \in K$ and $\widetilde{e} \in E$ the following inequality is satisfied:

$$V_i(s_i; \overline{e}) \geq [B - k \times [\frac{\widetilde{e}^2}{2}]] + \delta \times [Q(s_i|s_i; \widetilde{e}) \times V_i(s_i; \overline{e}) + Q(s_{-i}|s_i, \widetilde{e}) \times V_i(s_{-i}; \overline{e})] \quad (1.1)$$

The unimprovability criterion posits that $\overline{e}_A$ $(\overline{e}_B) \equiv \overline{e}$ is an equilibrium if a one-time deviation from $\overline{e}$ is unprofitable for candidate $i \in K$. Consider a node of the game tree in which candidate i is the incumbent. If she does not deviate from

[14]We assume that both candidates discount future payoffs at rate $\delta \in (0, 1)$.

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$\overline{e}$, her total discounted sum of payoffs is given by $V_i(s_i;\ e)$. On the other hand, should she deviate from $\overline{e}$ and choose $\widetilde{e}$: 1) her current payoff is $(B - k \times [\frac{\widetilde{e}^2}{2}])$; and 2) her future discounted sum of payoffs is $\delta \times V_i(s_i; \overline{e})(\delta \times V_i(s_{-i}; \overline{e}))$ if she is reelected (rejected). Furthermore, given $\widetilde{e}$, reelection (rejection) occurs with probability $Q(s_i \mid s_i, \widetilde{e})$ $(Q(s_{-i} \mid s_i, \widetilde{e}))$. By a standard conditioning argument, it is immediate that the right-hand side of equation (1.1) is the expected total discounted sum of payoffs to candidate i following deviation $\widetilde{e}$. The inequality of equation (1.1) ensures that all contemplated deviations from $\overline{e}$ are unprofitable.

1.3.3. Predictions from the Model's Sequential Equilibria

While details of the model's solution are provided in section 1.7, we summarize the two main predictions here. First, we introduce additional notation.

The model has five exogenous parameters: B, k, δ, π_L and π_H. For fixed voter behavior (r_L, r_H held constant) and parameter configuration, $\overline{e}(B, k, \delta, \pi_L, \pi_H; r_L, r_H)$ denotes the effort level in a sequential equilibrium satisfying assumptions [A.4] - [A.7]. Propositions 1 and 2 provide detailed characterizations of this "effort function."

Proposition 1: $\overline{e}(B, k, \delta, \pi_L, \pi_H; r_L, r_H)$ is increasing in B, δ, π_H and decreasing in

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k, π_L. Furthermore, $\bar{e}(B, k, \delta, \pi_L, \pi_H; r_L, r_H) = 0$ if $\delta = 0$ or $\pi_H = \pi_L$.

Proposition 2: As voter behavior, (r_L, r_H), is varied, the model generates a continuum of equilibrium effort levels. Any number in the interval $[0, [\frac{8 \times B}{12 \times k}]^{\frac{1}{2}}]$ can be supported as an equilibrium effort level.

We now draw out the substantive implications of the above propositions. Proposition 1 formalizes several standard intuitions. Consider, first, the comparative statics of effort with respect to B and k. When the private benefit from holding office, B, is increased, there is a corresponding increase in the marginal benefit of effort. When the effort cost parameter, k, is increased, there is a corresponding increase in the marginal cost of effort. Since candidates equate the marginal benefit and marginal cost of effort, effort levels increase (decrease) as $B(k)$ is raised. Second, if the discount factor, δ, is increased, future considerations begin to carry more weight. The added desire for reelection engenders greater electoral discipline and elicits larger effort levels from candidates. Third, when δ is equal to zero, future payoffs become irrelevant. Candidates maximize current payoffs and expend no effort. Fourth, as $\pi_H(\pi_L)$ is increased, the productivity of candidate effort increases (decreases). Effort expended is an increasing xm

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function of effort productivity; hence, a rise in $\pi_H(\pi_L)$ produces an increase (decrease) in effort levels. Finally, when π_H is equal to π_L, the productivity of effort becomes zero. Consequently, candidates are unwilling to exert any effort.

Proposition 2 is unsurprising. Since the setup is a repeated game, the abundance of equilibria is a consequence of Folk theorem-type results.[15] If electoral efficiency is measured by the amount of effort extracted from candidates, then proposition 2 derives a theoretical upper bound. The effort level actually elicited remains primarily an empirical issue.

1.4. Experimental Design

To test the predictions of the electoral model, we performed a series of experiments using undergraduates from a large public university. In the recruitment phase, care was taken to ensure that our subjects were unexposed to formal decision/game theory. The experiments were conducted on a computer network system and, except for reading the instructions (available upon request), all communication took place over the network.

The experimental sessions were of two sorts: repeated-interactions and one-shot sessions. The repeated-interactions sessions approximated the conditions of

[15] For an illuminating introduction to the literature on Folk theorems, the reader is referred to Fudenberg and Maskin (1986).

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the electoral model by allowing two candidates to interact in a sequence of periods. By contrast, in one-shot sessions candidate interactions were restricted to a single period. The possibility of repeated-game strategies was thereby eliminated.

The motivation for two session types is twofold. First, by mimicing the baseline model, the repeated-interactions sessions enable us to evaluate its predictive validity. Second, differences in experimental findings across session types allow estimation of the degree to which reelection pressure, present only in repeated-interactions sessions, elicits larger effort levels from candidates. The experimental procedures followed in each session type are detailed below.

1.4.1. Repeated-Interactions Setup — Experimental Procedures

An experimental session consisted of a cohort of nine subjects divided into an electorate of five voters and a pool of four potential candidates. A trial, with a fixed configuration of parameter values, lasted for a variable number of periods and involved the electorate facing the same pair of candidates. The uncertain termination date, coupled with unchanging candidates, was deemed sufficient to induce repeated-game considerations. A trial proceeded as follows.

[Step 1] At the start of the trial, two subjects from the candidate pool were randomly chosen to participate. Only the two "active" candidates were aware of

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[Step 2] At the start of period t, the incumbent candidate, denoted $i(t)$, selected her effort level, denoted e_t, from the interval $[0, 95]$.[16]

[Step 3] Given e_t, the computer program generated a number, denoted y_t, from the two-point set $Y \equiv \{y_L, y_H\}$. y_t equalled $y_H(y_L)$ with probability given by $(\pi_L + (\frac{e_t}{100}) \times (\pi_H - \pi_L))$ $((1 - \pi_L) - (\frac{e_t}{100}) \times (\pi_H - \pi_L))$. The y_t-value was transmitted to the seven subjects participating in the trial.[17]

[Step 4] Given y_t, voters cast their ballots and decided, by majority rule, whether to reelect or reject candidate $i(t)$. Once votes were tallied, the final outcome of the election as well as the vote margins realized were transmitted to the seven subjects participating in the trial.

[Step 5] Candidate $i(t)$ received a period-t payoff of $(B - k \times [\frac{e_t^2}{2}])$. Each voter received a period-t payoff of y_t.

[Step 6] The computer program switched to period $(t + 1)$. The winner of the period-t election was designated to be the incumbent candidate for period

[16] In the theoretical model (see section 1.2), candidates' effort space is the half-open unit interval. To allow for greater variation in observed behavior, the experimental setup expands the effort space to be [0, 95].

[17] The chosen effort, $e_t \in [0, 95]$, is mapped into the unit interval by the transformation $(e_t/100)$. Thereafter, assumptions [A.1] - [A.3] (see section 1.2) are used to determine the probability of generating y_H and y_L.

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$(t+1)$. At the end of a stochastic number of periods, the trial terminated.[18] Each subject's payoff for the trial was the sum of her period payoffs.

1.4.2. One-Shot Setup — Experimental Procedures

An experimental session consisted of a cohort of eleven subjects divided into an electorate of five voters and a pool of six potential candidates. A trial, with a fixed configuration of parameter values, lasted for six periods. Each candidate was randomly chosen to participate in two of the periods. A trial proceeded as follows.

[Step 1] At the start of period t, two subjects from the candidate pool were selected to be the period-t candidates. Only the two chosen candidates were aware of their role assignments. By random choice, one of the two candidates was designated to be the period-t incumbent.

[Step 2] The incumbent candidate, denoted $i(t)$, selected her effort level, denoted e_t, from the interval [0, 95].

[Step 3] Given e_t, the computer program generated a number, denoted y_t,

[18] Each trial was terminated as follows. Beginning in period twenty-five, the computer program generated a number from one to ten where each number was drawn with equal probability. The experiment was terminated if the number one was drawn; otherwise another period was conducted. This process was continued until, eventually, a one was drawn. All subjects were informed of the termination procedure adopted.

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from the two-point set $Y \equiv \{y_L, y_H\}$. y_t equalled $y_L(y_H)$ with probability given by $(\pi_L + (\frac{e_t}{100}) \times (\pi_H - \pi_L))$ $((1 - \pi_L) - (\frac{e_t}{100}) \times (\pi_H - \pi_L))$. The y_t-value was transmitted to all eleven subjects.

[Step 4] Candidate $i(t)$ received a period-t payoff of $(B - k \times [\frac{e_t^2}{2}])$. Each voter received a period-t payoff of y_t.

[Step 5] The computer program switched to period $(t+1)$. The sequence of events in period $(t+1)$ replicated that of period t. At the end of six periods, the trial terminated. Each subject's payoff for the trial was the sum of her period payoffs.[19]

1.4.3. Experimental Parameter Values

An experimental session consisted of four trials. Individual trials differed in the values assumed by the four exogenous parameters: B, k, π_L, and π_H. Table 1 in Appendix A displays the parameter value configurations that were considered. For example, in Treatment 1, we set the private benefit of office, B, to be 7425; the scale parameter of effort cost, k, to be 1; and the parameter vector of the output generation process, (π_L, π_H), to be (0, 1). The parameter values in Table

[19]In contrast to the repeated-interactions case, there was no "voting phase" in one-shot sessions. Therefore, it was impossible for the electorate to express approval (disapproval) of the incumbent's performance by reelecting (rejecting) her.

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1 correspond to subjects' payoffs denominated in a laboratory currency called the franc. At the conclusion of the experimental session, cumulative earnings in francs were converted into dollars using a preassigned exchange rate.

For repeated-interactions sessions, the primary goal of our experimental work was to sort out the factors that affect candidates' effort choice. Specifically, we considered the influence of two potentially important factors. First, by a pairwise comparisons of Treatments 1 and 3 and Treatments 2 and 4, we investigated the effect of the benefits of office. In short, we asked: if B is increased (decreased), is there a systematic effect on the level of candidates' effort? Second, by a pairwise comparisons of Treatments 1 and 2 and Treatments 3 and 4, we considered the impact of effort productivity. In brief, we asked: if $(\pi_H - \pi_L)$ is increased (decreased), is there a systematic effect on the level of candidates' effort? For Treatments 5 and 6, the productivity of effort is equal to zero. Thus, we asked: if effort is entirely unproductive, are candidates nonetheless willing to expend effort?

By contrasting experimental findings across session types, we evaluated the extent to which reelection pressure elicits effort from candidates. Note, first, that reelection pressure is present only in repeated-interactions sessions. Hence, if candidates' effort in one-shot trials is significantly less than that in repeatedsea

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1.5. Experimental Results

Our experiments consisted of two session types: repeated-interactions and one-shot. In this section we present the experimental results for each session type. We consider the repeated-interactions sessions first.

1.5.1. Experimental Results for Repeated-Interactions Sessions

The analysis of the data is comprised of four parts. First, we provide results that characterize the aggregate behavior of candidates and voters. Second, we estimate two alternative models that explain the electoral choices of individual voters. Third, we estimate a model that accounts for the effort decisions of individual candidates. Fourth, we compute the relative efficiency of experimental elections.[20]

Aggregate Behavior in Repeated-Interactions Sessions

The repeated-interactions sessions consisted of six treatment conditions (see Table 1). For each treatment condition, we conducted several trials where each

[20] The definition of "relative efficiency" is given later.

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trial, in turn, consisted of a variable number of election periods. Corresponding to each treatment condition, we pooled all the observations. Table 2 in Appendix A provides a summary of the data.

In Table 2, for each treatment condition, "# of trials" indicates the number of trials that were conducted. Corresponding to each treatment condition, we pooled observations across trials and periods. "Average effort" ("std. dev. of effort") computes the average (standard deviation) of the effort levels chosen by candidates. "Realized output" is a two-element vector where the first and second elements represent, respectively, the number of instances that the observed output was $y_L(y_H)$. "Reelection probability" is a two-element vector where the first and second elements represent, respectively, the empirical probability of reelection conditional on outputs y_L and y_H.

Table 2 is read as follows. In the experiment, we conducted six trials with Treatment 1-parameter values. These trials yielded a total of 201 observations: the average of candidates' effort levels was 67.43 while the standard deviation was 18.66. The vector "realized output" indicates that the observed output was $y_L(y_H)$ on 67(134) occasions. The "reelection probability" vector indicates that an output of $y_L(y_H)$ resulted in reelection 8%(100%) of the time.

Consider, first, aggregate behavior in Treatments 5 and 6. In both treatments, more

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the productivity of candidate effort is equal to zero. Hence, proposition 1 maintains that candidates will be unwilling to expend effort. Table 2 provides striking support for this prediction. Specifically, in Treatments 5 and 6, average candidate effort was, respectively, only 5.24 and 2.51.[21] Conclusion 1 summarizes our findings.

Conclusion 1: As predicted by proposition 1, when the productivity of candidate effort is equal to zero, candidates expend negligible effort.

Consider, now, aggregate behavior in Treatments 1, 2, 3 and 4. Table 2 allows us to make the following three observations. First, for each of the treatment conditions, reelection probabilities are increasing in output levels.[22] Since the electorate rewards (punishes) "good" ("poor") candidate performance, an incentive to undertake costly effort emerges. Second, candidates' effort levels averaged over Treatments 1 and 2 ($B = 7425$) is 55.93 while that averaged over Treatments 3 and 4 ($B = 5000$) is 40.50.[23] Thus, in accord with proposition 1, average effort

[21] For comparison, recall that the feasible upper bound for candidate effort is 95.

[22] Consider Treatment 1. The "reelection probability" vector indicates that the probability of reelection when y_L occurs (0.08) is less than that when y_H occurs (1.0).

[23] 55.93 is the average of two numbers: 67.43 and 44.42. 40.50 is the average of two numbers: 48.72 and 32.27.

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increases when the private benefit of office is raised. Third, candidates' effort levels averaged over Treatments 1 and 3 ($(\pi_H - \pi_L) = 1$) is 58.08 while that averaged over Treatments 2 and 4 ($(\pi_H - \pi_L) = 0.6$) is 38.35.[24] Thus, in accord with proposition 1, average effort increases when the productivity of candidate effort is raised. Conclusion 2 summarizes the above observations.

Conclusion 2: The data provide support for the comparative statics predictions of proposition 1. Specifically, the average of candidates' effort levels is an increasing function of 1) the private benefit of office and 2) the productivity of candidate effort.

We supplement conclusion 2 with regression-based analyses of candidates' effort choices in Treatments 1, 2, 3 and 4. In the first regression, the dependent variable is the effort expended by candidates while the independent variables control for treatment conditions. The base group, represented by a constant, α, refers to the treatment in which the private benefit of office, B, is equal to 5000 and the productivity of candidate effort, $(\pi_H - \pi_L)$, is equal to 0.6.[25] Additionally,

[24] 58.08 is the average of two numbers: 67.43 and 48.72. 38.35 is the average of two numbers: 44.42 and 32.27.

[25] The base group represents Treatment 4 (see Table 1).

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two dummy variables are included. Specifically, Highb is a dummy variable that equals 0(1) if the B-value for the treatment equals 5000(7425).[26] The coefficient of Highb, denoted β_1, represents the difference in candidates' average effort level when, ceteris paribus, B is raised from 5000 to 7425. The second dummy variable, called Highprod, equals 0(1) if the $(\pi_H - \pi_L)$-value of the treatment equals 0.6(1).[27] The coefficient of Highprod, denoted β_2, represents the difference in candidates' average effort level when, ceteris paribus, $(\pi_H - \pi_L)$ is raised from 0.6 to 1.0. In sum, the first regression estimates the following model:

$$e_{it} = \alpha + \beta_1 Highb_{it} + \beta_2 Highprod_{it} + \varepsilon_{it} \tag{1.2}$$

where: 1) e_{it} is the effort expended by candidate i in period t; 2) β's are coefficients; 3) Highb_{it} is a dummy variable that equals 0(1) if candidate i in period t is in a treatment with B equal to 5000(7425); 4) Highprod_{it} is a dummy variable that equals 0(1) if candidate i in period t is in a treatment with $(\pi_H - \pi_L)$ equal to 0.6(1); and 5) ε_{it} is an i.i.d. error term.

The results of the estimation are detailed in column 1 of Table 3 (refer to Appendix A). The point estimates of β_1 and β_2 are positive and statistically

[26]Highb is equal to 0(1) for Treatments 3 and 4 (1 and 2) (see Table 1).
[27]Highprod is equal to 0(1) for Treatments 2 and 4 (1 and 3) (see Table 1).

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significant. Therefore, there is a positive relationship between candidates' effort levels and the $B-$ and $(\pi_H - \pi_L)-$values of the electoral environment.

Another method of estimating the impact of treatment conditions on candidates' effort levels explicitly recognizes heterogeneity in the pool of candidates. The errors-components approach estimates the following model:

$$e_{it} = \beta_1 Highb_{it} + \beta_2 Highprod_{it} + \theta_i + \varepsilon_{it} \tag{1.3}$$

Note that the constant, α, in equation (1.2) is replaced by the fixed effects, θ_i, in equation (1.3). Heterogeneity in the candidate pool is modeled by allowing the θ_i's to vary across candidates.[28]

We estimate equation (1.3) using two approaches. First, we include the fixed effects directly as regressors. The coefficients (β's) are measured by using the within-subject variation in treatment conditions.[29] The results are detailed in column 2 of Table 3. As in the OLS case, the point estimates of the β's are positive and statistically significant, thereby confirming conclusion 2. Since the fixed effects are treated as regressors, they have no distribution. However, a measure of candidate heterogeneity can be obtained by computing the sample standard de-

[28]For an introduction to panel data models, the reader is referred to Chamberlain (1984).

[29]Each candidate subject participated in more than one treatment condition. Thus, treating the θ_i's as regressors becomes a feasible way of estimating equation (1.3).

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viation of the estimated θ_i's ($\widehat{\theta}_i$'s). In the data, the sample standard deviation of the $\widehat{\theta}_i$'s is 10.73. Since the average of candidates' effort levels across Treatments 1 through 4 is 48.21, the sample standard deviation of the $\widehat{\theta}_i$'s represents significant heterogeneity in the candidate pool.[30]

Given the random assignment of candidates to the various treatments, the fixed effects are uncorrelated with the two treatment variables on the right-hand side of equation (1.3). Consequently, a random-effects estimator is consistent and potentially more efficient. This is a generalized-least-squares (GLS) estimator of equation (1.3).[31] The results of the random-effects estimator are detailed in column 3 of Table 3. They are similar to the results of the fixed-effects estimator.[32] As before, the point estimates of the β's are positive and statistically significant. Since the fixed effects now have a distribution, we can formally check for heterogeneity in the candidate pool by determining whether the standard deviation of the distribution of the fixed effects is zero. The Breusch and Pagan Lagrange

[30]Another measure of heterogeneity is the ratio: (sample standard deviation of the $\widehat{\theta}_i$'s) $\div$ (estimated standard deviation of the ε_{it}'s). In the data, this ratio is equal to 0.70. Hence, the conclusion of "significant heterogeneity" is validated.

[31]For details, the reader is referred to Chamberlain (1984).

[32]If the random-effects specification is correct, then fixed- and random-effects estimators should yield comparable point estimates of the β's. We performed a Hausman test (see Hausman (1978)) to check whether the point estimates of the β's in columns two and three of Table 3 are statistically indistinguishable. The null hypothesis of "equality of the $\widehat{\beta}$'s" could not be rejected at the 0.1 level of significance.

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Multiplier test detects heterogeneity in the candidate pool.[33] The results of the three regressions are summarized in the following conclusion.

Conclusion 3: The regression-based analysis supports conclusion 2. Specifically, the average of candidates' effort levels is an increasing function of 1) the private benefit of office and 2) the productivity of candidate effort. Also, there is heterogeneity in the candidate pool.

Voter Behavior in Repeated-Interactions Sessions

To analyze voter behavior, we introduce additional notation. Let $i(t) \in \{A, B\}$ be the identity of the incumbent in period t and let $y_t \in Y \equiv \{y_L, y_H\}$ be the realized output in period t. In the experiment, voters are unaware of candidate effort or the mechanism by which expended effort stochastically generates output values. Thus, in period t, a voter's history consists of two parts: 1) the identity of the incumbent for periods 1 through t (i.e., $\{i(j)\}_{j=1}^{t}$); and 2) the stream of realized outputs for periods 1 through t (i.e., $\{y_j\}_{j=1}^{t}$). We wish to construct plausible models that account for how a voter in period t uses her information in

[33] Under the null hypothesis of "no heterogeneity," the test statistic is distributed as $\chi^2_{[1]}$. At the 0.1 significance level, the critical value is 2.71. In our dataset, the test statistic assumes a value of 373.03.

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deciding whether to reelect or reject candidate $i(t)$.

We build two distinct micro-models of voter behavior. In both models, a voter utilizes the available retrospective information and rewards (punishes) candidate $i(t)$ with reelection (rejection) when her performance is deemed to be satisfactory (unsatisfactory). The models differ in the specification of the process by which candidate $i(t)'s$ performance is rated.

In model 1 of voter behavior, called the Average Payoff Model (hereafter, APM), a voter in period t first computes the average payoff received over periods 1 through $(t-1)$. Thereafter, if the observed y_t-value is above (below) the payoff average, candidate $i(t)$ is reelected (rejected). For the two-point output set, $Y \equiv \{y_L, y_H\}$, the prediction of APM is as follows: If the sequence of outputs upto period $(t-1)$ comprises both y_L and y_H, then candidate $i(t)$ is reelected with probability equal to $0(1)$ if y_t equals $y_L(y_H)$.

To test the explanatory power of APM we proceed as follows. First, for each of the six treatment conditions, we pool the vote decisions across trials and periods. Thereafter, we compute the percentage of vote decisions that violate APM's predictions. The results are detailed in Table 4 of Appendix A.

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(hereafter, DAPM), a voter discriminates between the two candidates, A and B.[34] Therefore, in period t, a voter computes two average (perhaps, discounted) payoffs received over periods 1 through t — one for each candidate. In period t, let $EV_j^i(t)$ denote the discounted average payoff attached to candidate $j \in \{A, B\}$ by voter i. $EV_j^i(t)$ is calculated by considering only those periods for which the incumbent candidate is j. More formally, suppose that A is candidate $i(t)$. In addition, let $\rho_i \in [0, 1]$ denote the rate at which voter i discounts past observations. Then, $\{EV_A^i(t), EV_B^i(t)\}$ satisfies the following recursion:

$$EV_A^i(t) = (1 - \rho_i)^k \times EV_A^i(t-1) + [1 - (1 - \rho_i)^k] \times y_t$$

$$EV_B^i(t) = EV_B^i(t-1)$$

where k is the number of periods since A was the incumbent last.[35] Given $\{EV_A^i(t), EV_B^i(t)\}$, voter i casts her ballot for candidate $A(B)$ if $EV_A^i(t) > EV_B^i(t)$

[34] The idea behind DAPM, though developed independently, is identical to that in Collier et al (1987). For a lengthier discussion of DAPM, the reader is referred to that paper.

[35] If B is candidate $i(t)$, $\{EV_A^i(t), EV_B^i(t)\}$ is computed as follows:
$EV_B^i(t) = (1 - \rho_i)^k \times EV_B^i(t-1) + [1 - (1 - \rho_i)^k] \times y_t$
$EV_A^i(t) = EV_A^i(t-1)$
where k is the number of periods since B was the incumbent last.

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$(EV_B^i(t) > EV_A^i(t))$. In the case of a tie $(EV_A^i(t) = EV_B^i(t))$, voter i randomly selects one of the two candidates.

DAPM is empirically implemented as follows. Note, first, that the model involves the following free parameters: 1) voter $i's$ discount rate, ρ_i; 2) voter $i's$ initial expectation about candidate A, $EV_A^i(0)$; and 3) voter $i's$ initial expectation about candidate B, $EV_B^i(0)$. For each of the six treatment conditions, we consider one trial at a time. We set $EV_A^i(0) = EV_B^i(0) = EV(0)$ and, using a grid search, find the trial-specific $EV(0)-$ and ρ_i-values that minimize the number of "errors" in voting behavior. The results are detailed in Table 4.

Table 4 is read as follows. In our experiment, the six trials with Treatment 1-parameter values yielded observations for two hundred and one periods and, hence, one thousand and five vote decisions.[36] The "error rate, APM" ("error rate, DAPM") entry indicates that 10.75% (14.23%) of the vote decisions violated the predictions of APM (DAPM).

For the entire experiment, APM and DAPM explain, respectively, 81.90% and 77.89% of the vote decisions.[37] If, on the other hand, voters cast their ballots with-

[36]Since the electorate consists of five voters, the number of vote decisions is five times the number of periods.

[37]81.90 is computed as the difference between 100 and the average of the six error rates: 10.75, 13.06, 18.77, 26.37, 23.95 and 15.73 (see Table 4). 77.89 is computed as the difference between 100 and the average of the six error rates: 14.23, 22.59, 23.09, 27.67, 23.42 and 21.64 (see Table 4).

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out considering candidates' performance, a model of "random choice" accounts for 50% of the vote decisions. Relative to a "random choice" model, both APM and DAPM possess superior predictive power. Voters, therefore, use candidates' performance in determining electoral outcomes.

While APM has a slightly higher prediction rate than DAPM, the difference is not substantively significant. For both models, approximately 20% of the vote decisions remain unexplained. Voter errors, for the most part, occur when the realized output is y_L.[38] Despite the unsatisfactory performance, voters reelect the incumbent with a probability that exceeds the predictions of either model. A more complete theory of voter behavior remains to be developed. Conclusion 4 summarizes the above discussion.

Conclusion 4: Voters use candidates' performance in determining electoral outcomes. Specifically, the reelection probability of the incumbent candidate is higher when the realized output is y_H rather than y_L. However, about twenty percent of the vote decisions cannot be accounted for by the two theoretical models.

A more detailed analysis of voter behavior detects significant heterogeneity

[38]The details of the analysis are available upon request.

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in the subject pool. We consider heterogeneity of two sorts. First, we consider heterogeneity of voter error rates. We proceed as follows. Since APM has higher predictive power than DAPM, we measure an individual voter's error rate relative to the APM predictions. Corresponding to each of the six treatment conditions, we equate heterogenity of voter error rates with the standard deviation of the error rates of voters assigned to that treatment. Second, we consider heterogeneity of voter preferences. The empirical implementation of DAPM generates an estimate of each voter's discount rate, $\widehat{\rho}_i$. Corresponding to each of the six treatment conditions, we equate heterogeneity of voter preferences with the standard deviation of the discount rates of voters assigned to that treatment. The results are detailed in Table 5 of Appendix A.

To read Table 5, consider the Treatment 1 sessions. The entry for the "avg., error rates" ("std. dev., error rates") column indicates that the average (standard deviation) of the error rates of voters participating in Treatment 1 sessions was 10.75(6.70). The benchmark for voter behavior was APM. The entry for the "avg., $\widehat{\rho}_i$'s" ("std. dev., $\widehat{\rho}_i$'s") column indicates that the average (standard deviation) of the discount rates of voters participating in Treatment 1 sessions was .35(.28). The benchmark for voter behavior was DAPM.

Table 5 reveals that for each of the six treatment conditions, both types of

voter heterogeneity - measured by the two standard deviations - exist. We now ask: which type of voter heterogeneity is more substantial? Corresponding to each treatment condition, we compute two summary measures. Normalized heterogeneity of voter error rates is defined to be the ratio: ("std. dev., error rates")/("avg., error rates"). Normalized heterogeneity of voter preferences is defined to be the ratio: ("std. dev., $\widehat{\rho}_i$'s")/("avg., $\widehat{\rho}_i$'s"). Averaged over the six treatments, the normalized heterogeneity of voter error rates (preferences) assumes the value of 0.45(0.91).[39] Since 0.91 exceeds 0.45, heterogeneity of preferences is more substantial than heterogeneity with respect to error rate. Conclusion 5 summarizes the above discussion.

<u>Conclusion 5:</u> In the pool of voters, there is heterogeneity with respect to error rate and discount rate. Heterogeneity of discount rates is more substantial than that of error rates.

Candidate Behavior in Repeated-Interactions Sessions

Table 2 indicates that for Treatments 1 through 4, the average of the candidate

[39] 0.45 is the average of the following six numbers: 0.62, 0.43, 0.39, 0.44, 0.33 and 0.54. 0.91 is the average of the following six numbers: 0.80, 1.05, 0.91, 1.38, 0.91 and 0.41.

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effort levels was significantly less than the feasible upper bound of the effort choice set (95). In this subsection we first construct a theoretical model of how the incumbent in period t uses her information in selecting an effort level. Once the theoretical model is empirically estimated, we determine whether the observed effort levels can be rationalized.

To describe the theoretical model, we introduce additional notation. Let 1) $i(t) \in \{A, B\}$ be the identity of the incumbent candidate in period t; 2) $y_t \in Y \equiv \{y_L, y_H\}$ be the observed output in period t; and 3) $v(t) \in \{1, 2, 3, 4, 5\}$ be the number votes received by candidate $i(t)$ in the period-t election. In the experiment, besides knowing her own sequence of past efforts, candidate $i(t)$ is aware of the public history $\{i(j), y_j, v(j)\}_{j=1}^{t-1}$. We now construct a model that specifies, as a function of history, the process by which candidate $i(t)$ picks her period-t effort, denoted $e^{mp}(t)$.

Before selecting $e^{mp}(t)$, candidate $i(t)$ must form an opinion on two issues: 1) the effort level of her opponent should she be placed in power and 2) the voting behavior of the electorate.We posit that candidate $i(t)$ views her environment as being stationary and that she employs likelihood techniques in estimating all the unobserved parameters pertaining to the above two issues.

Consider, first, how candidate $i(t)$ estimates her opponent's effort level, de-ie f

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noted $e^{me}(t)$, from the available information. Between periods 1 through $(t-1)$, let $l(t)$ be the number of times that candidate $i(t)'s$ opponent, denoted $-i(t)$, is in office and let $s(t)$ be the number of times that voters' payoffs under candidate $-i(t)'s$ administration is y_H. $e^{me}(t)$ is the maximum likelihood estimate of candidate $-i(t)'s$ effort level conditional on the information $\{l(t), s(t)\}$. Specifically, $e^{me}(t)$ solves the following program:

$$e^{me}(t) \in \arg\max_{e\in[0,95]} [\pi_L+(\frac{e}{100})\times(\pi_H-\pi_L)]^{s(t)}\times[(1-\pi_L)-(\frac{e}{100})\times(\pi_H-\pi_L)]^{l(t)-s(t)} \tag{1.4}$$

The interpretation of the program is as follows. Under the administration of candidate $-i(t)$, there are $s(t)(l(t)-s(t))$ draws of $y_H(y_L)$. The probability of generating output equal to $y_H(y_L)$, conditional on effort equal to e, is $(\pi_L + (\frac{e}{100}) \times (\pi_H - \pi_L))$ $((1-\pi_L) - (\frac{e}{100}) \times (\pi_H - \pi_L))$. Therefore, the probability of generating a sample of $s(t)$ y_H-values and $(l(t)-s(t))$ y_L-values is: $[\pi_L + (\frac{e}{100}) \times (\pi_H - \pi_L)]^{s(t)} \times [(1-\pi_L) - (\frac{e}{100}) \times (\pi_H - \pi_L)]^{l(t)-s(t)}$. The maximum likelihood estimate of candidate $-i(t)'s$ effort choice, $e^{me}(t)$, is the e-value that maximizes the probability of observing the sample.[40]

[40]If $l(t)$ equals zero, we set $e^{me}(t)$ to be fifty. The empirical results are insensitive to the choice of initial value.

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Consider, now, how candidate $i(t)$ estimates voter behavior from her available information. Candidate $i(t)$ assumes that voters are behaviorally identical. Specifically, each voter is characterized by two parameters, p_L and p_H, where $p_L(p_H)$ is the probability with which a voter reelects the incumbent candidate when the observed output is $y_L(y_H)$. Given her information, let $(p_L^{me}(t), p_H^{me}(t))$ be candidate $i(t)'s$ maximum likelihood estimate of (p_L, p_H). Specifically, $(p_L^{me}(t),$ $p_H^{me}(t))$ solves the following programs:

$$p_L^{me}(t) \in \arg \max_{p_L \in [0,1]} \prod_{j=1}^{t-1} 1[y_j = y_L] \times \{C_{v_j}^5 \times (p_L)^{v_j} \times (1 - p_L)^{5-v_j}\} \tag{1.5}$$

$$p_H^{me}(t) \in \arg \max_{p_H \in [0,1]} \prod_{j=1}^{t-1} 1[y_j = y_H] \times \{C_{v_j}^5 \times (p_H)^{v_j} \times (1 - p_H)^{5-v_j}\} \tag{1.6}$$

where: $1[y_j = y_L]$ $(1[y_j = y_H])$ is the indicator function which equals one when the period-j output, y_j, equals $y_L(y_H)$ and is zero otherwise.

The interpretation of the programs are as follows. Consider equation (1.5). Given period t, we first look at all the past periods for which the realized output is

y_L. For one such period, say period j, the probability of generating v_j votes for the period-j incumbent candidate is $C^5_{v_j} \times (p_L)^{v_j} \times (1-p_L)^{5-v_j}$. Consider the observed subhistory: $\{(y_j, v_j)|y_j = y_L, j \leq (t-1)\}$. For a fixed value of p_L, the probability of generating this subhistory is: $\prod_{j=1}^{t-1} 1[y_j = y_L] \times \{C^5_{v_j} \times (p_L)^{v_j} \times (1-p_L)^{5-v_j}\}$ The maximum likelihood estimate of p_L (i.e., $p_L^{me}(t)$) is the p_L-value that maximizes the above expression. A similar interpretation applies to equation (1.6).[41]

Having estimated $\{e^{me}(t), p_L^{me}(t), p_H^{me}(t)\}$, the optimal effort level of candidate $i(t)$ (i.e., $e^{mp}(t)$) solves the following program:

$$\begin{aligned} Q(e|t) &= [\pi_L + (\frac{e}{100}) \times (\pi_H\text{-}\pi_L)] \times [\sum_{k=3}^{5} C^5_k \times (p_H^{me}(t))^k \times (1\text{-}p_H^{me}(t))^{5-k}] \quad (1.7) \\ &+[(1\text{-}\pi_L) - (\frac{e}{100}) \times (\pi_H\text{-}\pi_L)] \times [\sum_{k=3}^{5} C^5_k \times (p_L^{me}(t))^k \times (1\text{-}p_L^{me}(t))^{5-k}] \end{aligned}$$

$$V^I(e|t) = (B - k \times [\frac{e^2}{2}]) + \delta \times [Q(e|t) \times V^I(e|t) + (1 - Q(e|t)) \times V^O(e|t)] \quad (1.8)$$

$$V^O(e|t) = \delta \times [Q(e^{me}(t)|t) \times V^O(e|t) + (1 - Q(e^{me}(t)|t)) \times V^I(e|t)] \quad (1.9)$$

[41]If in period t, there is no previous occurence of $y_L(y_H)$, we arbitrarily set $p_L^{me}(t)$ $(p_H^{me}(t))$ to be 0(1). The empirical results are insensitive to the choice of initial values.

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$$e^{mp}(t) \in \arg \max_{e \in [0,95]} V^I(e|t) \tag{1.10}$$

The basic idea behind the program is simple. Given voter behavior, ($p_L^{me}(t)$, $p_H^{me}(t)$), $Q(e|t)$ is candidate $i(t)'s$ estimate of an incumbent's reelection probability when her effort level is equal to e.[42] Suppose, now, that candidate $i(t)$ always chooses an effort level of e when placed in office. Then, $V^I(e|t)$ ($V^O(e|t)$) is candidate $i(t)'s$ estimate of her discounted sum of payoffs over the infinite horizon starting at any node of the game tree where she is in (out of) office. Consider the expression for $V^I(e|t)$. When candidate $i(t)$ expends effort e, her current period payoff is $(B - k \times [\frac{e^2}{2}])$. Thereafter, she is reelected (rejected) with probability equal to $Q(e|t)$ $(1-Q(e|t))$ and her discounted sum of future payoffs is $\delta \times V^I(e|t)$ $(\delta \times V^O(e|t))$. Equation (1.8) indicates that $V^I(e|t)$ comprises of candidate $i(t)'s$ current and estimated expected discounted sum of future payoffs. Consider the expression for $V^O(e|t)$. When candidate $i(t)$ is at a node where she is out of office, her current period payoff is zero. Thereafter, when candidate $-i(t)$ expends her

[42]Note, first, that an incumbent requires at least three votes to be reelected. Given voter behavior, $(p_L^{me}(t), p_H^{me}(t))$, Prob{incumbent reelected | y_L} is equal to $[\sum_{k=3}^5 C_k^5 \times (p_L^{me}(t))^k \times (1-p_L^{me}(t))^{5-k}]$ while Prob{incumbent reelected | y_H} is equal to $[\sum_{k=3}^5 C_k^5 \times (p_H^{me}(t))^k \times (1-p_H^{me}(t))^{5-k}]$. From [A.1] and [A.2] (see section 1.2), Prob$\{y_L|e\}$ is equal to $[(1-\pi_L)-(\frac{e}{100})\times(\pi_H-\pi_L)]$ while Prob$\{y_H|e\}$ is equal to $[\pi_L + (\frac{e}{100}) \times (\pi_H - \pi_L)]$. Finally, $Q(e|t) =$ Prob{incumbent reelected | y_L}×Prob$\{y_L|e\}$ + Prob{incumbent is reelected | y_H}×Prob$\{y_H|e\}$. Substituting for each of the four terms in the above expression for $Q(e|t)$, we obtain equation (1.7).

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estimated effort, $e^{me}(t)$, candidate $i(t)$ is subsequently placed in (out of) office with probability equal to $(1 - Q(e^{me}(t)|t))$ $(Q(e^{me}(t)|t))$ and her discounted sum of future payoffs is $\delta \times V^I(e|t)$ $(\delta \times V^O(e|t))$. A standard conditioning argument immediately yields equation (1.9). Finally, equation (1.10) posits that candidate $i(t)'s$ period-t effort choice, $e^{mp}(t)$, maximizes her estimated expected discounted sum of future payoffs starting from period t (i.e., $V^I(e|t)$).

For each treatment condition and past history, the theoretical model of candidate behavior generates an "optimal" effort choice.[43] We now compare the theoretically predicted effort levels with observed candidate behavior. We proceed as follows. For each treatment condition, we pool observations across trials and periods. Thereafter, we compare the average and the standard deviation of the observed candidate effort levels (e_{it}'s) with the corresponding summary statistics of the predicted candidate effort levels ($e^{mp}(t)$'s). The results are detailed in Table 6 of Appendix A.

To read Table 6, consider the Treatment 1 sessions. Across all trials and periods with Treatment 1-parameter values, the average (standard deviation) of observed candidates' effort levels was 67.43(18.66). The average (standard devia-

[43]To obtain $e^{mp}(t)$, equations (1.4) - (1.10) need to be solved simultaneously. Since closed form solutions are unavailable, numerical techniques were employed.

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tion) of predicted candidates' effort levels was 66.53(18.65).

A striking pattern appears in Table 6. Except for the Treatment 1 sessions, observed effort is larger on average and more volatile than the theoretical predictions. What accounts for these anomalies?

Consider, first, the anomaly in the level of observed effort. In Treatments 5 and 6, average observed effort was larger than zero because for some subjects it took a few periods before they realized that it was unprofitable to expend effort when its productivity is zero. For Treatments 2, 3 and 4, we conjecture that the main reason for the discrepancy between theory and data is the risk aversion of candidates. In the theoretical model of effort choice, the risk neutrality assumption is implicitly invoked: candidates maximized the expected discounted sum of period payoffs. If, on the other hand, candidates are risk averse, the model's solution will be misleading. In brief, a larger effort level smoothens the benefit stream of a candidate by increasing her probability of retaining power and thereby avoiding the drastic payoff of zero when she is out of office. For a risk-averse candidate, there is a utility gain from this "benefit smoothing". Consequently, expended effort will be larger than the optimum under risk neutrality. Our risk aversion explanation is, at best, partially correct. We cannot account for the close match between theory and data for Treatment 1 sessions. Conclusion 6 nai

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summarizes the above discussion.

Conclusion 6: Except for Treatment 1 sessions, the average of candidates' effort levels exceeds that predicted by the theoretical model. The discrepancy may reflect the risk aversion of candidates.

Consider, now, the anomaly in the volatility of observed effort. Why in Treatments 2, 3, 4, 5 and 6 is the standard deviation of observed candidate effort larger than the theoretically predicted magnitude? We conjecture that two forces account for this discrepancy. First, as candidates learn the structure of the game, their actions change. Thus, learning induces volatility in the data. Second, as indicated in conclusion 3, there is heterogeneity in the candidate pool. Aggregating all treatment specific periods generates an additional volatility that reflects (merely) the inherent heterogeneity of candidates. Our explanations are, at best, partially correct. They cannot account for the close match between theory and data for Treatment 1 sessions. Conclusion 7 summarizes the above discussion.

Conclusion 7: Except for Treatment 1 sessions, the standard deviation of candidates' effort levels exceeds that predicted by the theoretical model. The dis-

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We now ask whether discrepancies between observed effort levels and theoretical predictions decrease as candidates gather experience. Since non-trivial effort choice occurs only in Treatments 1, 2, 3 and 4, we restrict our analysis of "effort discrepancy" to these treatments.[44]

The regression-based analysis of "effort discrepancy" is as follows. In the first regression, the dependent variable is the absolute value of the difference between the effort expended by candidates and the level predicted by the theoretical model. The independent variables control for treatment conditions and the experience of candidates. The treatment conditions are represented with two dummy variables: Highb and Highprod. Highb equals 0(1) if the B-value of the treatment equals 5000(7425). The coefficient of Highb, denoted β_1, represents the difference in error discrepancy when, ceteris paribus, B is raised from 5000 to 7425. Highprod equals 0(1) if the $(\pi_H - \pi_L)$-value of the treatment equals 0.6(1). The coefficient of Highprod, denoted β_2, represents the difference in error discrepancy when, ceteris paribus, $(\pi_H - \pi_L)$ is raised from 0.6 to 1.0. Candidate experience is represented

[44]The substantive conclusions are unchanged if, instead, we consider all six treatments.

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with the variable Exper. Exper specifies the number of times in the past that the current incumbent was in office.[45] The coefficient of Exper, denoted β_3, represents the difference in error discrepancy when, ceteris paribus, a candidate is in office for one more period. In sum, the first regression estimates the following model.

$$d_{it} = \alpha + \beta_1 Highb_{it} + \beta_2 Highprod_{it} + \beta_3 Exper_{it} + \varepsilon_{it} \tag{1.11}$$

where: 1) d_{it} is the absolute value of the difference between effort expended by candidate i in period t (e_{it}) and the theoretically predicted effort level ($e^{mp}(t)$); 2) β's are coefficients; 3) Highb$_{it}$ is a dummy variable that equals 0(1) if candidate i in period t is in a treatment with B equal to 5000(7425); 4) Highprod$_{it}$ is a dummy variable that equals 0(1) if candidate i in period t is in a treatment with $(\pi_H - \pi_L)$ equal to 0.6(1); 5) Exper$_{it}$ computes the number of times, between periods 1 and $(t-1)$, that candidate i is in power; and 6) ε_{it} is an i.i.d. error term.

The results of the estimation are detailed in column 1 of Table 7 (refer to Appendix A). The point estimate of β_3 is negative and statistically significant. Thus, as candidates gather experience, the discrepancy between data and theory

[45] We experimented with several ways of measuring candidate experience. The substantive conclusions are robust to the various approaches.

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diminishes. The absolute value of β_3 (0.25) is not large. Thus, the rate at which effort discrepancy diminishes is slow.

Another method of estimating the effects of treatment conditions and experience on effort discrepancy explicitly recognizes heterogeneity in the candidate pool. The errors-components approach estimates the following model.

$$d_{it} = \beta_1 Highb_{it} + \beta_2 Highprod_{it} + \beta_3 Exper_{it} + \theta_i + \varepsilon_{it} \tag{1.12}$$

Note that the constant, α, in equation (1.11) is replaced by the fixed effects, θ_i, in equation (1.12). Heterogeneity in the candidate pool is modeled by allowing the θ_i's to vary across candidates.

We estimate equation (1.12) using two approaches. First, we include the fixed effects directly as regressors. The coefficients (β's) are measured by using the within-subject variation in treatment conditions and experience. The results are detailed in column 2 of Table 7. As in the OLS case, the point estimate of β_3 is negative and statistically significant, thereby confirming that as candidates' experience accumulates effort discrepancies decline. Since the fixed effects are treated as regressors, they have no distribution. Nonetheless, a measure of subject heterogeneity can be obtained by computing the sample standard deviation of the mat

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estimated θ_i's ($\widehat{\theta}_i$'s). In the data, the sample standard deviation of the $\widehat{\theta}_i$'s is 5.08. Since the average of candidates' effort discrepancies across Treatments 1 through 4 is 10.67, the sample standard deviation of the $\widehat{\theta}_i$'s represents significant heterogeneity in the candidate pool.[46]

Given the random assignment of candidates to the various treatments, a random-effects (GLS) estimator is consistent and potentially more efficient. The results of the random-effects estimator of equation (1.12) are detailed in column 3 of Table 7. As in the OLS and fixed-effects case, the point estimate of β_3 is negative and statistically significant.[47] Since the fixed effects now have a distribution, we can formally check for heterogeneity in the candidate pool by determining whether the variance of the distribution of the fixed effects is zero. The Breusch and Pagan Lagrange Multiplier test detects heterogeneity in the candidate pool.[48] The results of the three regressions are summarized in the following conclusion.

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[46]Another measure of heterogeneity is the ratio: (sample standard deviation of the $\widehat{\theta}_i$'s) $\div$ (estimated standard deviation of the ε_{it}'s). In the data, this ratio is equal to 0.44. Hence, the conclusion of "significant heterogeneity" is validated.

[47]If the random-effects specification is correct, then fixed- and random-effects estimators should yield comparable point estimates of the β's. We performed a Hausman test (see Hausman (1978)) to check whether the point estimates of the β's in columns two and three of Table 7 are statistically indistinguishable. The null hypothesis of "equality of the $\widehat{\beta}$'s" could not be rejected at the 0.1 level of significance.

[48]Under the null hypothesis of "no heterogeneity," the test statistic is distributed as $\chi^2_{[1]}$. At the 0.1 significance level, the critical value is 2.71. In our dataset, the test statistic assumes a value of 144.56.

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Conclusion 8: As candidates gather experience, the discrepancies between candidates' effort levels and the corresponding theoretical predictions decrease. There is heterogeneity in the candidate pool with respect to effort discrepancy. Thus, the model fits the behavior of some candidates better than others.

Relative Efficiency of Experimental Elections

We conclude by computing the relative efficiency of experimental elections. Our procedure is as follows. For each of the six treatment conditions, proposition 2 places a theoretical upper bound on the effort that can be elicited from candidates in any symmetric and stationary sequential equilibrium. Corresponding to each treatment condition, we pool all the observations and determine the average effort level of candidates. We define relative efficiency to be the ratio of the average candidate effort to its theoretical upper bound. Table 8 in Appendix A presents the results.

To read Table 8, consider the Treatment 1 sessions. The "effort upper bound" of 70.36 is computed by plugging the $B-$ and $k-$values of Treatment 1 ($B = 7425$ and $k = 1$) into the formula, $(\frac{8 \times B}{12 \times k})^{\frac{1}{2}}$, derived in proposition 2. On average, candidates assigned to Treatment 1 expend effort equal to 67.43. Therefore, the

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resulting relative efficiency is $(\frac{67.43}{70.36}) \times 100\% = 95.84\%$.[49]

Two conclusions show up in Table 8. First, relative efficiency averaged over Treatments 1 and 2 (B = 7425) is 79.49% while relative efficiency averaged over Treatments 3 and 4 (B = 5000) is 70.14%. Thus, relative efficiency increases when the private benefit of office is raised. Second, relative efficiency averaged over Treatments 1 and 3 ($(\pi_H - \pi_L) = 1$) is 90.11% while relative efficiency averaged over Treatments 2 and 4 ($(\pi_H - \pi_L) = 0.6$) is 59.51%. Thus, relative efficiency increases when the productivity of candidate effort is raised. We do not possess a theory that accounts for relative efficiency. We simply summarize the above observations in the following conclusion.

<u>Conclusion 9:</u> The relative efficiency of experimental elections is an increasing function of 1) the private benefit of office and 2) the productivity of candidate effort.

[49]For Treatments 5 and 6, since $(\pi_H - \pi_L)$ is equal to zero, proposition 1 maintains that candidates will be unwilling to expend effort. Hence, the upper bounds on effort are zero. To avoid dividing by zero, the relative efficiency numbers are not computed.

1.5.2. Experimental Results for One-Shot Sessions

The one-shot sessions consisted of Treatments 1, 2, 3 and 4. For each treatment condition, we conducted two trials where each trial, in turn, consisted of six election periods. Corresponding to each treatment condition, we pooled all the observations.[50] Table 9 in Appendix A provides a summary of the data.

To read Table 9, consider the Treatment 1 sessions. In the experiment, we conducted two trials with Treatment 1-parameter values. In these trials, the average of candidates' effort levels was 8.58 while the standard deviation was 16.39.[51]

In one-shot sessions, since the reelection pressure is absent, proposition 1 maintains that candidates will be unwilling to expend costly effort. In each of the four treatment conditions, while the theoretically predicted effort level of zero was exceeded, the magnitude of the discrepancy was small. Therefore, we draw the following conclusion.

Conclusion 10: As predicted by proposition 1, when the reelection pressure is

[50] With two trials and six periods per trial, each treatment condition had twelve observations.

[51] In one-shot sessions, voters have no task to undertake. They only receive the period payoffs that are stochastically generated from candidates' effort choices. Thus, effort choices of candidates are the relevant observations for these sessions.

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absent, candidates are willing to expend negligible effort levels.

1.6. Conclusion

Using a principal-agent model of elections with moral hazard, we experimentally investigated the extent to which the desire for reelection elicits costly and unobserved effort from candidates.

The experimental data supports the theoretical predictions. Specifically, the average of candidates' effort levels is an increasing function of the private benefit of office and the productivity of candidate effort. Furthermore, candidates expend negligible effort when the productivity of candidate effort is zero or the reelection pressure is absent.

The individual decisions of voters and candidates reveal two anomalies. First, while voters use candidate performance in determining electoral choices, poor candidate performance is punished less harshly than theoretical models predict. Second, candidates' effort choices respond to the incentives implicit in the elections game, but the average effort level exceeds that predicted by the theoretical model. The reasons for these anomalies are as yet largely unexplained.

Many theoretically-interesting questions remain to be explored. The experiment considered the case of a homogenous electorate — the realized period output

was equally valued by all voters. An extension of the experimental setup could allow the incumbent candidate to divide the realized output in any manner among the voters. The data generated from this modified experiment allow estimation of the loss of electoral accountability from two factors: 1) unobserved candidate effort, and 2) the ability of the incumbent to endogenously select her own "voting constituency."

In addition, our experiment bases candidate evaluation on the sequence of outputs generated. A future extension could graft a spatial structure onto the current model. Specifically, policy-motivated candidates could simultaneously choose unobserved effort levels and locations on a policy space. The data generated from this modified experiment allow estimation of the loss of electoral accountability from two factors: 1) unobserved candidate effort, and 2) differences in policy preferences of the median voter and candidates.

Drawing broad conclusions from our analysis would be a risky undertaking. While the experiments themselves are extensive, the challenge of verisimilitude is a threat to the validity of any experimental research. Our study nonetheless provides a useful look at voters' capacity to overcome the moral hazard problem. Given the institutional structure of repeated elections, voters do have the requisite ability to elicit effort from candidates. However, candidates' effort choices

fall short of the feasible upper bound. Thus, the electorate's ability to sanction candidates is not sufficient to eliminate the rents of office.

1.7. Formal Proofs of Propositions

In this section, we formally prove propositions 1 and 2. Throughout, the notation employed is that of section 1.3.

In section 1.3, we defined the state space of the model — $S \equiv \{s_A, s_B\}$ — and a transition map, $Q : S \times E \to S$. From the formulas supplied in the text, the following equalities are immediate:

$$Q(s_A \mid s_A, e) = Q(s_B \mid s_B, e) \tag{1.13}$$

$$Q(s_A \mid s_B, e) = Q(s_B \mid s_A, e) = (1 - Q(s_A \mid s_A)) \tag{1.14}$$

$$Q(s_A \mid s_A, e) = (\pi_L + e \times (\pi_H - \pi_L)) \times r_H + ((1 - \pi_L) - e \times (\pi_H - \pi_L)) \times r_L \tag{1.15}$$

In section 1.3, we defined the value function $\{V_i(s_j; e)\}_{i,j \in K}$ and supplied the

following relevant formulas:

$$V_A(s_A;e) = (B - k \times [\frac{e^2}{2}]) + \delta \times (Q(s_A \mid s_A, e) \times V_A(s_A;e) + Q(s_B \mid s_A, e) \times V_A(s_B;e)) \tag{1.16}$$

$$V_A(s_B;e) = \delta \times (Q(s_A \mid s_B, e) \times V_A(s_A;e) + Q(s_B \mid s_B, e) \times V_A(s_B;e)) \tag{1.17}$$

For fixed voters' strategy — i.e., r_L, r_H held constant — $\overline{e}(B, k, \delta, \pi_L, \pi_H; r_L, r_H)$ denotes the symmetric equilibrium effort level of both candidates. For notational convenience, we suppress the dependence on B, k, δ, π_L and π_H and write, instead, $\overline{e}(r_L, r_H)$. From equation (1.1) of section 1.3, it is clear that for all $\tilde{e} \in E$, $\overline{e}(r_L, r_H)$ satisfies the following inequality:

$$\begin{aligned} V_A(s_A; \overline{e}(r_L, r_H)) \geq \; & (B - (k \times \tilde{e}^2) \div 2) + \delta \times (Q(s_A | s_A, \tilde{e}) \times \\ & V_A(s_A; \overline{e}(r_L, r_H)) + Q(s_B | s_A, \tilde{e}) \times V_A(s_B; \overline{e}(r_L, r_H))) \end{aligned} \tag{1.18}$$

In other words, the right-hand side of equation (1.18) attains its maximum value

when $\tilde{e}$ is set equal to $\overline{e}(r_L, r_H)$. Therefore, the derivative of the right-hand side of equation (1.18) with respect to $\tilde{e}$ equals zero when evaluated at $\overline{e}(r_L, r_H)$. Performing the above manipulations, we obtain the following condition:

$$\overline{e}(r_L, r_H) = (\frac{\delta}{k}) \times (r_H - r_L) \times (\pi_H - \pi_L) \times (V_A(s_A; \overline{e}(r_L, r_H)) - V_A(s_B; \overline{e}(r_L, r_H))) \tag{1.19}$$

Subtracting equation (1.17) from equation (1.16) and rearranging terms, we obtain the following condition:

$$(V_A(s_A; e) - V_A(s_B; e)) \times (1 - \delta \times Q(s_A|s_A; e) - \delta \times Q(s_B|s_A; e)) = (B - k \times [\frac{e^2}{2}]) \tag{1.20}$$

Combining equation (1.19) and equation (1.20) and rearranging terms, we obtain the following condition:

$$\overline{e}(r_L, r_H) \times (1 - \delta \times Q(s_A|s_A; \overline{e}(r_L, r_H)) - \delta \times Q(s_B|s_A; \overline{e}(r_L, r_H))) =$$

$$(B - k \times \overline{e}(r_L, r_H)^2 \div 2) \times (\frac{\delta}{k}) \times (r_H - r_L) \times (\pi_H - \pi_L) \qquad (1.21)$$

We use equation (1.14) and equation (1.15) to plug in the formulas for $Q(s_A|s_A;\overline{e}(r_L,r_H))$ and $Q(s_B|\ s_A;\overline{e}(r_L,r_H))$ in equation (1.21). Rearranging terms, we obtain the following quadratic equation:

$$\alpha \times \overline{e}(r_L, r_H)^2 - \beta \times \overline{e}(r_L, r_H) + \gamma = 0 \qquad (1.22)$$

where:

$$\alpha = \delta \times (\pi_H - \pi_L) \qquad (1.23)$$

$$\beta = (2 \times (1 + \delta - 2 \times \delta \times \overline{\pi})) \div (3 \times (r_H - r_L)) \qquad (1.24)$$

$$\gamma = (\frac{2}{3}) \times (\frac{\delta}{k}) \times B \times (\pi_H - \pi_L) \qquad (1.25)$$

Consider $\delta = 0$ or $(\pi_H - \pi_L) = 0$. Then, $\alpha = \gamma = 0$ (see equations (1.23) and (1.25)). It follows from equation (1.22) that $\overline{e}(r_L, r_H) = 0$. Consider, now, $\delta > 0$ and $(\pi_H - \pi_L) > 0$. The solution to equation (1.22) is as follows:

$$\overline{e}(r_L, r_H) = \left\{ b - \sqrt{b^2 - \frac{8 \times B}{3 \times k}} \right\} \div 2; \text{ where } b \equiv \beta \div (\pi_H - \pi_L) \qquad (1.26)$$

Direct computations reveal that $\overline{e}(r_L,\ r_H)$ is increasing in B, δ and π_H and decreasing in π_L and k. Hence, proposition 1 is proved.

When $\delta > 0$ and $(\pi_H - \pi_L) > 0$, we obtain the upper bound on candidate effort by maximizing $\overline{e}(r_L, r_H)$ in equation (1.26) with respect to r_L and r_H. The upper bound, denoted $\overline{e}^u$, obtains when $(r_L,\ r_H)$ is such that $b^2 = (\frac{8 \times B}{3 \times k})$. The corresponding $\overline{e}^u$–value is $[\frac{8 \times B}{12 \times k}]^{\frac{1}{2}}$. Hence, proposition 2 is proved. (Note: The formula for $\overline{e}^u$ reveals that $\overline{e}^u \in E$ iff $[\frac{8 \times B}{12 \times k}]^{\frac{1}{2}} < 1$. We ensure that this condition is satisfied in all experimental setups.)

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2. CHAPTER 2: SIGNALING IN ONE-SHOT AND REPEATED ELECTIONS — SOME EXPERIMENTAL EVIDENCE

2.1. Introduction

A key factor in the social contract is the voter's ability to sanction public officials. This presupposes that citizens can distinguish between "good" and "bad" outcomes and that they also estimate, with some degree of accuracy, the extent to which realized outcomes reflect candidate characteristics. In a complete information environment, electoral accountability can be readily achieved. However, if informational asymmetries characterize all real-world democracies, then the relevant policy question becomes: how does the quality of available information affect a representative democracy?

Researchers have examined this question by constructing abstract election models that acknowledge, in varying detail, the presence of informational frico je

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tions between voters and potential candidates. Theoretical discussions subdivide into two categories: Barro (1973), Ferejohn (1986), and Austen-Smith and Banks (1989) consider informational problems from a moral hazard (hidden action) perspective; Rogoff and Sibert (1988), Alesina and Cukierman (1990), Reed (1990), Rogoff (1990), Harrington (1993), and Banks and Sundaram (1993) consider informational problems from an adverse selection (hidden types) perspective. By computing a model's equilibrium, the theoretical exercises investigate the effect of information in an election environment.

The theoretical literature provides intuition regarding the performance of democratic systems when information is of poor quality. Yet, predictive validity is difficult to ascertain. Without exception, electoral outcomes depend on variables such as information structure, characteristics of utility functions, values of rewards and punishments. Data seldom provide even error-laden measures of the aforementioned variables.[52] Therefore, we adopt a different stance. First, we construct a model of elections that incorporates informational asymmetries between the elected public officials and the electorate. Second, we evaluate the theoretical model using experimental techniques.[53] Within the structured environment of a

[52] A large empirical literature tests the reduced form comparative static predictions of theoretical political-agency models. Examples include Kalt and Zupan (1990), Lott and Davis (1992), Lott and Bronars (1993), and Besley and Case (1995a, 1995b).

[53] We are not arguing that experimental methods are intrinsically superior to non-experimental

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laboratory, it is relatively simple to both induce and systematically control the values of the parameters of interest. This allows for a thorough consistency-check of the theory.

Our theoretical model is based on the idea that although the quest for reelection is dependent on various exogenous factors (health of the economy, redistricting, public mood, etc.), incumbent candidates, in addition to revealing preferences on underlying issues, also desire to stress that they are of high competency. We treat competency as a shorthand for attributes (administrative efficiency, policy expertise, etc.) that all voters find desirable. Therefore, when an incumbent candidate possesses an abundance of such attributes, she will wish to emphasize them. However, the electorate never directly observes the competency parameter. It follows that the electorate encounters an adverse selection environment.

The baseline model is a one-shot election with one incumbent candidate and an electorate of identical voters. The sequence of events is as follows. The incumbent candidate, cognizant of her competency level, implements a privately costly but publicly observable policy (casework solicitation, sponsoring of legislation, etc.). Consistent with the principal-agent literature, the marginal and average

methods. Rather, they are a valid tool for testing theory when naturally occuring data is of dubious quality. The close relationship between experimental evidence and innovative field studies is explored in Roth (1991).

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cost in policy-space is presumed to be decreasing in the incumbent candidate's competency level. Once the incumbent candidate's policy choice is witnessed, the electorate attempts to evaluate her implicit competency. Thereafter, if the estimated competency is satisfactory, reelection follows.

We compute the set of rational expectations equilibria. The presence of private candidate-specific information leads to multiple equilibria that are qualitatively distinct. The equilibrium set can be divided into two cases. In the "pooling" case, the incumbent candidate's choice of policy does not depend upon her competency level. The consequent lack of transmission of competency information leads to electoral outcomes that are inefficient. By contrast, in the "separating" case, the incumbent candidate's choice of policy increases with her competency level. Since there is complete transmission of competency information, electoral outcomes are efficient.

To test the predictions of the model, we conducted a series of laboratory experiments. A primary goal of the experimental work was to sort out the various factors that could affect equilibrium selection. To this end, we varied three background conditions of interest: 1) the incumbent candidate's private benefit of holding office; 2) the incumbent candidate's private cost of implementing policy; and 3) the amount of information available to voters.

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We also conducted experimental sessions involving repeated interactions. In a repeated-interactions session, with the composition of the electorate held fixed, the same candidate subject participated in a series of structurally identical election periods. This allows the incumbent candidate to develop reputations of various kinds. The experiments were designed to examine the robustness of one-shot experimental outcomes to reputational considerations.

In both one-shot and repeated-interactions sessions, experimental outcomes are, for the most part, consistent with equilibrium signaling. Since candidate specific information is transmitted in a signaling equilibrium, experimental elections are informationally efficient. Somewhat surprisingly, background conditions (electorate's information level and parameters of the utility functions) do not substantively affect the probability with which signaling emerges in the experimental setups. In sum, extant theoretical models of elections with adverse selection demonstrate the coesxistence of pooling and signaling equilibria. Using experimental techniques, our study establishes that signaling is likely to be observed in practice.

The remainder of this chapter is organized as follows. In section 2.2 we describe the experimental model. Section 2.3 provides the analytical solution(s) to the experimental model for both the one-shot and repeated interactions cases.

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The experimental design for our empirical tests is in section 2.4 and the results are described in section 2.5. Section 2.6 concludes the chapter from a substantive perspective. All analytical proofs are relegated to section 2.7 while tables presenting the empirical results are gathered in Appendix B.

2.2. The Experimental Model

The model consists of two periods. The basic setup is as follows. There is one incumbent candidate and one challenger. The incumbent exhibits either high competence, I_H, or low competence, I_L. I_H and I_L are represented as elements (numbers) in $\Re_+$ with $I_H > I_L$. Similarly, a challenger possesses either high competence, C_H, or low competence, C_L — and just as with I_H and I_L — C_H and C_L are represented as elements in $\Re_+$ with $C_H > C_L$. A candidate's type is not known to voters. The commonly known and shared prior belief is that there is a probability $\pi \in (0, 1)$ that a candidate is highly competent and a probability $1 - \pi$ that she possesses low competence.

At the beginning of the period, the incumbent candidate chooses a policy outcome, denoted $y_I \in \Re_+$, at a privately borne cost given by $k \times [\frac{y_I^2}{I_X}]$.[54] Two assumptions are implicit in the cost function. First, the incurred cost is a convex

[54]Recall that policy outcomes refer to the tangible benefits conferred upon the incumbent candidate's constituents. Examples include pork barrel projects and casework.

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and increasing function of the policy outcome level. Second, total and marginal cost in policy-space is lower for the high competency incumbent candidate than for the low competency incumbent candidate.[55]

All voters observe the choice of y_I. Once y_I is observed, the electorate votes and decides, by majority rule, whether to reelect the incumbent candidate. Following the vote, period one concludes.

Before proceeding, we introduce additional notation for later use. Both V and B are mappings from the positive real numbers, $\Re_+$, to $[0, 1]$. $V(y_I)$ is the proportion of votes cast in favor of the incumbent candidate when the observed policy outcome is y_I. Conditional on having observed the policy outcome y_I, $B(y_I)$ is the electorate's posterior probability that the incumbent has high competence (I_H).[56] When the policy outcome is y_I and the electorate uses vote function V, $P(V, y_I)$ is the probability with which the incumbent candidate is reelected.

In period two, the incumbent candidate and voters receive their payoffs. Should the incumbent candidate be reelected, she receives a gross reward of W, where W represents the value of holding office for a single additional term. When the

[55]The "total" and "marginal cost" conditions are equivalent to the single-crossing property of Spence (1973). For a detailed theoretical treatment of one-period signaling games, see Mailath (1987). For a detailed survey of signaling games in political science, see Banks (1991).

[56]Voters have identical information and preferences. In equilibrium, the beliefs and vote decisions of voters should be indistinguishable. Thus, it is legitimate to let B and V represent, respectively, "the" electorate's beliefs and vote function.

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electorate adopts the vote function V and the incumbent candidate of type, I_X, chooses policy outcome, y_I, her net expected payoff is given by $[W \times P(V, y_I) - k \times [\frac{y_I^2}{I_X}]]$.

Consider, now, a voter's payoff. Should the incumbent candidate be reelected, each voter receives a payoff of $R(I_X)$. Otherwise, each voter's payoff is $R(C_X)$ since the challenger is elected. We maintain, furthermore, that: 1) $R(I_H) = R(C_H)$; 2) $R(I_L) = R(C_L)$; and 3) $R(\_,_H) > R(\_,_L)$. Two observations clarify our interpretation of voters' payoffs. First, a voter's interest in the incumbent candidate is restricted to her competency. Policy outcome is relevant only because it provides a noisy signal of the incumbent's competency. Second, when voters reject the incumbent candidate, their subsequent payoffs are also random due to the ex ante uncertainty concerning the competency of the new office holder.[57] In words, if voters are convinced that the incumbent is of low competence, they are to take a chance on the challenger being highly competent.

[57] A more elaborate model would allow voters' payoffs to depend on period one policy outcome, y_I, the incumbent candidate's type, I_X, as well as the policy outcome and type of the period two incumbent candidate. However, it can readily be established that in any subgame perfect equilibrium of our "elaborate" model, the policy outcome selected by the period two incumbent candidate is 0. Thus, electoral decisions in period one reduce to a choice between the incumbent candidate and her challenger on the basis of their type characteristics. The simple model presented in section 2.2 fully captures the asymmetric information aspects of the vote decision.

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2.3. Solution to the Experimental Model

While our experimental model is a one-period game, the experimental sessions were of two sorts. In one-shot sessions, we approximate the single period interaction between the incumbent candidate and the electorate at large. By contrast, in repeated-interactions sessions, we allow the incumbent candidate to participate in a sequence of structurally identical election periods. Consequently, the repeated-interactions sessions allow for the possibility of supergame strategies.

The motivation for introducing two session-types is twofold. First, by mimicing our baseline experimental model, the one-shot sessions enables us to evaluate its predictive validity. Second, by contrasting the experimental findings across session-types, we evaluate the extent to which reputational considerations displace the predictions of one-period signaling games.

In this section, we provide theoretical solutions for our experimental model for both the one-shot and repeated-interactions case. We consider first the one-shot version.

2.3.1. Model Solution: The One-Shot Case

In this subsection, we define and characterize rational expectations equilibria (hereafter, r.e.e.) of the one-shot model. An r.e.e., denoted by the triple $<$

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$Y^*, B^*, V^* >$, is comprised of three parts: $Y^*(I_L)(Y^*(I_H))$ is the policy outcome chosen by the incumbent candidate when her competency turns out to be low (high). Conditional on the realized policy outcome y_I, $B^*(y_I)$ is the electorate's belief function about candidate competency while $V^*(y_I)$ is the electorate's vote function.

Definition 1: We call $<Y^*, B^*, V^*>$ a one-shot r.e.e. if and only if the following three conditions are satisfied:

(i) $Y^*(I_X) \in \underset{y_I \in \Re_+}{\arg\max} \; [W \times P(V^*, y_I) - k \times [\frac{y_I^2}{I_X}]]$

$$\text{(ii) } B^*(y_I) = \begin{cases} 1 & \text{if} \quad y_I = Y^*(I_H) \text{ and } Y^*(I_H) \neq Y^*(I_L) \\ 0 & \text{if} \quad y_I = Y^*(I_L) \text{ and } Y^*(I_H) \neq Y^*(I_L) \\ \pi & \text{if} \quad y_I = Y^*(I_X) \text{ and } Y^*(I_H) = Y^*(I_L) \end{cases}$$

$$\text{(iii) } V^*(y_I) = \begin{cases} 1 & \text{if} \quad B^*(y_I) > \pi \\ 0 & \text{if} \quad B^*(y_I) < \pi \end{cases}$$

Since the incumbent candidate is a rational actor, condition (i) maintains that the policy outcome choice must maximize her expected ex ante utility. We also require that the electorate's belief function be consistent with the incumbent candidate's policy outcome choice. Specifically, condition (ii) stipulates that for y_I on the

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equilibrium path (i.e., $y_I \in \{Y^*(I_L), Y^*(I_H)\}$), beliefs are pinned down by Bayes' Rule. Suppose that the electorate observes a policy outcome of y_I. $B^*(y_I)$ is the posterior probability that the incumbent candidate is of type I_H. Therefore, if the incumbent gets reelected, each voter receives a payoff of $R(I_H)$ with probability $B^*(y_I)$ and $R(I_L)$ with probability $(1 - B^*(y_I))$. If the challenger is elected, each voter receives a payoff of $R(C_H)$ with a probability π and $R(C_L)$ with probability $(1 - \pi)$. Since voters maximize their expected payoff, condition (iii) requires that the challenger (incumbent) be selected when $B^*(y_I)$ exceeds (is less than) π.

While details of the r.e.e. are given in section 2.7, we summarize the main findings. The model generates multiple equilibria. The set of equilibria can be divided into two cases. In case one, the "pooling case," $Y^*(I_L) = Y^*(I_H)$. In case two, the "separating case," $Y^*(I_L) \neq Y^*(I_H)$. We consider the pooling (separating) case in Proposition 1 (Proposition 2).

Proposition 1: There is a continuum of pooling equilibria. By definition, in a specific pooling equilibrium, $Y^*(I_L) = Y^*(I_H) \equiv y^*$. Any $y^* \in [0, [[\frac{W}{k}] \times I_L]^{\frac{1}{2}}]$ can be supported as an equilibrium outcome.

In a pooling equilibrium, the incumbent candidate's choice of policy outcome,

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y^*, is independent of her competency. The electorate realizes that the observed y^* is a thoroughly uninformative signal. Given that the incumbent candidate and her challenger are ex ante identical in terms of competency, the incumbent candidate is reelected with some prespecified probability. As a result, the electoral system is informationally inefficient. Ex post informational efficiency requires that the incumbent candidate be reelected if and only if she possesses high competency. Since votes cast are not conditioned on the incumbent's type, informational efficiency occurs only by chance.

The continuum of pooling equilibria can be ranked in terms of aggregate welfare. Recall that the policy outcome does not directly affect a voter's payoff: the policy outcome is relevant only because it potentially contains information about the incumbent candidate's competency. In every pooling equilibrium, y^* transmits no competency information. Thus, a voter's expected payoff in every pooling equilibrium is the same. However, since higher values of y^* impose larger costs on the incumbent candidate, her net payoff is maximized in the pooling equilibrium with the smallest policy outcome level (i.e., $y^* = 0$). Aggregate welfare, measured as the sum of the payoffs of all agents (the incumbent candidate and voters) in the model, is maximized when $y^* = 0$. Aggregate welfare declines as y^* is raised.

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Proposition 2: There is a continuum of separating equilibria. By definition, in a specific separating equilibrium, $Y^*(I_L) \neq Y^*(I_H)$. Any pair $\{Y^*(I_L), Y^*(I_H)\}$ such that: 1) $Y^*(I_L) = 0$ and 2) $Y^*(I_H) \in [[\frac{W}{k}] \times I_L]^{\frac{1}{2}}, [[\frac{W}{k}] \times I_H]^{\frac{1}{2}}]$ can be supported as an equilibrium outcome.

In a separating equilibrium, the incumbent candidate's choice of policy outcome varies with her competency. The electorate recognizes that the observed y_I is a fully informative signal of the incumbent's competency. Reelection of the incumbent occurs if and only if $y_I = Y^*(I_H)$. Equivalently, the incumbent candidate is reelected if and only if she possesses high competency. Therefore, the electoral system is ex post informationally efficient.

The continuum of separating equilibria can also be ranked in terms of aggregate welfare. In every separating equilibrium, the policy pair $\{Y^*(I_L), Y^*(I_H)\}$ completely transmits the incumbent candidate's competency information to the electorate. Thus, a voter's expected payoff in every separating equilibrium is the same. However, since higher values of $Y^*(I_H)$ impose larger costs on the incumbent candidate, her net payoff is maximized in the separating equilibrium with minimal separation — i.e., $\{Y^*(I_L), Y^*(I_H)\} = \{0, [[\frac{W}{k}] \times I_L]^{\frac{1}{2}}\}$. Aggregate welfare, measured as the sum of incumbent candidate's and voter's payoffs, is a pos

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maximized at this "minimal separation" equilibrium. Aggregate welfare declines as $Y^*(I_H)$ is raised.

The principal characteristics of the equilibria generated by our experimental model are: 1) for a fixed set of exogenous parameters, there is a continuum of equilibria. The equilibrium set can be divided into a "pooling set" and a "separating set"; 2) in a pooling equilibrium, no information is transmitted regarding the competency of the incumbent candidate and the electoral system is ex post informationally inefficient. In a separating equilibrium, the incumbent candidate's competency is fully revealed to the electorate. Consequently, the electoral system is ex post informationally efficient.

2.3.2. Model Solution: The Repeated-Interactions Case

Since our subjects participated in a sequence of structurally identical games with uncertain termination date, we employ the theory of repeated games to provide theoretical guidance regarding likely experimental outcomes. Given our multi-player, repeated-interactions environment, Folk theorem-type results guarantee the existence of an abundance of equilibria. For the purposes of sharper predictions, we focus on solutions that satisfy an additional condition of stationarity.[58]

[58]Stationarity is satisfied if along the equilibrium path: 1) the incumbent candidate of competency I_X selects a time- and history-independent policy $Y^*(I_X)$; and 2) the electorate reelects

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The emphasis on stationarity yields an extra dividend: solutions for one-shot and repeated-interactions setups become directly comparable.

As in the one-shot case, the equilibrium set can be divided into two cases. In the "pooling case," the incumbent candidate chooses the same policy outcome for both levels of competency. In the "separating case," the incumbent candidate chooses policy outcomes that vary with her competency. We consider the pooling (separating) case in Definition 2 and Proposition 3 (Definition 3 and Proposition 4).

In a pooling equilibrium — along the equilibrium path — $Y^*(I_L) = Y^*(I_H) \equiv y^*$ is the policy outcome chosen by the incumbent candidate. Also, 1) $V^*(y^*)$ is the portion of votes cast in favor of the incumbent candidate; 2) $P(V^*, y^*)$ is the resulting probability with which the incumbent candidate is reelected; and 3) $B^*(y^*)$ is the electorate's posterior probability that I_X is equal to I_H. Finally, $Q^*(I_X)$ denotes the incumbent candidate's expected discounted sum of payoffs over the infinite horizon when her current competency is I_X. Given the above notation, it is immediate that: $Q^*(I_X) = [W \times P(V^*, y^*) - k \times [y^*]^2 \div I_X] + \delta \times [(1-\pi) \times Q^*(I_L) + \pi \times Q^*(I_H)]$, where δ is the probability with which the game is continued from one period to the next.

the incumbent candidate with a time- and history-independent probability $P(V^*, Y^*(I_X))$.

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Definition 2: We call $<y^*, B^*(y^*), V^*(y^*)>$ a stationary path of a repeated- interactions pooling equilibrium if and only if the following two conditions are satisfied:

(i) $Q^*(I_L) \geq 0$ and $Q^*(I_H) \geq 0$

(ii) $B^*(y^*) = \pi$ and $V^*(y^*) \in (0, 1)$

To support "repeated play of y^*" as an equilibrium path, we need to specify voter behavior subsequent to a possible deviation by the incumbent candidate. Given our experimental setup, any candidate deviation from the pooling equilibrium in period-t is immediately detected by the electorate. Without loss of generality, we invoke the harshest possible punishment following a deviation: from period-t onwards, the incumbent candidate is never selected by the electorate.[59] Subsequent to a deviation, the incumbent candidate's expected discounted sum of payoffs over the infinite horizon is 0. Thus, condition (i) ensures that it is unprofitable for the incumbent candidate to deviate from the putative pooling equilibrium. Consider, now, condition (ii) of the above definition. Since the equi-

[59] Such drastic punishments can easily be supported as part of a repeated-game equilibrium. Specifically, following a deviation, let the electorate harbor the belief that $B(y_I) = \pi; \forall\, y_I \in Y$. Since the electorate is now indifferent between the incumbent candidate and her challenger, it becomes rational to always reject the incumbent candidate. Finally, given voter behavior, the incumbent candidate, for both levels of competency, chooses a policy outcome of 0.

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librium choice of policy outcome, y^*, does not reveal the incumbent candidate's current competency level, the electorate's posterior assessment about candidate competency equals its prior assessment. Hence, $B^*(y^*) = \pi$. Finally, given the electorate's beliefs, the incumbent candidate and her challenger are identical options. As a result, the electorate's vote behavior, summarized by $V^*(y^*)$, remains unconstrained.

Proposition 3: There is a continuum of stationary pooling equilibria. By definition, in a specific pooling equilibrium, $Y^*(I_L) = Y^*(I_H) \equiv y^*$. Any $y^* \in [0, \lambda \times [[\frac{W}{k}] \times I_L]^{\frac{1}{2}}]$ can be supported as an equilibrium outcome, where $\lambda \equiv [I_H \div [I_H - \delta \times \pi \times [I_H - I_L]]]^{\frac{1}{2}}$ is greater than 1.

As in the one-shot setup, stationary pooling equilibria in the repeated- interactions setup are both informationally inefficient and Pareto ordered. Furthermore, a comparison of propositions 1 and 3 shows that the set of pooling equilibrium outcomes expands relative to the one-shot setup when reputational considerations are introduced through the repeated-interactions setup.

In a separating equilibrium — along the equilibrium path — $Y^*(I_L)(Y^*(I_H))$ is the policy outcome chosen by the incumbent candidate when her competency

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is I_L (I_H). Also, for $I_X \in \{I_L, I_H\}$: 1) $V^*(Y^*(I_X))$ is the proportion of votes cast in favor of the incumbent candidate when the chosen policy outcome is $Y^*(I_X)$; 2) $P(V^*, Y^*(I_X))$ is the resulting probability with which the incumbent candidate of type I_X is reelected; and 3) $B^*(Y^*(I_X))$ is the electorate's posterior probability that I_X is equal to I_H conditional on observing the policy outcome $Y^*(I_X)$. Finally, $Q^*(I_X)$ denotes the incumbent candidate's expected discounted sum of payoffs over the infinite horizon when her current competency is I_X. Given the above notation, it is immediate that: $Q^*(I_X) = [W \times P(V^*, Y^*(I_X)) - k \times [Y^*(I_X)]^2 \div I_X] + \delta \times [(1-\pi) \times Q^*(I_L) + \pi \times Q^*(I_H)]$, where δ is the probability with which the game is continued from one period to the next.

<u>Definition 3:</u> We call $<Y^*(I_X), B^*(Y^*(I_X)), V^*(Y^*(I_X)) \mid I_X \in \{I_L, I_H\}>$ a stationary path of a repeated-interactions separating equilibrium if and only if the following four conditions are satisfied:

(i) $Q^*(I_L) \geq [W \times P(V^*, y_I) - k \times [y_I]^2 \div I_L]; \forall y_I \in Y \backslash \{Y^*(I_L)\}$

(ii) $Q^*(I_H) \geq [W \times P(V^*, y_I) - k \times [y_I]^2 \div I_H]; \forall y_I \in Y \backslash \{Y^*(I_H)\}$

(iii) $B^*(Y^*(I_L)) = 0$ and $B^*(Y^*(I_H)) = 1$

(iv) $V^*(Y^*(I_L)) = 0$ and $V^*(Y^*(I_H)) = 1$

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To support "repeated play of $\{Y^*(I_L), Y^*(I_H)\}$" as an equilibrium path, we need to specify voter behavior subsequent to a possible deviation by the incumbent candidate. If a low competency incumbent deviates from the separating equilibrium in period t, her period-t payoff is the right-hand-side expression of condition (i). However, the period-t candidate deviation is detected by the electorate prior to period-$(t+1)$ play. Therefore, from period $(t+1)$ onwards the incumbent candidate is never selected by the electorate. Subsequent to a deviation, the incumbent candidate's expected discounted sum of payoffs over the infinite horizon is the right-hand-side expression of condition (i). Thus, condition (i) ensures that it is, at all times, unprofitable for a low competency incumbent candidate to deviate from the putative separating equilibrium. Condition (ii) is the corresponding "no profitable deviation" criterion for a high competency incumbent candidate. Condition (iii) demands that voters' beliefs be consistent with the fact that the equilibrium choice of policy outcome reveals the incumbent candidate's current competency level. Condition (iv) requires that the electorate maximize its own payoff by reelecting the incumbent candidate if and only if the observed policy outcome is $Y^*(I_H)$.

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Proposition 4: In the repeated-interactions experimental model, there is a continuum of stationary separating equilibria. The stationary separating equilibria are both informationally efficient and Pareto ordered.[60] The set of separating equilibrium outcomes for the repeated-interactions setup strictly includes that corresponding to the one-shot setup.

2.4. Experimental Design

To test the predictions of the electoral model, we performed a series of experiments using undergraduates from a large public university. In the recruitment stage, care was taken to ensure that the subjects were unexposed to formal decision/ game theory. The experiments were conducted on a computer network system and, except for reading the instructions (available upon request), all communication took place over the network.

The experimental sessions were of two sorts: one-shot and repeated-interactions sessions. The amount of information available to voters varied. In full-information sessions, only the incumbent candidate's realized competency, I_X, was left undisclosed. By contrast, in incomplete-information sessions, voters were unaware of the parameters in the incumbent candidate's utility function. The experimental

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procedures followed in each session type are detailed below.

2.4.1. One-Shot Setup - Experimental Procedures

An experimental session consisted of a cohort of fifteen subjects divided into an electorate of five voters and a pool of ten potential candidates. A trial, with a fixed configuration of parameter values, lasted for either ten or twenty structurally identical election periods. In a ten-period (twenty-period) trial, each candidate was randomly chosen to participate in exactly one (two) of the election periods. The fixed termination date, coupled with randomly chosen candidate subjects, was deemed sufficient to eliminate supergame considerations. In full-information situations, all subjects were aware of the trial-specific parameter values for W, k, $\pi, R(_{-,L})$ and $R(_{-,H})$. In incomplete-information situations, only candidates were aware of all trial-specific parameter values. Voters were apprised of their own payoff-specific parameter values $(\pi, R(_{-,L}), R(_{-,H}))$. A detailed account of the experimental procedures adopted in a ten-period (twenty-period) trial follows.

[Step 1] At the start of election period t, one candidate, denoted $i(t)$, was designated to be the period-t incumbent candidate. Only candidate $i(t)$ was made aware of her role assignment.

[Step 2] The computer program generated a random variable, denoted I_t, where

I_t assumed the value of I_L (I_H) with probability $(1-\pi)(\pi)$. Only candidate $i(t)$ was made aware of her realized competency, I_t.

[Step 3] Candidate $i(t)$ selected her policy outcome, y_t, from the four-point set, $Y \equiv \{0, 3, 6, 9\}$. The recorded y_t-value was transmitted to all subjects.[61]

[Step 4] Given y_t, voters cast their ballots and decided, by majority rule, to reelect or reject candidate $i(t)$. Once votes were tallied, the final outcome of the election, as well as the vote margins realized were transmitted to all subjects.

[Step 5] Candidate $i(t)$ and the five voters received their period-t payoffs according to the rules of the model in section 2.2.

[Step 6] The computer program switched to election period $(t+1)$. At the end of ten (twenty) election periods, the trial terminated. Each subject's payoff for the trial was the sum of her period payoffs.

2.4.2. Repeated-Interactions Setup - Experimental Procedures

An experimental session consisted of a cohort of subjects divided into an electorate of five voters and a pool of ten potential candidates. A trial, with a fixed configuration of parameter values, lasted for a variable number of structurally

[61] While the theoretical model in section 2.2 allows the policy outcome set to be $\Re_+$, we have, for tractability, restricted the experimental policy outcome set, Y, to be $\{0, 3, 6, 9\}$. The distinction between pooling and separating outcomes, as well as equilibrium multiplicity, applies to Y.

identical election periods and involved the electorate facing the same candidate each time. The uncertain termination date, coupled with an unchanging candidate, was deemed sufficient to induce the possibility of reputational equilibria. As in the one-shot case, repeated-interactions sessions were of two types: full-information and incomplete-information. The information available to subjects in each session mirrored that of the one-shot setup. A trial proceeded as follows.

[Step 1] At the start of the trial, one candidate was designated to be the incumbent candidate. Only the chosen candidate knew her role assignment.

[Step 2] At the start of election period t, the computer program generated a random variable, denoted I_t, where I_t assumed the value of I_L (I_H) with probability $(1-\pi)(\pi)$. Only the incumbent candidate knew her competency, I_t.

[Step 3] The incumbent candidate selected her period-t policy outcome, y_t, from the four-point set, $Y \equiv \{0, 3, 6, 9\}$. The recorded y_t-value was transmitted to all subjects.

[Step 4] Given y_t, voters cast their ballots and decided, by majority rule, to reelect or reject the incumbent candidate. Once votes were tallied, the final outcome of the election, as well as the vote margins realized were transmitted to all subjects.

[Step 5] The incumbent candidate and the five voters received their period-t

payoffs according to the rules of the model in section 2.2.

[Step 6] The computer program switched to election period $(t+1)$. At the end of a stochastic number of election periods, the trial terminated.[62] Each subject's payoff for the trial was the sum of her period payoffs.

2.4.3. Experimental Parameter Values

An experimental session consisted of a number of trials. Individual trials differed in the values assumed by the five exogenous parameters: W, k, I_L, I_H, and π. Table 10 in Appendix B displays the parameter value combinations that were considered. For example, in Treatment 1, we set the benefit of reelection, W, to be 600; the scale parameter of policy cost, k, to be 100; the "low" competency level, I_L, to be 1; the "high" competency level, I_H, to be 10; and the prior probability of a high competency incumbent candidate, π, to be 0.5. The parameter values in Table 10 correspond to subjects' payoffs denominated in a laboratory currency called the franc. At the conclusion of the experimental session, cumulative earnings in francs were converted into dollars using a preassigned exchange rate.

The primary goal of our experimental work was to sort out the factors that

[62]Each trial lasted for at least fifteen election periods. Thereafter, at the conclusion of each election period, the trial was terminated with a probability of $\frac{1}{10}$. Subjects were aware that the termination date of a trial was stochastic. They were not apprised of the process by which trial length was determined.

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affect equilibrium selection. We considered the influence of two potentially important factors. First, by a pairwise comparison of Treatments 1 and 2, we investigated the influence of policy cost. Specifically, if policy cost (k) is increased (or decreased), is there a systematic effect on the equilibrium selected? Second, by a pairwise comparison of Treatments 2 and 3, we considered the effect of reelection benefits. If the reelection benefit (W) is increased (or decreased), is there a systematic effect on the equilibrium selected? The equilibrium predictions of the one-shot and repeated-interactions models are detailed, respectively, in Tables 11 and 12 of Appendix B.

A pooling equilibrium is a two-element vector. The first element is the policy outcome chosen by the incumbent candidate; the second element is the probability of reelection. A separating equilibrium is a four-element vector. The first element is the policy outcome chosen by the incumbent candidate when her competency is low; the second element is the policy outcome chosen by an incumbent with high competency; the third element is the probability of reelection when the observed policy outcome is $Y^*(I_L)$; the fourth element is the probability of reelection if the observed policy oucome is $Y^*(I_H)$.

For each treatment condition, the one-shot model generates multiple pooling equilibria (column two of Table 11). The pooling equilibria are obtained as follows.

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We plug the values of the exogenous parameters from Table 10 into proposition 1 to recover the y^*-values that can be supported as outcomes of some pooling equilibrium. It can be demonstrated (see section 2.7) that if $y^* \neq 0$, the reelection probability must be one.

The cost of implementing policy, k, is smaller in Treatment 2 than in Treatment 1; the benefit of reelection, W, is larger in Treatment 3 than in Treatment 2. A decrease in policy cost or an increase in reelection benefit makes pooling relatively attractive. Thus, there is an increase in the number of pooling equilibria as we move from Treatment 1 to Treatment 3. Since no payoff-relevant information is transmitted in a pooling equilibrium, efficient pooling requires that the chosen policy outcome be the cost minimizing one, $Y^*(I_X) = 0$. This intuition is reflected in the entries in column three of Table 11.

The set of separating equilibria for the one-shot model (column four of Table 11) is obtained as follows. We plug the parameter values from Table 10 into proposition 2 to obtain the pairs $(Y^*(I_L), Y^*(I_H))$ that can be supported as outcomes of some separating equilibrium. The reelection probability corresponding to $Y^*(I_L)$ $(Y^*(I_H))$ is 0(1). Thus, a particular separating equilibrium, in the notation of Table 11, becomes $(Y^*(I_L), Y^*(I_H), 0, 1)$.

For Treatments 1 and 2, there are multiple separating equilibria. As we move

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from Treatment 1 to Treatment 3, separation becomes increasingly difficult and the set of separating equilibria shrinks to a singleton. Since all payoff-relevant information is transmitted in a separating equilibrium, efficient separation requires that policy choices corresponding to candidate competencies I_L and I_H be distinct and as small as possible. For each treatment condition, the entry in column five of Table 11 selects the separating equilibrium (from column four of Table 11) satisfying the two conditions noted above.

Table 12 indicates that for each treatment condition, the repeated-interactions model generates multiple pooling and separating equilibria. Furthermore, a comparison of Tables 11 and 12 reveals that for each treatment condition, the equilibrium set of the repeated-interactions model weakly includes that of the one-shot model. Thus, reputational considerations expand the set of equilibrium outcomes.

The pooling equilibria of the repeated-interactions model (column two of Table 12) are obtained as follows. We plug the parameter values from Table 10 into proposition 3 to recover the y^*-values that can be supported as outcomes of a pooling equilibrium. It can be demonstrated (see section 2.7) that if $Y^*(I_X) \neq 0$, the reelection probability must equal one.[63] As in the one-shot case, the pooling

[63]In repeated-interactions sessions, each trial lasted for at least fifteen election periods. Thereafter, at the conclusion of each election period, the trial was terminated with a probability of $\frac{1}{10}$. When computing the set of pooling equilibria, we let $\delta = \frac{9}{10}$. The equilibrium set is invariant to slight perturbations in the chosen δ-value.

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equilibrium set expands as we move from Treatment 1 to Treatment 3. Efficient pooling requires that the incumbent candidate's policy choice be the cost minimizing one — $Y^*(I_X) = 0$, $I_X \in \{I_L, I_H\}$. The entries in column three of Table 12 reflect this intuition.

The separating equilibria of the repeated-interactions model (column four of Table 12) are obtained as follows. For each treatment condition, we note the parameter values detailed in Table 10. Thereafter, we check for policy pairs $(Y^*(I_L), Y^*(I_H))$ that satisfy conditions A and B of section 2.7. The reelection probability corresponding to $Y^*(I_L)$ $(Y^*(I_H))$ is 0(1). Thus, a particular separating equilibrium becomes $(Y^*(I_L), Y^*(I_H), 0, 1)$.[64] Efficient separation requires that policy choices impose minimum cost on the incumbent candidate. The entry in column five of Table 12 selects the separating equilibrium (from column four of Table 12) that is least expensive for the incumbent candidate.

2.5. Experimental Results

Our experiment consists of four session types: full-information one-shot (hereafter, FI-OS), incomplete-information one-shot (hereafter, II-OS), full-information repeated-interactions (hereafter, FI-RI), and incomplete-information repeated in-

[64] When computing the set of separating equilibria, we set $\delta = \frac{9}{10}$. The equilibrium set is invariant to slight perturbations in the chosen δ-value.

teractions (hereafter, II-RI). In this section we present the experimental results for each session type. We consider the one-shot sessions first.

2.5.1. Experimental Results for FI-OS and II-OS Sessions

The FI-OS and II-OS sessions consisted of three treatment conditions (see Table 10). We conducted four trials for each treatment condition. Each trial consisted of a single ten-period or twenty-period election game. Table 13 in Appendix B summarizes the data.

In Table 13, "policy outcome, I_X" is a four-element vector. For each session type and treament condition, we pooled all cases for which the realized incumbent candidate competency is I_X. The first, second, third, and fourth elements represent, respectively, the number of instances that policy outcomes $0, 3, 6$ and 9 were chosen. "Reelection probability" is a four-element vector where the first, second, third, and fourth elements represent, respectively, the empirical probability of reelection conditional on policy outcomes $0, 3, 6$ and 9.

Table 13 is read as follows. For the FI-OS Treatment 1 session there were 40 observations and incumbent candidates' realized competency was low on 27 occasions and high on 13 occasions. The vector "policy outcome, I_L" indicates that for the 27 observations involving low competency, the policy outcome of 0

was always selected. The vector "policy outcome, I_H" indicates that for the 13 observations involving high competency, the policy outcome of 0 was selected once and the policy outcome of 3 was selected 12 times. The electorate observed a policy outcome of 0 on 28 occasions; the observed policy outcome was 3 on 12 occasions. The "reelection probability" vector indicates that a policy outcome of 0(3) resulted in reelection 14%(100%) of the time. Since policy outcomes of 6 and 9 were not observed, the corresponding reelection probabilities were not computed.

Two conditions must be satisfied for each session type if signaling characterizes the aggregate data of Table 13. Since larger policy outcomes signal higher incumbent candidate competency, reelection probabilities are required to be non-decreasing in policy outcome levels. Second, the distribution of policy outcomes when incumbent candidates' competency is high should stochastically dominate in a first-order sense the distribution of policy outcomes when incumbent candidates' competency is low.

Consider, first, whether reelection probabilities are (weakly) increasing in policy outcome levels. Note that for each of the six session types, reelection probabilities satisfy the required weak monotonicity property (column four of Table 13). To check whether the second condition for signaling applies, observe the dis

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distribution of policy outcomes chosen by incumbent candidates when realized competency is low (high) (columns two and three of Table 13). For each of the six session types, application of the Median Test and Kolmogorov-Smirnov Two Sample Test (see Conover 1980) rejects the null hypothesis of equality between the two empirical distributions (.01 significance level).[65] Conclusion 1 summarizes our results.[66]

<u>Conclusion 1:</u> For each of the six session types, aggregate data reveals separation in both policy outcomes and reelection probabilities.

Having ascertained that signaling characterizes the aggregate data, we now determine whether the individual decisions of incumbent candidates and voters are consistent with the private incentives implicit in the model. We evaluate the optimality of incumbent candidates' behavior as follows.

[65]As an example, for the FI-OS Treatment 1 session, we test whether the sample distribution of policy outcomes contingent on low competency - i.e., (27, 0, 0, 0) - is stochastically dominated by the sample distributon of policy outcomes contingent on high competency - i.e., (1, 12, 0, 0).

[66]For the Median Test, the test statistic is distributed as $\chi^2_{[1]}$. The critical value, at the .01 significance level, is 6.64. The minimum realized value of the test statistic, across the six session types, is 7.86. For the Kolmogorov-Smirnov Two-Sample Test, the critical value of the test statistic, at the .01 significance level, is 9.21. The minimum realized value of the test statistic, across the six session types, is 9.96. For both tests, the minimum value occurs in the II-OS Treatment 3 session.

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For each of the six session types, we observe the vector of reelection probabilities (column four of Table 13). Given the empirical reelection probabilities, for each level of candidate competency, we rank order the four policy outcomes in terms of their average payoff for the incumbent candidate. Thereafter, for each competency level, we compare the computed optimal policy choice with the observed distribution of policy outcomes (columns two and three of Table 13). Our results are presented in Table 14 of Appendix B.

In Table 14, "optimal policy choice" is a two-element vector, where the first (second) element equals the policy outcome that yields the highest average payoff when the incumbent candidate's competency is low (high). "Modal policy choice" is a two-element vector, where the first (second) element equals the modal policy choice when the incumbent candidate's competency is low (high). Consider, for example, the FI-OS Treatment 1 session. Given the vector of reelection probabilities $((0.14, 1.0, \_, \_))$ and the parameter configurations detailed in Table 10 ($k = 100$ and $W = 600$) computations indicate that the policy outcome of 0(3) maximizes the expected payoff to the incumbent candidate when her competency is low (high).[67] Columns two and three of Table 13 show that the modal policy

[67]Let $\pi(y_I)$ be the empirical probability of reelection when policy outcome is $y_I \in Y$. For an I_X-type incumbent candidate, the expected payoff from y_I is: $[W \times \pi(y_I) - k \times [y_I]^2 \div I_X]$. The theoretically optimal policy for an I_X-type incumbent candidate is the y_I-value yielding

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chosen by the incumbent candidate is also 0(3) when realized competency is low (high).

In nine out of twelve cases (two competency levels $\times$ six session types), incumbent candidates' modal policy choice is the privately optimal one. For the three anomalous cases, the modal policy choice of incumbent candidates turns out to be the second best alternative. We have conclusive evidence that incumbent candidates' policy choices are consistent with the maximization of private utility.

Next, we evaluate the optimality of voters' behavior. For each session type, we pool the data and compute, for each policy level, the empirical conditional probability that the incumbent candidate's competency is high. We classify the electorate's aggregate behavior to be privately rational if, for each policy level, the reelection probability is greater (less) than $\frac{1}{2}$ when the empirical conditional probability of high competency is greater (less) than $\frac{1}{2}$.[68] The results are presented in Table 14.

In Table 14, "reelection probability" is a four-element vector identical to that

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the highest expected payoff.

[68]Since rejection of the incumbent candidate results in the electorate's payoff being a 50-50 gamble between $R(C_L)$ and $R(C_H)$, a more stringent test of the electorate's rationality would require that the reelection probability be 1(0) when the conditional probability of I_H is greater (less) than $\frac{1}{2}$. However, in experimental setups, subjects estimate the conditional probability of I_H only as evidence accumulates. Our proposed test is a reasonable compromise.

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shown in column four of Table 13. "Conditional probability of I_H" is a four-element vector where the first, second, third, and fourth elements represent, respectively, the empirical probability that the incumbent candidate's competency is high conditional on policy outcomes $0, 3, 6$ and 9. Consider the FI-OS Treatment 1 session. The vector "conditional probability of I_H" is computed as follows. During the session, a policy outcome of 0 was observed 28 times and a policy outcome of 3 was observed 12 times. Out of the 28 observations of policy outcome 0, incumbent candidates' competency was high on 1 occasion; of the 12 observations of policy outcome 3, incumbent candidates' competency was high on 12 occasions. Thus, corresponding to the policy outcome of 0, the conditional probability of high competency equals $\frac{1}{28}$; for the policy outcome of 3, the conditional probability of high competency equals $\frac{12}{12}$. Since policy outcomes of 6 and 9 were unobserved, the corresponding conditional probabilities were not computed.

Note that in the FI-OS Treatment 1 session the conditional probability of high competency exceeds $\frac{1}{2}$ when the observed policy outcome is 3 and is less than $\frac{1}{2}$ when the observed policy outcome is 0. The electorate's aggregate behavior is rational in this case: the reelection probability corresponding to policy outcome of 3 exceeds $\frac{1}{2}$ and the reelection probability corresponding to policy outcome of 0 is less than $\frac{1}{2}$. Columns four and five of Table 14 demonstrate that in twenty ns o

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out of twenty-one cases, reelection probabilities and conditional probabilities of high competency satisfy our condition. The electorate's vote decision is consistent with the maximization of private utility.

Conclusion 2 summarizes our findings regarding candidate and voter behavior.

Conclusion 2: For each of the six session types, the behavior of incumbent candidates and voters is uniformly consistent with the maximization of private utility.

Recall from section 2.3.1 that the one-shot model generates a multitude of equilibria. We now determine which of the equilibria in Table 11 is most consistent with experimental observations.

For each of the six session types, we pool the data. An individual observation, i, is viewed as a triple (y_i, I_i, e_i) where: 1) $y_i \in Y$ is the choice of policy outcome; 2) $I_i \in \{I_L, I_H\}$ is the realized competency of the incumbent candidate; and 3) $e_i \in \{0, 1\}$ is a binary choice variable that assumes the value 0 if the incumbent candidate is rejected and 1 if she is reelected. A specific equilibrium predicts the occurrence of certain kinds of experimental observations. For example, when incumbent candidates separate such that $\{Y^*(I_L) = 0, Y^*(I_H) = 3\}$ (i.e., the equilibrium is $(0, 3, 0, 1)$ in the notation of Table 11) experimental observations are p

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are predicted to be either $(0, I_L, 0)$ or $(3, I_H, 1)$. For each session type and each possible equilibrium we compute the percentage of observations consistent with its prediction. Table 15 in Appendix B presents the results.

In Table 15, each entry is a three-element vector (α, β, γ). α depicts a particular equilibrium. $\beta \in \{s, p\}$ is a binary variable equal to s if the corresponding equilibrium, α, involves separation and p if it involves pooling. $\gamma \in [0, 100]$ denotes the percentage of the observations consistent with the equilibrium predictions of α.[69]

Table 15 reads as follows. For the FI-OS Treatment 1 session the equilibrium with the best empirical fit is the separating equilibrium $(0, 3, 0, 1)$. In fact, 90% of the observations for the session matched equilibrium predictions (i.e., were of the form $(0, I_L, 0)$ or $(3, I_H, 1)$). The second-best empirical fit is achieved by the separating equilibrium $(0, 6, 0, 1)$; the pooling equilibrium $(0, 0)$ is the third-best fit.

Table 15 provides additional support for the preponderance of signaling in the data. Except for the II-OS Treatment 3 session, the best-fitting equilibrium model involves signaling (column two). On comparing column five of Table 11 with col-

[69]Recall that if $\beta = s$, then α is a four-element vector, $(Y^*(I_L), Y^*(I_H), 0, 1)$. Alternatively, if $\beta = p$, then α is a two-element vector $(Y^*(I_X), P(V^*, Y^*(I_X)))$.

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umn 2 of Table 15, a striking fact emerges. Except for the II-OS Treatment 3 session, the best-fitting signaling model is also the most efficient one. Experimental elections are not simply informationally efficient. Informational efficiency obtains at a minimum cost to the incumbent candidate.

Why does signaling cease in the II-OS Treatment 3 session? We conjecture that two factors are at work. First, since the benefit of reelection is large, the separating equilibrium set shrinks to a singleton and entails extreme separation; that is, the policy choice of the incumbent candidate for low (high) competency is 0(9). Second, since payoff information is unavailable to voters, observation of policy outcome equal to 9 does not immediately establish that the incumbent candidate's competency is high. On the other hand, after observing a policy outcome equal to 9, should the electorate choose the challenger, the incumbent candidate incurs a substantial loss. In sum, in an incomplete information setting, extreme and risky separation is difficult to induce. We summarize these results in conclusion 3.

Conclusion 3: Except for the II-OS Treatment 3 session, the data is best explained by the efficient separating equilibrium.

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By ranking the various equilibria by consistent observations, we have discarded information present in unpredicted outcomes. Therefore, we suggest a simple theory of errors and reanalyze the data using maximum likelihood procedures.[70] For each session type, we pool the data and obtain a sample of size N where observation i is a triple $(y_{i,}I_i, e_i)$. Thereafter, for each of the equilibria in Table 11, we compute the probability of generating the observed sample $\{(y_{i,}I_i, e_i)\}_{i=1}^{N}$. The computation of the probability requires estimation of two parameters, the error rates of incumbent candidates and voters. Finally, Akaike's Information Criterion (see Amemiya 1985) enables us to rank order the various equilibria in terms of the log of the computed probabilities.

For the sake of brevity, we only show how to compute the probability of generating the sample $\{(y_{i,}I_i, e_i)\}_{i=1}^{N}$ when the putative separating equilibrium is as follows: 1) $Y^*(I_L) = 0$; 2) $Y^*(I_H) = 3$; 3) $P(V^*, 0) = 1$; and 4) $P(V^*, 3) = 1$.[71] If some of the observed data violates the equilibrium predictions above, we encounter the zero probability problem. To avoid the problem, we assume that, with probability $\varepsilon_I(\varepsilon_E)$, the incumbent candidate (electorate) randomly selects an outcome different from the equilibrium prediction.

[70]Our estimation procedure is based on Harless and Camerer (1995) and Hey (1995).
[71]The probability computations for other equilibria are available upon request.

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Before proceeding, we introduce additional notation. Let $\pi_I(y_I|I_X)$ denote the probability that the incumbent candidate chooses policy outcome y_I when her competency is I_X. Let $\pi_E(y_I)$ denote the probability that the electorate reelects the incumbent candidate when the observed policy outcome is y_I. A "noisy" version of the putative separating equilibrium specifies the following conditional probabilities: 1) $\pi_I(0|I_L) = \pi_I(3|I_H) = 1 - 3\varepsilon_I$; 2) $\pi_I(y_I|I_X) = \varepsilon_I$ if $(y_I, I_X) \notin \{(0, I_L), (3, I_H)\}$; 3) $\pi_E(0) = \varepsilon_E$; and 4) $\pi_E(y_I) = 1 - \varepsilon_E, y_I \neq 0$.[72] It is now immediate that the probability of generating the sample $\{(y_i, I_i, e_i)\}_{i=1}^N$ is $\Pi_{i=1}^N \pi_I(y_i|I_i) \times \pi_E(y_i)^{e_i} \times (1 - \pi_E(y_i))^{1-e_i}$. The probability is a function of two unknown parameters, ε_I and ε_E. However, ε_I and ε_E can be estimated by standard likelihood methods and the probability of generating the sample evaluated. The results of ranking the various equilibria in terms of log likelihoods are detailed in Table 16 of Appendix B.

For Table 16, consider the FI-OS Treatment 1 session.[73] The equilibrium with

[72]Conditions 2 and 3 represent the random deviations from the putative "noiseless" equilibrium by, respectively, the incumbent candidate and the electorate. Conditions 1 and 4 represent, respectively, the probability with which the incumbent candidate and the electorate implements the predicted actions of the putative "noiseless" equilibrium. We have implicitly assumed that the electorate's voting rule has the monotonicity property (i.e., in the "noiseless" equilibrium, $P(V^*, y_i) \geq P(V^*, y_j)$ if $y_i > y_j$).

[73]An entry in columns two, three, and four is a two-element vector (α, β). Using the notation of Table 11, α depicts a particular equilibrium. $\beta \in \{s, p\}$ is a binary variable that is set equal to s if the corresponding equilibrium, α, involves separation and is equal to p if the equilibrium involves pooling. For the equilibrium with the best empirical fit, indicated in column two, $\hat{\varepsilon}_I$is the MLE point estimate for the incumbent's error rate and $\widehat{\varepsilon}_E$ is the MLE point estimate for

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the best empirical fit (largest log likelihood value) is the separating equilibrium $(0, 3, 0, 1)$. The second-best empirical fit is achieved by the separating equilibrium $(0, 6, 0, 1)$; the third-best empirical fit is achieved by the pooling equilibrium $(0, 1)$. For the best-fitting equilibrium, the maximum likelihood point estimates of the error rates for incumbent candidates and voters are, respectively, .04 and .14.

Conclusion 3, based on the crude counting of consistent outcomes, is robust to the introduction of a simple error structure and maximum likelihood techniques. Except for the II-OS Treatment 3 session, the efficient signaling equilibrium best characterizes the data (see column 2 of Tables 15 and 16). The data from the II-OS Treatment 3 session is difficult to characterize; the best-fitting pooling model, $(6, 1)$, estimates substantial errors for incumbent candidates and voters. We summarize these results in conclusion 4.

Conclusion 4: Except for the II-OS Treatment 3 session, maximum likelihood estimation indicates that the data is best explained by a noisy version of the efficient separating equilibrium.

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the electorate's error rate.

2.5.2. Experimental Results for FI-RI and II-RI Sessions

The FI-RI and II-RI sessions consisted of three treatment conditions (see Table 10). For each treatment condition we conducted an average of eleven trials. Each trial consisted of a single game with a variable number of election periods. Table 17 in Appendix B provides a summary of the data.

In Table 17, "Policy outcome, I_X" is a four-element vector. For each session type and treatment condition, we pooled all cases for which the realized incumbent candidate competency is I_X. The first, second, third, and fourth elements represent, respectively, the number of instances that policy outcomes $0, 3, 6$ and 9 were chosen. "Reelection probability" is a four-element vector where the first, second, third, and fourth elements represent, respectively, the empirical probability of reelection conditional on policy outcomes $0, 3, 6$ and 9.

Table 17 is read as follows. For the FI-RI Treatment 1 session, there were 209 observations and incumbent candidates' realized competency was low on 105 occasions and high on 104 occasions. The vector "policy outcome I_L" indicates that for the 105 observations involving low competency, policy outcomes of $0, 3$ and 6 were chosen, respectively, $100, 4$ and 1 times. The vector "policy outcome, I_H" indicates that for the 104 observations involving high competency, policy outcomes of 0 and 3 were chosen, respectively, 6 and 98 times. The "reelection probability" vector

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vector indicates that policy outcomes of $0, 3$ and 6 resulted in reelection $14\%, 99\%$ and 100% of the time. Since the policy outcome of 9 was not observed, the corresponding reelection probability was not computed.

Two conditions must be satisfied for each session type if signaling characterizes the aggregate data of Table 17. First, the reelection probability must be (weakly) monotonically increasing in policy outcome levels. Second, the distribution of policy outcomes when incumbent candidates' competency is high should stochastically dominate in a first-order sense the distribution of policy outcomes when incumbent candidates' competency is low.

Consider, first, whether reelection probability is (weakly) monotonically increasing in policy outcome levels. Observe that across the six session types, the only minor violation of weak monotonicity occurs in the FI-RI Treatment 1 session: the policy outcome of 3 produces a reelection probability of 0.99 while the policy outcome of 6 results in a reelection probability of 0. This anomaly may be dismissed since the policy outcome of 6 was observed only once.

To check whether the second condition for signaling applies, note the distribution of policy outcomes chosen by incumbent candidates when realized competency is low (high) (columns two and three of Table 17). For each of the six session types, application of the Median Test and Kolmogorov-Smirnov Two Sample T

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ple Test (see Conover 1980) rejects the null hypothesis of equality between the two empirical distributions (.01 significance level).[74] Conclusion 5 summarizes our results.[75]

Conclusion 5: For each of the six session types, aggregate data reveals separation in both policy outcome and reelection probabilities.

Recall from section 3.3.2 that the repeated-interactions model generates a multitude of equilibria. We now determine which of the equilibria in Table 12 is most consistent with experimental observations.

For each of the six session types, we conducted several trials. For each trial, we pooled the data and obtained a sample $\{(y_i, I_i, e_i)\}_{i=1}^{N}$ where (y_i, I_i, e_i) denotes the observation corresponding to the i'th election period.[76] Corresponding to each possible equilibrium, detailed in columns two and four of Table 12, we computed

[74] As an example, for the FI-OS Treatment 1 session, we test whether the sample distribution of policy outcomes contingent on low competency - i.e., (100, 4, 1, 0) - is stochastically dominated by the sample distributon of policy outcomes contingent on high competency - i.e., (6, 98, 0, 0).

[75] For the Median Test, the test statistic is distributed as $\chi^2_{[1]}$. The critical value, at the .01 significance level, is 6.64. The minimum value of the test statistic, across the six session types, is 66.68. For the Kolmogorov-Smirnov Two Sample Test, the critical value, at the .01 significance level, is 9.21. The minimum value of the test statistic, across the six session types, is 82.93. For both tests, the minimum value occurs in the II-RI Treatment 3 session.

[76] Recall (y_i, I_i, e_i) is a three-element vector where: 1) $y_i \in Y$ is the choice of policy outcome; 2) $I_i \in \{I_L, I_H\}$ is the realized competency of the incumbent candidate; and 3) $e_i \in \{0, 1\}$ is a binary variable that assumes the value 0(1) if the incumbent candidate is rejected (reelected).

the percentage of observations consistent with its predictions. Finally, each trial was categorized according to the equilibrium with the best empirical fit.[77] Table 18 in Appendix B presents the results.

Table 18 is read as follows. For the FI-RI Treatment 2 session, twelve trials were conducted. A separating (pooling) equilibrium had the best empirical fit in eleven (one) of the trials. The efficient separating equilibrium $(0,3,0,1)$ best accounted for the data in six of the eleven trials with separation.

The results in Table 18 are similar to those for one-shot elections: except in the II-RI Treatment 3 session, signaling explains a substantial portion of the experimental data. Note that excluding the II-RI Treatment 3 session, we conducted a total of fifty-three trials (column two of Table 18). Remarkably, data for forty-eight of the trials (column three of Table 18) are characterized by signaling.

A distinction, however, emerges between one-shot and repeated-interactions elections. In repeated-interactions elections, efficient separation is not guaranteed to emerge. Consider, for example, the II-RI Treatment 2 session. While ten of the eleven conducted trials produced separation, efficient separation — i.e., $(0,3,0,1)$ — had maximal predictive power in only two of the trials. Excluding the II-RI Treatment 3 session, separation was observed in a total of forty-eight

[77] Detailed results for each trial are available on request.

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trials (column three of Table 18). Of these trials, efficient separation occurred only twenty-seven times (column four of Table 18).[78]

Table 18 also indicates that information levels affect the probability of observing efficient separation. We consider, first, only trials involving separation (column three of Table 18). Thereafter, for each of the three treatment conditions, we construct a two-element vector (p_{FI}, p_{II}), where $p_{FI}(p_{II})$ denotes the probability that efficient separation emerges when the session involves full-information (incomplete-information). From columns three and four of Table 18, for Treatments 1, 2 and 3, the vectors are, respectively, $(\frac{9}{9}, \frac{4}{10}), (\frac{6}{11}, \frac{2}{10})$ and $(\frac{6}{8}, \frac{2}{6})$.[79] Since p_{FI} exceeds p_{II} for each treatment condition, efficient separation survives more readily in complete information environments. Conclusions 6 and 7 summarize the analysis of Table 18.

<u>Conclusion 6:</u> Except for the II-RI Treatment 3 session, a signaling model best accounts for the data in almost all trials.

[78] By contrast, in one-shot elections, efficient separation survived in each of the corresponding five session types.

[79] The (p_{FI}, p_{II}) vector corresponding to Treatment 1 is derived as follows. In the FI-RI Treatment 1 session there were 9 trials with separation; efficient separation occurred in all 9 of the trials. Hence, $p_{FI} = \frac{9}{9}$. In the II-RI Treatment 1 session there were 10 trials with separation; efficient separation occurred in 4 of the 10 trials. Hence, $p_{II} = \frac{4}{10}$.

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Conclusion 7: Efficient separation is more likely to emerge in complete rather than incomplete information environments.

Before conducting the experiments, we believed that in repeated-interactions environments, efficient separation would be trivial to induce. The data provides a sharp contradiction. Why does efficient separation not occur more frequently? Our conjecture is as follows. In repeated-interactions elections, the strategy spaces for incumbent candidates and voters are "large." As a result, no single equilibrium (e.g. efficient signaling) emerges as a natural focal point.

A slight variation of the above argument may also explain why complete information environments are relatively conducive to the occurrence of efficient separation. When incumbent candidates' payoffs are known to voters, it is possible to evaluate the cost associated with each policy pair $(Y^*(I_L), Y^*(I_H))$. Perhaps, the computation of equilibrium cost enables the least costly signaling equilibrium to emerge as a focal point.

2.5.3. Informational Efficiency in Experimental Elections

We conclude by comparing the informational efficiency of our experimental elections. Recall that informational efficiency obtains if and only if the incumbent

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candidate is reelected when her realized competency is high. For each session type, we pooled the data and determined the proportion of cases for which electoral outcomes are informationally efficient. The results are detailed in Table 19 of Appendix B.

As a baseline, note that an electoral equilibrium of complete pooling (separation) generates informational efficiency of 50% (100%). Except for the incomplete-information Treatment 3 sessions, informational efficiency of our experimental elections is substantial and reflects the preponderance of signaling in the aggregate data.

Two surprising conclusions show up in Table 19. First, informational efficiency averaged over one-shot sessions is 83.92% while informational efficiency averaged over repeated-interactions sessions is an indistinguishable 82.78%.[80] Informational efficiency does not depend on the frequency of interactions (one-shot or repeated). Second, excluding Treatment 3, informational efficiency averaged over full-information sessions is 86.21% while informational efficiency averaged over incomplete-information sessions is an indistinguishable 86.23%.[81] Informational efficiency does not depend on voter information. We therefore draw the

[80] 83.92 is the average of the following six numbers: $92.50, 80.00, 90.00, 92.22, 85.00$, and 63.75. 82.78 is the average of the following six numbers: $87.56, 84.76, 81.98, 79.35, 88.44$, and 74.69.

[81] 86.21 is the average of the following four numbers: $92.50, 80.00, 86.56$, and 84.76. 86.23 is the average of the following four numbers: $92.22, 85.00, 79.25$, and 88.44.

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following conclusion.

Conclusion 8: Full information of payoff parameters or repeated interactions are unnecessary for informational efficiency. Electoral accountability obtains even when background conditions appear, a priori, to be unpromising.

2.6. Discussion

We derive a model of elections that incorporates informational asymmetries between elected public officials and voters and compute the set of rational expectations equilibria. The baseline model is a one-shot election with one incumbent candidate and an electorate of homogenous voters. We compute the set of rational expectations equilibria. The presence of private candidate-specific information leads to multiple equilibria. In the "pooling" case, the incumbent candidate's choice of policy does not depend upon her competency level. The consequent lack of transmission of competency information leads to electoral outcomes that are inefficient. By contrast, in the "separating" case, the incumbent candidate's choice of policy increases with her competency level. Since there is complete transmission of competency information, electoral outcomes are efficient.

We conducted a series of lab experiments. A primary goal of the experimental work was to so

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work was to sort out the various factors influencing equilibrium selection. These factors included: 1) the incumbent candidate's private benefit of holding office; 2) the incumbent candidate's private cost of implementing policy; 3) the amount of information available to voters, and 4) the frequency of interactions (one-shot versus repeated-interactions elections). These factors were adjusted individually in order to isolate their respective influence on equilibrium selection.

In regards to experimental outcomes, the principal similarity between one-shot and repeated-interactions sessions is the preponderance of signaling in the data. Since candidate specific information is transmitted in a signaling equilibrium, experimental elections are informationally efficient. While signaling explains most of the outcomes for both one-shot and repeated-interactions elections, there is one distinction: in one-shot elections, efficient signaling is more likely to occur.

These findings aid in resolving the ambiguities raised in theoretical models of elections with adverse selection that previously demonstrate the coexistence of pooling and separating equilibria. Using experimental techniques, this chapter establishes that signaling is likely to be observed in practice. Drawing broad generalizations from our analysis would be a risky undertaking. While the experiments themselves are extensive, the question of verisimilitude is a threat to the validity of any experimental research. Our study, nonetheless, provides a useful look at voters

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2.7. Formal Proofs of Propositions

This section presents formal proofs for propositions 1, 2, 3 and 4. Throughout, the notation employed is that of section 2.3.

Proof of Proposition 1.— Suppose $Y^*(I_L) = Y^*(I_H) \equiv y^*$. It follows from definition 1 (see conditions (ii) and (iii)) that $B^*(y^*) = \pi$ and $V^*(y^*)$ is any number in the unit interval $[0,1]$. To ensure that y^* is indeed an equilibrium outcome, we need to specify beliefs, $B^*(y_I)$, and vote decisions, $V^*(y_I)$, for out-of-equilibrium policy outcomes — i.e., $y_I \neq y^*$. Without loss of generality, we specify the "harshest punishments" for all contemplated deviations. Specifically, we set $B^*(y_I) = 0$ and $V^*(y_I) = 0$ if $y_I \neq y^*$. (Note, for all $y_I \in \Re_+$, the specified B^* and V^* functions satisfy conditions (ii) and (iii) of definition 1.) It is also trivial to check that condition (i) of definition 1 is satisfied as well iff: $y^* \leq [[\frac{W}{k}] \times I_L \times V^*(y^*)]^{\frac{1}{2}}$. Finally, to obtain the entire set of y^*-values that can be supported as outcomes of pooling equilibria, set $V^*(y^*) = 1$. In sum, in the one-shot electoral model, there is a continuum of pooling equilibrium outcomes. In a specific pooling equilibrium, we have: 1) $Y^*(I_L) = Y^*(I_H) = y^*$ and 2) y^*

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Proof of Proposition 2.— Suppose $Y^*(I_L) \neq Y^*(I_H)$. It follows from definition 1 (see conditions (ii) and (iii)) that $B^*(Y^*(I_L)) = V^*(Y^*(I_L)) = 0$ and $B^*(Y^*(I_H)) = V^*(Y^*(I_H)) = 1$. To ensure that $\{Y^*(I_L), Y^*(I_H)\}$ is indeed an equilibrium policy outcome pair, we need to specify beliefs, $B^*(y_I)$, and vote decisions, $V^*(y_I)$, for out-of-equilibrium policy outcomes — i.e., $y_I \notin \{Y^*(I_L), Y^*(I_H)\}$. Without loss of generality, we specify the "harshest punishments" for all contemplated deviations. Specifically, we set $B^*(y_I) = V^*(y_I) = 0$ for $y_I \notin \{Y^*(I_L), Y^*(I_H)\}$. (Note, for all $y_I \in \Re_+$, the specified B^* and V^* functions satisfy conditions (ii) and (iii) of definition 1.) It is also trivial to check that condition (i) of definition 1 is satisfied as well iff: 1) $Y^*(I_L) = 0$ and 2) $Y^*(I_H) \in [[\frac{W}{k}] \times I_L]^{\frac{1}{2}}, [\frac{W}{k}] \times I_H]^{\frac{1}{2}}]$. In sum, in the one-shot electoral model, there is a continuum of separating equilibrium outcomes. In a specific separating equilibrium, we have: 1) $Y^*(I_L) = 0$ and 2) $Y^*(I_H) \in [[\frac{W}{k}] \times I_L]^{\frac{1}{2}}, [\frac{W}{k}] \times I_H]^{\frac{1}{2}}]$.

Proof of Proposition 3.— Suppose $Y^*(I_L) = Y^*(I_H) \equiv y^*$. It is then immediate that $Q^*(I_H) \geq Q^*(I_L)$. Thus, condition (i) of definition 2 is satisfied iff: $Q^*(I_L) \geq 0$. It is also clear that $Q^*(I_L)$ is increasing in $V^*(y^*)$. Hence, to obtain the entire set of y^*-values that can be supported as outcomes of stationary pooling equilibria, set $V^*(y^*) = 1$. The corresponding $Q^*(I_L) \geq 0$ condition reduces to:

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$y^* \leq \lambda \times [[\frac{W}{k}] \times I_L]^{\frac{1}{2}}$, where $\lambda \equiv [I_H \div [I_H - \delta \times \pi \times (I_H - I_L)]]^{\frac{1}{2}}$ In sum, in the repeated-interactions electoral model, there is a continuum of stationary pooling equilibrium outcomes. In a specific stationary pooling equilibrium, we have: 1) $Y^*(I_L) = Y^*(I_H) \equiv y^*$ and 2) $y^* \in [0, \lambda \times [[\frac{W}{k}] \times I_L]^{\frac{1}{2}}]$.

Proof of Proposition 4.— Suppose $Y^*(I_L) \neq Y^*(I_H)$. Given conditions (iii) and (iv) of definition 3, we obtain: 1) $Q^*(I_L) = [[-k \times Y^*(I_L)^2] \div I_L] + \delta \times [(1 - \pi) \times Q^*(I_L) + \pi \times Q^*(I_H)]$ and 2) $Q^*(I_H) = [W - [k \times Y^*(I_H)^2] \div I_H] + \delta \times [(1-\pi) \times Q^*(I_L) + \pi \times Q^*(I_H)]$. The above two equations can be solved to obtain expressions for $Q^*(I_L)$ and $Q^*(I_H)$. It can then be shown that conditions (i)-(iv) of definition 3 reduce to: A) $[W - [[k \times Y^*(I_H)^2] \div I_H]] \geq 0$ and B) $Q^*(I_L) \geq$ Max $\{0, [W - [[k \times Y^*(I_H)^2] \div I_L]]\}$. In sum, in the repeated-interactions electoral model, there is a continuum of stationary separating equilibrium outcomes. In a specific stationary separating equilibrium: $\{Y^*(I_L),\ Y^*(I_H)\}$ must satisfy conditions A and B. Finally, we observe that every separating equilibrium of the one-shot model satisfies conditions A and B. Therefore, the set of separating equilibrium outcomes for the repeated-interactions model strictly includes that corresponding to the one-shot model.

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3. CHAPTER 3: RIGIDITY OF RULES IN ELECTORAL SYSTEMS

3.1. Introduction

In a well-functioning representative democracy, it is commonplace to view public policies as outcomes of a principal-agent game. Legislators, as agents of the electorate, condition their behavior on some notion of the "common will." Periodic elections are the mechanism by which the electorate disciplines these legislators. In sum, irrespective of the extent of divergence between the innate interests of the public and elected officials, the threat of electoral defeat provides sufficient incentive for the latter to comply with popular demands. Despite its elegance, the principal-agent paradigm overlooks an important consideration. In a modern state, legislators rarely implement public policy. Rather, the task of policy implementation is delegated to administrative agencies. A question naturally arises: what prevents unelected bureaucrats from engaging in bureaucratic drift — i.e., flouting legislative intent?

The scholarly literature investigating bureaucratic drift makes two substantive contrib

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tive contributions. First, the various types of bureaucratic drift are elucidated. Calvert, McCubbins and Weingast (1989), Epstein and O'Halloran (1994, 1996), Ferejohn and Shipan (1990) and Hill (1985), for example, assume that bureaucrats have policy preferences distinct from that of legislators. Given discretion, bureaucrats may override democratic values and implement public policies in accord with their own desires. Among others, Banks (1989), Banks and Weingast (1992), Bendor, Taylor and Van Gaalen (1985), Miller and Moe (1983) and Niskanen (1971, 1975) posit that bureaucrats seek to maximize an agency's budget. Left unmonitored, bureaucrats provide their political overseers with inflated cost estimates for projects assigned to them. Finally, Laffont and Tirole (1990, 1991), Peltzman (1976), Posner (1974), Stigler (1971) and Tirole (1986) have pioneered the economic approach to agency capture: bureaucrats entrusted with the task of regulating an industry engage in graft and begin, instead, to champion the industry's concerns.

Given the possibility of bureaucratic drift, several authors have explored the ways by which politicians can design the structure and procedures (i.e., rules and regulations) of an agency so as to control bureaucrats. Arnold (1987) emphasizes the myriad oversight techniques available to politicians: extensive hearings may ruin bureaucratic careers; the annual appropriations process can reward (punish) compliant (d

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compliant (deviant) agencies; and the original legislation authorizing a program can be made suitably specific. McCubbins and Schwartz (1984) indicate how legislators can institute procedures that enable individual citizens and interest groups to examine an agency's decisions and sound a 'fire alarm' when legislative intent is violated. Finally, McCubbins, Noll and Weingast (1987, 1989) elaborate on the arguments in McCubbins and Schwartz. Specifically, they demonstrate that administrative procedures affect an 'agency's range of feasible actions': the constraints of due process imposed by the Administrative Procedures Act make it relatively cheap for any interested party to gather information about agency behavior; and the ease with which agency decisions can be challenged in court determines the level of agency discretion.

As Horn and Shepsle (1989), Moe (1990a, 1990b), Moe and Wilson (1994) and Shepsle (1992) rightly point out, the extensive preoccupation with the ramifications of bureaucratic drift has glossed over other factors affecting agency design. In particular, the aforementioned papers suggest that an agency's structure is also fundamentally affected by the possibility of 'coalitional drift.' The basic idea is as follows: Consider an enacting coalition (of legislators and interest groups) engaged in the task of setting up an agency. By making the agency's structure sufficiently permeable, the enacting coalition can exercise strict control over public policy in the present.

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the present. Political power, however, is ephemeral. Thus, when the enacting coalition loses authority, the deal struck at enactment is subjected to predation by future political coalitions — a permeable agency structure serves only to facilitate agency capture. In sum, an enacting coalition must create an agency that has 'the capacity to survive and prosper in an uncertain political environment.' A well-designed agency exhibits resilience to the 'authority that its opponents might gain.'

In contrast to extant theoretical models exploring the politics of agency design, this chapter simply assumes away bureaucratic drift — bureaucrats, without exception, obey legislative intent. Instead, the principal goal of the chapter is to isolate the design implications of coalitional drift. Specifically, we ask: in the presence of legislative turnover — and, hence, coalitional drift — what sort of agency does an enacting coalition construct?

Our theoretical setup is as follows. We examine a polity in a Westminster-style parliamentary system with a unicameral legislature. There is an agency that employs public funds to provide a service valued by citizens. Furthermore, there are two political parties that assign different shadow prices to public funds — one party is more fiscally conservative than the other. When a particular political party is in power (i.e., controls the legislature), it establishes the budgetary rules for the agen

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What determines the nature of the budgetary rules that emerge in equilibrium? Suppose that the political party currently in power writes flexible budgetary rules that cede discretion to future legislative coalitions. Should the incumbent party be removed from office, its replacement can subsequently exploit the granted flexiblity to implement any public policy it desires. In short, when political uncertainty is substantial and the two political parties are ideologically separated, flexible rules are risky structures. If the risk associated with flexible rules is deemed unacceptable, the incumbent party institutes rigid budgetary rules for the agency. Rigid rules, by definition, are riskless structures: public policy implemented in the future is determined in advance and is independent of the electoral fortunes of the two political parties. However, rigid rules impose a cost as well — because public policy cannot respond to changing circumstances, inefficient outcomes are frequently generated. In sum, equilibrium budgetary rules reflect a tradeoff between the riskiness of flexibility and the inefficiency of rigidity.[82]

[82]The idea behind our paper is similar to that developed independently in Epstein and O'Halloran (1994, 1996). They construct a one-period model of an administrative state in which Congress determines the amount of leeway granted to bureaucrats. Since the president appoints agency heads, who in turn implement public policies, Congress places tighter (looser) constraints on bureaucrats when congressional and presidential preferences diverge (converge).

Despite the underlying similarity between our paper and their, the formal structures are quite distinct. Furthermore, our paper contrasts two distinct electoral arrangements: the parliamentary system and the separation-of-powers system. Epstein and O'Halloran only consider the

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Our chapter also has a comparative perspective. Besides the aforementioned parliamentary system, we analyze budgetary rules for polities in a separation-of-powers system. Such polities consist of one agency and two political parties, with differing preferences, that jointly oversee the agency. However, the legislature is now presumed to be bicameral. Therefore, in periods of divided government, budgetary rules for the agency involve a compromise between the two political parties. By contrast, in periods of unified government, the party in control unilaterally determines the agency's budgetary rules.

The comparative perspective yields an unexpected dividend. We directly compare the two electoral systems (parliamentary and separation-of-powers) in terms of the rigidity of the budgetary rules that emerge in equilibrium. Surprisingly, for an enacting coalition, flexible budgetary rules are always riskier structures in a separation-of-powers system than in a parliamentary system. Since an enacting coalition is presumed to maximize its own welfare, equilibrium budgetary rules in a separation-of-powers system are uniformly more rigid than that in a parliamentary system. In sum, the two electoral arrangements can theoretically be rank-ordered in terms of rigidity (or flexibility). Our theoretical result has an empirical counterpart. Moe (1990a) and Moe and Caldwell (1994) examine

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the structural design of regulatory agencies. The evidence they summarize spans several countries (though, the United States and Britain are emphasized) and principally concerns environmental regulation. Without exception, they discover that agencies in a parliamentary system are less encumbered by rigid rules than those in a separation-of-powers system.

The rest of the chapter is structured as follows. As a baseline case, in section 3.2 we consider a polity in which a single political party has jurisdiction over an agency. The goal of this section is twofold: we 1) establish basic notation and 2) demonstrate that, absent electoral uncertainty, the equilibrium budgetary rule for the agency is both flexible and efficient. In section 3.3, we extend our analysis of budgetary rules to polities in a separation-of-powers system. Budgetary rules in a parliamentary system are examined in section 3.4. In section 3.5, we compare the two electoral systems in terms of the rigidity (or flexibility) of the budgetary rules that are generated. Section 3.6 concludes the chapter from a substantive perspective. All theoretical proofs are relegated to section 3.7 while pertinent diagrams are gathered in Appendix C.

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3.2. A One-Party State

As a baseline case, we construct a model of a one-party state. The model consists of two players: an agency, denoted by A, that supplies a service valued by citizens and a political party, denoted by P, that oversees the agency and undertakes budgetary decisions. The interaction spans an infinite sequence of structurally identical periods.

Each period, $t \in Z_{+}$, proceeds as follows. At the start of period t, Nature makes a draw from the distribution of a random variable, θ. θ is uniformly distributed on the interval $[0, \overline{\theta}]$ and θ_t denotes its period-t realization. Without exception, agencies provide services (e.g., unemployment compensation) that are subject to demand shocks of a transitory character. We interpret θ_t to be the period-t benefit obtained by citizens in aggregate for each dollar spent by the agency.

Once the agency is apprised of the θ_t-value, it truthfully transmits the θ_t-value to its overseer, party P. Since the agency does not engage in information manipulation, standard principal-agent problems are assumed away. Thus, delegation of authority engenders no loss of control.

Given θ_t, party P fixes the size of the agency's budget as follows. Party P can raise a maximum of $\overline{B}$ dollars through taxation. However, distortionary taxation causes ineff

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causes inefficiencies in the system: specifically, $\lambda \in [0, \overline{\theta}]$ is the deadweight loss inflicted on citizens in order to levy one dollar for the party. The party behaves benevolently and selects a budget level that maximizes citizens' net surplus. Thus, the budget, denoted by $b(\theta_t, \lambda)$, solves the following program:

$$b(\theta_t, \lambda) \in \arg \max_{b \in [0, \overline{B}]} \{b \times (\theta_t - \lambda)\} \tag{3.1}$$

Since the objective function in equation (3.1) is linear, the solution is immediate:

$$b(\theta_t, \lambda) \in \begin{cases} \{0\} & \text{if} \quad \theta_t < \lambda \\ [0, \overline{B}] & \text{if} \quad \theta_t = \lambda \\ \{\overline{B}\} & \text{if} \quad \theta_t > \lambda \end{cases} \tag{3.2}$$

The budget rule, b(. , .), has two properties. First, since $b(\theta_t, \lambda)$ is weakly increasing in θ_t, the budget rule is flexible and responds to demand shocks. Second, the budget rule is efficient; i.e., the budget size is at a maximum (minimum) when benefits, θ_t, are greater (less) than costs, λ. In sum, an agency in a one-party state is an optimal organization.

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3.3. A Two-Party Separation-of-Powers System

In this section, we examine a stylized model that approximates a separation-of-powers system. The section is divided into three parts. First, we provide a verbal description of the model. We then formally define an equilibrium for the model. Finally, we discuss the principal predictions that follow from the model's solution.

3.3.1. Description of the Model

To emphasize the dispersion of political power in a separation-of-powers system, we consider a polity with a bicameral legislature; the two chambers being labelled C and P.[83] There are two political parties, denoted P_L and P_R, that stochastically occupy the two chambers and jointly oversee an agency, denoted A.[84]

Like the model in section 3.2, the agency employs public funds to provide a service valued by citizens. Raising public funds, however, induces welfare-reducing distortions in the economy. The two political parties have different estimates of the magnitude of these distortions: specifically, parties P_L and P_R assign, respectively, a deadweight loss to society of λ_L and λ_R in order to levy one dollar for the agency. Party P_R is (weakly) more fiscally conservative than party P_L;

[83]It is also reasonable to interpret chamber $C(P)$ as Congress (Presidency). In fact, the labels are chosen to encourage this association.

[84]P_L and P_R are mnemonics for "left party" and "right party" respectively.

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The interaction between the two political parties spans an infinite sequence of structurally identical periods. Each period, in turn, consists of three phases. In phase one, the parties (or party) in power determine(s) the agency's budget for that period. In phase two, budgetary rules for the next period are written. In phase three, elections in both chambers indicate whether incumbents are reelected. A description of the three phases follows.

Phase One: Determining the agency's budget

Each period, $t \in Z_+$, begins with a particular configuration of political power. We let $P_{C(t)}$ and $P_{P(t)}$ denote, respectively, the party controlling chambers C and P in period t.[86] When $P_{C(t)}$ and $P_{P(t)}$ are both party $P_L(P_R)$, we say that period t exhibits "unified party $P_L(P_R)$ control." Instead, if $P_{C(t)}$ and $P_{P(t)}$ represent different parties, we say that period t exhibits "divided government."

In each period t, Nature makes a draw from the distribution of a random variable, θ. θ is uniformly distributed on the interval $[0, \overline{\theta}]$ and θ_t denotes its period-t realization. θ_t is interpreted to be the period-t benefit obtained by citizens in aggregate for each dollar spent by the agency.

[85]In an alternative interpretation, the two political parties have distinct constituencies. λ_R is larger than λ_L because a dollar raised in taxes inflicts greater deadweight loss on party P_R's constituency than on party P_L's constituency.

[86]Given our notation, $C(t)$ and $P(t)$ are elements of the set $\{L, R\}$.

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Once the agency is apprised of the θ_t-value, it truthfully transmits the θ_t-value to its political overseers, parties $P_{C(t)}$ and $P_{P(t)}$. Given θ_t, how is the agency's period-t budget determined? We now need to distinguish between two cases: the "discretion regime" and the "no discretion regime."

Discretion regime.— Case one considers the possibility wherein the parties (or party) in power in period $(t-1)$ established budgetary rules that yielded discretion to the future coalition. Under this "discretion regime," the agency's period-t budget involves the following compromise between the two chambers, C and P. The political parties (or party) in power in period t — i.e., $P_{C(t)}$ and $P_{P(t)}$ — can raise a maximum of $\overline{B}$ dollars through taxation. Given this exogenous constraint on the availability of public funds, note that the "ideal" period-t budget level according to party $P_{C(t)}(P_{P(t)})$ is $b(\theta_t, \lambda_{C(t)})$ $(b(\theta_t, \lambda_{P(t)}))$ where:

$$b(\theta_t, \lambda_j) = \underset{b \in [0, \overline{B}]}{\arg\max} \; [b \times (\theta_t - \lambda_j)]; \; j \in \{C(t), P(t)\} \tag{3.3}$$

The realized period-t budget simply averages the desires of the two chambers. Hence, it assumes the value: $[(\frac{1}{2}) \times (b(\theta_t, \lambda_{C(t)}) + b(\theta_t, \lambda_{P(t)}))]$.

Before proceeding further, we observe that the two chambers have conflicting budget demands only when period t exhibits "divided government" $(C(t) \neq P(t))$

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and demand shock θ_t lies in the interval (λ_L, λ_R). In this situation, one chamber, controlled by party P_L, seeks a budget of $\overline{B}$ while the other chamber, controlled by party P_R, hopes to shut down the agency. The resulting compromise budget is equal to $\frac{\overline{B}}{2}$.

No discretion regime.— The parties (or party) in power in period $(t-1)$ may not have written budgetary rules that ceded discretion to the period-t coalition. Case two considers the situation wherein the period-$(t-1)$ enacting coalition rigidly fixed the period-t agency budget at some level $b \in [0, \overline{B}]$. Under this "b no discretion regime," the parties in period t have their hands tied. The demand shock θ_t is ignored and the period-t funding of b is implemented.

Phase Two: Writing budgetary rules

Once the agency's period-t budget is determined, the budgetary regime for period $(t+1)$ needs to be established. Who writes the rules? A separation-of-powers system forces the two chambers to bargain over rules. We model this bargain starkly: specifically, with probability $\alpha(1-\alpha)$, the party controlling chamber $C(P)$ is invested with the rights to stipulate the budgetary regime for period $(t+1)$.

The party choosing the budgetary regime for period $(t+1)$ selects an element from the set $[0, \overline{B}] \cup \{\text{"}DR\text{"}\}$ where: 1) $b \in [0, \overline{B}]$ implies implementation of the "b no disc

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"b no discretion regime" in period $(t+1)$; and 2) "DR" implies implementation of the "discretion regime" in period $(t+1)$.

Phase Three: Elections

After the budgetary regime for period $(t+1)$ is decided, elections are held in both chambers of the legislature. We model elections crudely and posit that with exogenous probability $\pi_C(\pi_P)$, the party controlling chamber $C(P)$ retains power in period $(t+1)$. Without loss of generality, we let π_C weakly exceed π_P (i.e., $\pi_C \geq \pi_P$). We assume, furthermore, that incumbency in both chambers is strictly advantageous. Thus:

$$\pi_C > \frac{1}{2} \text{ and } \pi_P > \frac{1}{2} \tag{3.4}$$

Following the two elections, period t concludes. The sequence of events in period $(t+1)$ replicates that in period t.

As mentioned previously, our model has an infinite horizon. Both parties discount future payoffs at rate $\delta \in (0,1)$ and have preferences that are separable over time. In sum, the parties' objective functions are as follows:

$$W_L = E_0\{\sum_{t=0}^{\infty} \delta^t \times [b_t \times (\theta_t - \lambda_L)]\} \tag{3.5}$$

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$$W_R = E_0\{\sum_{t=0}^{\infty} \delta^t \times [b_t \times (\theta_t - \lambda_R)]\} \quad (3.6)$$

where: b_t is the agency's budget in period t; θ_t is the period-t demand shock for the agency's services; E_0 is the expectation operator conditional on the information available at time 0; and $W_L(W_R)$ is the objective function of party $P_L(P_R)$.

3.3.2. Definition of a Markov Perfect Equilibrium

As detailed in section 3.3.1, the agency's budget in generic period t depends on three factors: 1) the period-t demand shock, θ_t; 2) the identity of the parties (or party) controlling chambers C and P in period t ($P_{C(t)}$ and $P_{P(t)}$); and 3) the budgetary regime currently in place ("discretion regime" or "b no discretion regime"). While factors one and two are outcomes of an exogenously specified stochastic process, factor three is determined endogenously — i.e., as part of the model's equilibrium. This section defines an equilibrium for the model.

Our model is a dynamic game, for which the solution concept typically employed is perfect equilibrium. Unfortunately, given the repeated interactions between the two political parties, folk theorem type results guarantee the existence of a plethora of perfect equilibria. Most of the perfect equilibria, however, are implausible: they depend critically on each party implementing elaborate historydependen

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dependent punishment strategies that deter deviation from the putative equilibrium. For purposes of credibility, we therefore consider a suitable refinement of perfect equilibrium: namely, Markov perfect equilibrium.[87]

Defining a Markov perfect equilibrium is notationally cumbersome. For clarity, we divide our exposition into three parts. First, we define the state space of the model and present the transition function specifying how states evolve over time. Second, we describe the strategies and value functions of the two political parties, P_L and P_R. Third, we provide the necessary and sufficient conditions for strategies to constitute a Markov perfect equilibrium.

State Space and Transition Function

Fix a generic period t and consider the phase in which budgetary rules for period $(t+1)$ are written (i.e., phase two). This phase is described by a three-element vector — $s \equiv (s_C, s_P, a)$ — where: 1) s_C equals $s_L(s_R)$ when party $P_L(P_R)$ controls chamber C; 2) s_P equals $s_L(s_R)$ when party $P_L(P_R)$ controls chamber P; and 3) a equals $0(1)$ when chamber $C(P)$ has the authority to specify the budgetary regime for the next period. S, the collection of the eight possible states s, is the state space of the model.

[87]For an interpretation of Markov perfection, the reader is referred to Baron (1996), Fudenberg and Tirole (1991) and Maskin and Tirole (1988, 1994).

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We let $\varphi : S \times S \to [0,1]$ denote the transition function for the model; thus, $\varphi(s,s')$ is the probability that the state next period is $s' \in S$ when the current state is $s \in S$. The construction of φ is as follows. For $s, s' \in S$, we first build a three-element vector $\rho(s,s') \equiv (\rho_1(s,s'), \rho_2(s,s'), \rho_3(s,s'))$ where: 1) $\rho_1(s,s')$ is a binary variable that equals 0(1) if $s'_C = s_C$ ($s'_C \neq s_C$); 2) $\rho_2(s,s')$ is a binary variable that equals 0(1) if $s'_P = s_P$ ($s'_P \neq s_P$); and 3) $\rho_3(s,s') = a'$. In words, the first (second) component of $\rho(s,s')$ assumes the value of 1 only when movement from state s to state s' involves a different party controlling chamber $C(P)$. The third component of $\rho(s,s')$ simply identifies the chamber writing the budgetary rule in state s'. Note, now, that electoral outcomes in the two chambers and the granting of rule writing authority are independent events. Therefore, we obtain the following expression for $\varphi(s,s')$:

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\begin{aligned}
\varphi(s,s') \quad = \quad & \{\pi_C^{(1-\rho_1(s,s'))} \times (1-\pi_C)^{\rho_1(s,s')}\} \times \{\pi_P^{(1-\rho_2(s,s'))} \times (1-\pi_P)^{\rho_2(s,s')}\} \\
& \times \{\alpha^{(1-\rho_3(s,s'))} \times (1-\alpha)^{\rho_3(s,s')}\} \qquad (3.7)
\end{aligned}
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Strategy Spaces and Value Functions

We let $\mathcal{P}$ be a mapping from S into $\{P_L, P_R\}$ where $\mathcal{P}(s)$ identifies the party writing t

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writing the budgetary rules in state $s \in S$. Generic strategies of the two parties are represented by a mapping $g : S \rightarrow [0, \overline{B}] \cup \{\text{“}DR\text{”}\}$ where $g(s)$ specifies the budgetary regime chosen by party $\mathcal{P}(s)$ in state $s \in S$.

We let $U_L(s,r,\theta)$ ($U_R(s,r,\theta)$) denote the period payoff received by party $P_L(P_R)$ when: 1) the current state is $s \in S$; 2) the current budgetary regime is $r \in [0, \overline{B}] \cup \{\text{“}DR\text{”}\}$; and 3) the current demand shock is $\theta \in [0, \overline{\theta}]$. From the model's description in section 3.3.1, the following expressions for $U_L(s,r,\theta)$ and $U_R(s,r,\theta)$ can be derived:

$$U_j(s, \text{“}DR\text{”}, \theta) = b(s, \text{“}DR\text{”}, \theta) \times (\theta - \lambda_j); \;\; j \in \{L, R\} \tag{3.8}$$

$$U_j(s,r,\theta) = r \times (\theta - \lambda_j); \;\; j \in \{L, R\} \text{ and } r \in [0, \overline{B}] \tag{3.9}$$

In equation (3.8), $b(s, \text{“}DR\text{”}, \theta)$ denotes the agency's budget when: 1) the current state is $s \in S$; 2) the current regime is the “discretion regime;” and 3) the current demand shock is θ.[88] Since $(\theta - \lambda_j)$ is the per dollar net benefit to party P_j, the total period payoff is the product of $b(s, \text{“}DR,\text{”}\theta)$ and $(\theta - \lambda_j)$. Consider now

[88] When state s exhibits “unified party P_L control” (i.e., $s \in \{(s_L, s_L, 0), (s_L, s_L, 1)\}$), $b(s, \text{“}DR\text{”}, \theta) = b(\theta, \lambda_L)$. When state s exhibits “unified party P_R control” (i.e., $s \in \{(s_R, s_R, 0), (s_R, s_R, 1)\}$), $b(s, \text{“}DR\text{”}, \theta) = b(\theta, \lambda_R)$. When state s exhibits “divided government” (i.e., $s \in \{(s_L, s_R, a), (s_R, s_L, a) | a \in \{0, 1\}\}$), $b(s, \text{“}DR\text{”}, \theta) = [(\frac{1}{2}) \times (b(\theta, \lambda_L) + b(\theta, \lambda_R))]$.

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equation (3.9). Under the "b no discretion regime," the agency's budget is fixed at b. Once again, the total period payoff to party P_j is the product of the current agency budget, b, and the current per dollar net benefit, $(\theta - \lambda_j)$.

Given generic strategies g, $V_L(s)$ ($V_R(s)$) denotes the expected present discounted sum of period payoffs for party $P_L(P_R)$ over the infinite horizon when: 1) the current state is $s \in S$; and 2) the agency's services for the current period have already been paid for and consumed. By a standard recursion argument, the following two equations can be established:

$$V_L(s) = \delta \times \sum_{s' \in S} \varphi(s, s') \times \{V_L(s') + \int_0^{\overline{\theta}} U_L(s', g(s), \theta) \times \frac{1}{\overline{\theta}} d\theta\} \tag{3.10}$$

$$V_R(s) = \delta \times \sum_{s' \in S} \varphi(s, s') \times \{V_R(s') + \int_0^{\overline{\theta}} U_R(s', g(s), \theta) \times \frac{1}{\overline{\theta}} d\theta\} \tag{3.11}$$

Consider equation (3.10). In state $s \in S$, party $\mathcal{P}(s)$ selects budgetary regime $g(s)$. Thereafter, with probability $\varphi(s, s')$ the state next period is $s' \in S$. In state s', party P_L's expected period payoff is $[\int_0^{\overline{\theta}} U_L(s', g(s), \theta) \times \frac{1}{\overline{\theta}} d\theta]$ while, over the remainde

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remainder of the game, its expected discounted sum of period payoffs is $V_L(s')$. Thus, at state s', the total expected payoff for party P_L is $[\int_0^{\overline{\theta}} U_L(s', g(s), \theta) \times \frac{1}{\overline{\theta}} d\theta + V_L(s')]$. Equation (3.10) indicates that from an ex ante perspective, conditional on starting at $s \in S$, $V_L(s)$ is simply: $\sum_{s' \in S} \varphi(s, s') \times \delta \times$ {total expected payoff for party P_L starting at s'}. Identical interpretation applies for equation (3.11).

Conditions for Markov Perfect Equilibrium

We divide the state space S into two disjoint subsets: specifically, we let $S_L(S_R)$ denote the set of states in which party $P_L(P_R)$ writes the budgetary rules for the next period.[89] For $s \in S_L(S_R)$, $V_L(s, a)$ ($V_R(s, a)$) denotes the expected present discounted sum of period payoffs for party $P_L(P_R)$ over the infinite horizon when: 1) the current state is $s \in S_L(S_R)$; 2) the agency's services for the current period have already been paid for and consumed; 3) party P_L's (P_R's) choice of budgetary regime for next period is $a \in [0, \overline{B}] \cup \{\text{“}DR\text{”}\}$ (not necessarily $g(s)$); and 4) that henceforth both parties play according to g. Following the logic of equations (3.10) and (3.11), the next two equations can be derived:

$$V_L(s, a) = \delta \times \sum_{s' \in S} \varphi(s, s') \times \{V_L(s') + \int_0^{\overline{\theta}} U_L(s', a, \theta) \times \frac{1}{\overline{\theta}} d\theta\}; \; s \in S_L \qquad (3.12)$$

[89]Hence, $S_L \equiv \{s | \mathcal{P}(s) = P_L\}$ and $S_R \equiv \{s | \mathcal{P}(s) = P_R\}$.

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$$V_R(s,a) = \delta \times \sum_{s' \in S} \varphi(s,s') \times \{V_R(s') + \int_0^{\overline{\theta}} U_L(s',a,\theta) \times \frac{1}{\overline{\theta}} d\theta\}; \ s \in S_R \quad (3.13)$$

'e now provide the necessary and sufficient conditions for g to be a Markov erfect equilibrium. Using the unimprovability criterion of dynamic programing (see Bellman (1957)), g is a Markov perfect equilibrium if and only if one 1ot deviations by parties P_L and P_R are unprofitable. Hence, the following two onditions ensure the optimality of g:

$$V_L(s) \geq V_L(s,a); \ \forall s \in S_L \text{ and } \forall a \in [0, \overline{B}] \cup \{\text{“}DR\text{”}\} \quad (3.14)$$

$$V_R(s) \geq V_R(s,a); \ \forall s \in S_R \text{ and } \forall a \in [0, \overline{B}] \cup \{\text{“}DR\text{”}\} \quad (3.15)$$

.3.3. The Model's Solution and Implications

he construction of the Markov perfect equilibrium for the separation-of-powers /stem is detailed in section 3.7. In this section, we present the main features of 1e solution, provide certain intuitions, and emphasize the principal implications.

A polity, in our model, is characterized by a four-tuple $(\lambda_L, \lambda_R, \pi_C, \pi_P)$. A separation-of-pow

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eparation-of-powers system is defined to be the set of admissible polities — e., $\{(\lambda_L, \lambda_R, \pi_C, \pi_P) | \lambda_i \in [0, \overline{\theta}], \pi_j \in (\frac{1}{2}, 1], \lambda_R \geq \lambda_L$ and $\pi_C \geq \pi_P\}$. With π_C nd π_P held fixed, the cross-section of admissible polities becomes the λ-space, $(\lambda_L, \lambda_R) | \lambda_i \in [0, \overline{\theta}]$ and $\lambda_R \geq \lambda_L\}$. In Figure 1 of Appendix C, triangle XYZ epicts this λ-space.

It turns out that the Markov perfect equilibrium of the model allows us to lentify two qualitatively distinct regions of the λ-space: 1) A polity lying in egion R_{BR} (see Figure 1) exhibits rigid budgets. In such a polity, for each state $\in S$, when party $\mathcal{P}(s)$ selects next period's budgetary regime it refuses to yield iscretion. Instead, the budget is some fixed element of the set $[0, \overline{B}]$. 2) A polity ying in region R_{BF} (see Figure 1) exhibits flexible budgets. In such a polity, for ach state $s \in S$, when party $\mathcal{P}(s)$ selects next period's budgetary regime it yields iscretion ("DR"). The precise locations of regions R_{BR} and R_{BF} are detailed in esult 1.[90]

esult 1: For a separation-of-powers system, fix the reelection parameters, (π_C, $_P$), and consider the λ-space, $\{(\lambda_L, \lambda_R) | \lambda_i \in [0, \overline{\theta}]$ and $\lambda_R \geq \lambda_L\}$. Then:

[90]Note that there are polities in the λ-space that do not belong in either R_{BR} or R_{BF}. These olities exhibit hybrid behavior: for certain states, the party setting next period's budget yields iscretion; for other states, the party setting next period's budget induces rigidity. In the interest f brevity, we do not consider such polities.

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$R_{BR} = \{(\lambda_L, \lambda_R) | \lambda_R \geq (\frac{1+j'}{j'}) \times \lambda_L \text{ and } \lambda_R \geq (\frac{\bar{\theta}}{1+j'}) + (\frac{j'}{1+j'}) \times \lambda_L\}$

where: $j' \equiv \sqrt{(1 - \frac{\pi_C}{2} - \frac{\pi_P}{2})}$

$R_{BF} = \{(\lambda_L, \lambda_R) | \lambda_R \leq (\frac{1+j''}{j''}) \times \lambda_L \text{ and } \lambda_R \leq (\frac{\bar{\theta}}{1+j''}) + (\frac{j''}{1+j''}) \times \lambda_L\}$

where: $j'' \equiv \sqrt{(\frac{1}{2} + \frac{\pi_C}{2} - \frac{\pi_P}{2})}$

roof: See section 3.7.

Figure 1 illustrates an important observation: the separation-of-powers system enerates multiple behavioral patterns; the budgetary regime of a specific polity epends on its location in the λ-space.

Result 1 enables us to derive predictions about the relationship between budet flexibility (or rigidity) and the level of polarization. Specifically, we hold fixed he reelection parameters, (π_C, π_P), and consider the corresponding cross-section f admissible polities (i.e., the λ-space). Associated with a generic polity (λ_L, λ_R) s its defined polarization level, $\psi(\lambda_L, \lambda_R) = \lambda_R - \lambda_L$. In the λ-space, the isopoarization curves are the level sets of ψ. In Figure 1, the isopolarization curves re straight lines parallel to the diagonal XY; the polarization level increases as he isopolarization curves move farther away from the diagonal. Consider, now, wo isopolarization curves, the A-line and the B-line.[91] Polities located on line A

[91]The A-line refers to the line through points A_1 and A_4. The B-line refers to the line through

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possess a higher polarization level than those located on line B. Observe that a randomly sampled polity from line A(B) exhibits budget flexibility with probability equal to 0((length of line segment B_2B_3) $\div$ (length of line segment B_1B_4)).[92] Conclusion 1.1 generalizes the foregoing discussion.

Conclusion 1.1: In a separation-of-powers system, as the level of polarization increases, the probability of observing budget rigidity (flexibility) increases (decreases).

Result 1 also predicts how the regions of budget rigidity (R_{BR}) and budget flexibility (R_{BF}) change as the reelection rates, (π_C, π_P), are varied. Holding fixed π_C and the λ-space, two changes occur as π_P is increased: 1) Line 1(2) rotates counter-clockwise (clockwise) about the point X(Y) (see Figure 1). Hence, region R_{BR} shrinks.[93] 2) Furthermore, line 3(4) rotates counter-clockwise (clockwise) about the point X(Y) (see Figure 1).[94] Hence, region R_{BF} expands. Conclusion

points B_1 and B_4.

[92]Line segment B_2B_3 refers to the line segment with endpoints B_2 and B_3. Line segment B_1B_4 refers to the line segment with endpoints B_1 and B_4 (see Figure 1).

[93]The equation of line 1 is: $\lambda_R = (\frac{1+j'}{j'}) \times \lambda_L$. The equation of line 2 is: $\lambda_R = (\frac{\overline{\theta}}{1+j'}) + (\frac{j'}{1+j'}) \times \lambda_L$. To determine the rotation of the two lines, note that the derivative of j' with respect to π_P is negative.

[94]The equation of line 3 is: $\lambda_R = (\frac{1+j''}{j''}) \times \lambda_L$. The equation of line 4 is: $\lambda_R = (\frac{\overline{\theta}}{1+j''}) +$

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1.2 sums up the comparative statics of budgetary regimes with respect to π_P.

Conclusion 1.2: In a separation-of-powers system, as the rate of reelection in chamber P, π_P, is increased, budget rigidity is unambiguously reduced.

The effect on budget rigidity of raising π_C is, however, ambiguous. Holding fixed π_P and the λ-space, two changes occur as π_C is increased: 1) Line 1(2) rotates counter-clockwise (clockwise) about the point X(Y) (see Figure 1).[95] Hence, region R_{BR} shrinks. 2) However, line 3(4) rotates clockwise (counter-clockwise) about the point X(Y) (see Figure 1).[96] Hence, region R_{BF} shrinks as well. Conclusion 1.3 summarizes the above discussion.

Conclusion 1.3: In a separation-of-powers system, as the rate of reelection in chamber C, π_C, is increased, the impact on budget rigidity is ambiguous; the regions of budget rigidity (R_{BR}) and budget flexibility (R_{BF}) shrink.

$(\frac{j''}{1+j''}) \times \lambda_L$. To determine the rotation of the two lines, note that the derivative of j'' with respect to π_P is negative.

[95]Given the equations of lines 1 and 2, the rotation is determined by noting that the derivative of j' with respect to π_C is negative.

[96]Given the equations of lines 3 and 4, the rotation is determined by noting that the derivative of j'' with respect to π_C is positive.

We now provide the intuition behind conclusions 1.1 - 1.3 and the mechanics of the model's solution. The construction of a Markov perfect equilibrium (see equations (3.10) - (3.15)) demands that at each node $s \in S$, the budgetary regime selected by party $\mathcal{P}(s)$ maximizes its expected next period payoff. Hence, even in an infinite-horizon setup, optimality of party $\mathcal{P}(s)$'s action is determined in terms of rewards in the immediate future.

To fix ideas, consider a polity in which λ_L is less than $\frac{\overline{\theta}}{2}$ while λ_R exceeds $\frac{\overline{\theta}}{2}$.[97] Suppose, furthermore, that in generic period t, the polity is in state $s \in S_L$– i.e., party P_L sets the budgetary regime for period $(t+1)$.[98] In an ideal world for party P_L, the period-$(t+1)$ budget follows the rule, $b(\theta_{t+1}, \lambda_L)$; specifically, the budget is set at $\overline{B}(0)$ when the period-$(t+1)$ demand shock, θ_{t+1}, exceeds (is less than) λ_L. Given the structure of the model, however, party P_L cannot enforce the $b(\theta_{t+1}, \lambda_L)$-rule. Recall that party P_L has only two budgetary options: 1) By selecting "DR", party P_L can cede discretion to the coalition in power in period $(t+1)$. 2) Alternatively, party P_L can rigidly fix the period $(t+1)$ budget at some level between 0 and $\overline{B}$.

[97]The intuitions do not depend on the locations of λ_L and λ_R relative to $\frac{\overline{\theta}}{2}$. We only require that λ_R weakly exceeds λ_L.

[98]The intuitions are unchanged if, instead, we consider state $s \in S_R$.

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Consider, now, what happens when party P_L opts to give discretion. With some probability, denoted $\rho_2(s)$, the polity in period $(t+1)$ exhibits "unified party P_R government."[99] Since party P_R now has the right to set the agency's period-$(t+1)$ budget, it therefore follows the individually rational $b(\theta_{t+1}, \lambda_R)$-rule; the budget is set at $\overline{B}(0)$ when θ_{t+1} exceeds (is less than) λ_R. The behavior of party P_R differs from the ideal of party P_L: specifically, when $\theta_{t+1} \in (\lambda_L, \lambda_R)$, party P_R shuts down the agency while party P_L prefers that the budget be $\overline{B}$. This incongruence in behavior inflicts on party P_L an expected welfare equal to: $[\rho_2(s) \times \overline{B} \times \int_{\lambda_L}^{\lambda_R}(\theta - \lambda_L) \times \frac{1}{\theta} d\theta]$.[100]

Furthermore, with some probability, denoted $\rho_3(s)$, the polity in period $(t+1)$ exhibits "divided government."[101] Given discretion, the agency's budget satisfies the $[(\frac{1}{2}) \times (b(\theta_{t+1}, \lambda_L) + b(\theta_{t+1}, \lambda_R))]$-rule; the compromise budget is set at: 1) $\overline{B}$ if θ_{t+1} exceeds λ_R; 2) $\frac{\overline{B}}{2}$ if $\theta_{t+1} \in (\lambda_L, \lambda_R)$; and 3) 0 if θ_{t+1} is less than λ_L. Once again, the above decision rule is suboptimal for party P_L in the region $\theta_{t+1} \in (\lambda_L, \lambda_R)$: specifically, party P_L desires a budget of $\overline{B}$ but obtains only half that amount. This incongruence in behavior inflicts on party P_L an expected welfare loss equal to: $[\rho_3(s) \times \frac{\overline{B}}{2} \times \int_{\lambda_L}^{\lambda_R}(\theta - \lambda_L) \times \frac{1}{\theta} d\theta]$.[102]

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[99]The reader should note that $\rho_2(s)$ varies across the states in S_L.
[100]The expected welfare loss is relative to the first-best payoff of party P_L.
[101]The reader should note that $\rho_3(s)$ varies across the states in S_L.
[102]The expected welfare loss is relative to the first-best payoff of party P_L.

The discussion in the above two paragraphs makes the following argument — when party P_L chooses to give discretion, it encounters two sources of welfare loss: 1) that under "unified party P_R government" and 2) that under "divided government." The total expected welfare loss, denoted $\Delta W_S(\text{"}DR\text{"}, s)$, combines losses from both sources. Hence, $\Delta W_S(\text{"}DR\text{"}, s)$ is given by the following expression:

$$\Delta W_S(\text{"}DR\text{"}, s) = [\rho_2(s) + \frac{\rho_3(s)}{2}] \times \overline{B} \times \int_{\lambda_L}^{\lambda_R} (\theta - \lambda_L) \times \frac{1}{\overline{\theta}} d\theta]; \ s \in S_L \quad (3.16)$$

$\Delta W_S(\text{"}DR\text{"}, s)$, is partially depicted in Figure 2 of Appendix C. Note that $\Delta W_S(\text{"}DR\text{"}, s)$ is proportional to the product of two terms: 1) the "total probability factor," $[\rho_2(s) + \frac{\rho_3(s)}{2}]$; and 2) the "total preference factor," $\int_{\lambda_L}^{\lambda_R} (\theta - \lambda_L) d\theta$, equal to the area of triangle ABC.[103]

Two observations regarding $\Delta W_S(\text{"}DR\text{"}, s)$ turn out to be crucial. First, for a generic polity, (λ_L, λ_R), the "total preference factor" (area of triangle ABC in Figure 2) is increasing in the level of its polarization, $\psi(\lambda_L, \lambda_R) = \lambda_R - \lambda_L$. In sum, $\Delta W_S(\text{"}DR\text{"}, s)$ is an increasing function of a polity's polarization level. Second, the "total probability factor" ($[\rho_2(s) + \frac{\rho_3(s)}{2}]$) varies across states $s \in S_L$.

[103]The constant of proportionality is $\frac{\overline{B}}{\overline{\theta}}$.

When party P_L controls both chambers — the polity is under "unified party P_L control" — the advantages of incumbency make the total probability factor relatively small in value. Therefore, $\Delta W_S(\text{“}DR\text{”}, s)$ is of smallest magnitude when $s \in \{(s_L, s_L, 0), (s_L, s_L, 1)\}$. On the other hand, the status of party P_L is most precarious when the polity is currently under "divided government" and it, furthermore, controls the chamber for which incumbency is less advantageous (i.e., chamber P). Hence, the total probability factor and $\Delta W_S(\text{“}DR\text{”}, s)$ assume their largest value when $s = (s_R, s_L, 1)$.

We have exhaustively discussed the consequences for party P_L, when in state $s \in S_L$, it yields discretion. However, party P_L has another option: it can set the budget for the next period (period $(t+1)$) at some level between 0 and $\overline{B}$. By assumption, we have fixed λ_L to be less than $\frac{\overline{\theta}}{2}$. Hence, on average, the agency's services in period $(t+1)$ are worth more than party P_L's estimate of the cost. The optimal rigid budget therefore involves precommitting all available funds, $\overline{B}$.

The fixed budget of $\overline{B}$ leads to an expected welfare loss for party P_L: specifically, when the demand shock for period $(t+1)$, θ_{t+1}, is less than λ_L, party P_L prefers ex post to shut down the agency but is instead committed to a funding level of $\overline{B}$. The welfare loss from rigid budgets, denoted $\Delta W_S(\overline{B}, s)$, is as follows:[104]

[104]The welfare loss $\Delta W_S(\overline{B}, s)$ is relative to the first-best payoff of party P_L.

$$\Delta W_S(\overline{B}, s) = [\overline{B} \times \int_0^{\lambda_L} (\lambda_L - \theta) \times \frac{1}{\overline{\theta}} d\theta]; \ s \in S_L \qquad (3.17)$$

Observe that welfare loss $\Delta W_S(\overline{B}, s)$ is proportional to the area of triangle OAD in Figure 2.[105]

In sum, party P_L has essentially two budgetary options in state $s \in S_L$: "DR" and $\overline{B}$. Relative to the first-best, $\Delta W_S($"$DR,$"$s)$ ($\Delta W_S(\overline{B}, s)$) measures the expected welfare loss to party P_L when it chooses discretion (a fixed budget of $\overline{B}$). Therefore, the optimal strategy for party P_L is to simply select the budgetary option with the smaller welfare loss. Given this intuition, we now provide explanations for conclusions 1.1 - 1.3.

Consider, first, conclusion 1.1. As a polity becomes more polarized, $(\lambda_R - \lambda_L)$ increases. Figure 2 indicates that the area of triangle ABC (and, hence, $\Delta W_S($"DR"$, s)$) increases as well. On the other hand, the area of triangle OAD (and, hence, $\Delta W_S(\overline{B}, s)$) does not depend on $(\lambda_R - \lambda_L)$. Thus, as the level of polarization rises, there is an enhanced incentive for party P_L to induce rigid rules. In sum, polarization level and budget flexibility (rigidity) are negatively (positively) correlated.[106]

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[105] The constant of proportionality is $\frac{\overline{B}}{\overline{\theta}}$.

[106] For ease of exposition, we only consider the behavior of party P_L (i.e., $s \in S_L$). Identical

Consider, now, how the region of budget rigidity, R_{BR}, varies with the reelection rates, (π_C, π_P). From party P_L's perspective, R_{BR} is the subset of the λ-space in which, for all states $s \in S_L$, $\Delta W_S(\text{"}DR\text{"}, s)$ weakly exceeds $\Delta W_S(\overline{B}, s)$.[107] Recall that $\Delta W_S(\text{"}DR\text{"}, s)$ varies across states in S_L and attains its minimum value when the polity exhibits "unified party P_L control" — i.e., $s \in \{(s_L, s_L, 0), (s_L, s_L, 1)\}$.[108] On the other hand, $\Delta W_S(\overline{B}, s)$ does not vary across states in S_L.[109] Given the foregoing observations, region R_{BR} can be characterized simply as follows: it is the subset of the λ-space in which party P_L prefers to set a rigid budget even though it currently controls both chambers of power, C and P. Suppose, now, that the incumbency advantage is exogenously increased; i.e., π_C or π_P is raised. Since party P_L controls both chambers, such a change enhances its current status and makes it less likely that there is "divided government" or "unified party P_R control" next period. Consequently, ceding discretion becomes less costly and $\Delta W_S(\text{"}DR\text{"}, s)$ decreases in magnitude.[110] In sum, when π_C or π_P is raised, there

arguments apply for party P_R (i.e., $s \in S_R$) as well.

[107]For ease of exposition, we only consider the perspective of party P_L. With two political parties to consider, R_{BR} is the subset of the λ-space in which: 1) $\Delta W_S(\text{"}DR\text{"}, s)$ weakly exceeds $\Delta W_S(\overline{B}, s)$ for all $s \in S_L$; and 2) $\Delta W_S(\text{"}DR\text{"}, s)$ weakly exceeds $\Delta W_S(0, s)$ for all $s \in S_R$.

[108]Note that $\Delta W_S(\text{"}DR\text{"}, s)$ is proportional to the product of two terms: "total preference factor" and "total probability factor." While "total preference factor" does not vary across states in S_L, we have argued that "total probability factor" attains its minimum value when $s \in \{(s_L, s_L, 0), (s_L, s_L, 1)\}$

[109]$\Delta W_S(\overline{B}, s)$ is independent of electoral factors and, hence, does not vary across states $s \in S_L$. $\Delta W_S(\overline{B}, s)$ is proportional to the area of triangle OAD in Figure 2.

[110]For $s \in \{(s_L, s_L, 0), (s_L, s_L, 1)\}$, we can show that $(\rho_2(s) + \frac{\rho_3(s)}{2})$ is equal to $(1 - \frac{\pi_C}{2} - \frac{\pi_P}{2})$.

is less incentive for party P_L to induce budget rigidity; i.e., region R_{BR} shrinks in size.

Consider, now, how the region of budget flexibility, R_{BF}, varies with the reelection rates, (π_C, π_P). From party P_L's perspective, R_{BF} is the subset of the λ-space in which, for all states $s \in S_L$, $\Delta W_S(\overline{B}, s)$ weakly exceeds $\Delta W_S(\text{“}DR\text{”}, s)$.[111] Recall that $\Delta W_S(\text{“}DR\text{”}, s)$ varies across states in S_L and attains its maximum value when $s = (s_R, s_L, 1)$ — i.e., the polity exhibits "divided government" with chambers C and P controlled, respectively, by parties P_R and P_L.[112] On the other hand, note that $\Delta W_S(\overline{B}, s)$ does not vary across states in S_L. Given the foregoing observations, region R_{BF} can be characterized simply as follows: it is the subset of the λ-space in which party P_L prefers to give discretion even though it currently controls only the weakest institution of power (chamber P).

Suppose, now, that the incumbency advantage of chamber P (i.e., π_P) is exogenously increased. Since, in state $s = (s_R, s_L, 1)$, party P_L controls chamber P,

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Thus, the partial derivatives of $(\rho_2(s) + \frac{\rho_3(s)}{2})$ with respect to π_C and π_P are negative. Since the "total probability factor" is a decreasing function of π_C and π_P, so too is $\Delta W_S(\text{“}DR\text{”}, s)$.

[111]For ease of exposition, we only consider the perspective of party P_L. With two political parties to consider, R_{BF} is the subset of the λ-space in which: 1) $\Delta W_S(\overline{B}, s)$ weakly exceeds $\Delta W_S(\text{“}DR\text{”}, s)$ for all $s \in S_L$; and 2) $\Delta W_S(0, s)$ weakly exceeds $\Delta W_S(\text{“}DR\text{”}, s)$ for all $s \in S_R$.

[112]Note that $\Delta W_S(\text{“}DR\text{”}, s)$ is proportional to the product of two terms: "total preference factor" and "total probability factor." While "total preference factor" does not vary across states in S_L, we have argued that "total probability factor" attains its maximum value when $s = (s_R, s_L, 1)$.

an increase in π_P enhances its current status: specifically, the "total probability factor," $(\rho_2(s)+\frac{\rho_3(s)}{2})$, associated with $\Delta W_S($"DR"$, s)$ decreases.[113] Consequently, because $\Delta W_S($"DR"$, s)$ is of smaller value, ceding discretion becomes less costly for party P_L. In sum, when π_P is raised, there is less incentive for party P_L to induce budget rigidity; i.e., region R_{BF} expands in size.

By contrast, an increase in the reelection rate of chamber C (i.e., π_C) weakens the status of party P_L by making it more likely that party P_R, currently controlling chamber C, will retain power next period. Therefore, the "total probability factor" and $\Delta W_S($"DR"$, s)$ increase in magnitude. Since ceding discretion becomes more costly, there is more incentive for party P_L to induce budget rigidity; i.e., region R_{BF} shrinks in size.

Our discussion of the comparative statics of regions R_{BR} and R_{BF} with respect to reelection rates, (π_C, π_P), provides an explanation for conclusions 1.2 and 1.3. The two conclusions highlight an interesting asymmetry: An increase in π_P shrinks region R_{BR} and expands region R_{BF}, thereby reducing the total rigidity in the λ-space. By contrast, an increase in π_C has an ambiguous impact on the total rigidity in the λ-space; both the regions R_{BR} and R_{BF} shrink in size.

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[113] For $s = (s_R, s_L, 1)$, we can show that $(\rho_2(s) + \frac{\rho_3(s)}{2})$ is equal to $(\frac{1}{2} + \frac{\pi_C}{2} - \frac{\pi_P}{2})$. Thus, the partial derivative of $(\rho_2(s) + \frac{\rho_3(s)}{2})$ with respect to $\pi_P(\pi_C)$ is negative (positive).

3.4. A Two-Party Parliamentary System

In this section, we examine a stylized model that approximates a Westminster-style parliamentary system. The section is divided into three parts. First, we provide a verbal description of the model. We then formally define an equilibrium for the model. Finally, we discuss the principal predictions that follow from the model's solution.

3.4.1. Description of the Model

To emphasize the concentration of political power in a parliamentary system, we consider a polity with a unicameral legislature. There are two political parties, denoted P_L and P_R, and an agency, denoted A.

As before, the agency employs public funds to provide a service valued by citizens. Raising public funds, however, induces welfare-reducing distortions in the economy. The two political parties have different estimates of the magnitude of these distortions: specifically, parties P_L and P_R assign, respectively, a deadweight loss to society of λ_L and λ_R in order to levy one dollar for the agency. Party P_R is (weakly) more fiscally conservative than party P_L; hence, $\lambda_R \geq \lambda_L > 0$.

The interaction between the two political parties spans an infinite sequence of structurally identical periods. Each period, in turn, consists of three phases. In

phase one, the party in power (i.e., the party controlling the unicameral legislature) determines the agency's budget for that period. In phase two, budgetary rules for the next period are written. In phase three, an election indicates whether the incumbent party is reelected. A description of the three phases follows

Phase One: Determining the agency's budget

Each period, $t \in Z_{+}$, begins with one of the two political parties, P_L or P_R, controlling the unicameral legislature. The party in power in period t is denoted $P_{W(t)}$.[114] When $P_{W(t)}$ equals $P_L(P_R)$, we say that period t exhibits "party $P_L(P_R)$ control."

In each period t, Nature makes a draw from the distribution of a random variable, θ. θ is uniformly distributed on the interval $[0, \overline{\theta}]$ and θ_t denotes its period-t realization. θ_t is interpreted to be the period-t benefit obtained by citizens in aggregate for each dollar spent by the agency.

Once the agency is apprised of the θ_t-value, it truthfully transmits the θ_t-value to its political overseer, party $P_{W(t)}$. Given θ_t, how is the agency's period-t budget determined? We now need to distinguish between two cases: the "discretion regime" and the "no discretion regime."

Discretion regime.— Case one considers the possibility wherein the party in

[114]Given our notation, $W(t)$ is an element of the set $\{L, R\}$.

power in period $(t-1)$ (i.e., party $P_{W(t-1)}$) established budgetary rules that ceded discretion to party $P_{W(t)}$. Under this "discretion regime," party $P_{W(t)}$ can unilaterally raise a maximum of $\overline{B}$ dollars through taxation. Subject to this exogenous constraint on the availability of public funds, party $P_{W(t)}$ selects a period-t budget level that maximizes its version of citizens' net surplus. In sum, the period-t budget level equals $b(\theta_t, \lambda_{W(t)})$ where:

$$b(\theta_t, \lambda_{W(t)}) = \arg \max_{b \in [0, \overline{B}]} \left[b \times (\theta_t - \lambda_{W(t)}) \right] \tag{3.18}$$

No discretion regime.— The party in power in period $(t-1)$ may not have written budgetary rules that ceded discretion to party $P_{W(t)}$. Case two considers the situation wherein party $P_{W(t-1)}$ rigidly fixed the period-t agency budget at some level $b \in [0, \overline{B}]$. Under this "b no discretion regime," party $P_{W(t)}$ is rendered powerless. The demand shock θ_t is ignored and the period-t funding of b is implemented.

Phase Two: Writing budgetary rules

Once the agency's period-t budget is determined, the budgetary regime for period $(t+1)$ needs to be established. Who writes the rules? In a Westminster-style parliamentary system, the party in power — to a first approximation — is all-

powerful. We assume, therefore, that it is invested with the rights to unilaterally stipulate the budgetary regime for period $(t+1)$.

Party $P_{W(t)}$ determines the budgetary regime for period $(t+1)$ by selecting an element from the set $[0, \overline{B}] \cup \{\text{"}DR\text{"}\}$ where: 1) $b \in [0, \overline{B}]$ implies implementation of the "b no discretion regime" in period $(t+1)$; and 2) "DR" implies implementation of the "discretion regime" in period $(t+1)$.

Phase Three: Election

Once the budgetary regime for period $(t+1)$ is decided, an election takes place. We model electoral outcomes crudely and posit that with exogenous probability π_W, the incumbent party retains control in period $(t+1)$. Incumbency, furthermore, is assumed to be strictly advantageous; thus: $\pi_W > \frac{1}{2}$.

Following the election, period t concludes. The sequence of events in period $(t+1)$ replicates that in period t. As mentioned previously, our model has an infinite horizon. Both parties discount future payoffs at rate $\delta \in (0,1)$ and have preferences that are separable over time. In sum, the parties' objective functions are as follows:

$$W_L = E_0\{\sum_{t=0}^{\infty} \delta^t \times [b_t \times (\theta_t - \lambda_L)]\} \tag{3.19}$$

$$W_R = E_0\{\sum_{t=0}^{\infty} \delta^t \times [b_t \times (\theta_t - \lambda_R)]\} \tag{3.20}$$

where: b_t is the agency's budget in period t; θ_t is the period-t demand shock for the agency's services; E_0 is the expectation operator conditional on the information available at time 0; and $W_L(W_R)$ is the objective function of party $P_L(P_R)$.

3.4.2. Definition of a Markov Perfect Equilibrium

As detailed in section 3.4.1, the agency's budget in generic period t depends on three factors: 1) the period-t demand shock, θ_t; 2) the identity of the party controlling the legislature in period t ($P_{W(t)}$); and 3) the budgetary regime in place in period t ("discretion regime" or "b no discretion regime"). While factors one and two are outcomes of an exogenously specified stochastic process, factor three is determined endogenously — i.e., as part of the model's equilibrium.

The motivation for defining equilibrium in terms of Markov perfection is given in section 3.3.2 and need not be reprised here. Our exposition of the conditions for Markov perfect equilibrium is given in two parts. First, we specify the state space of the model and the strategy spaces and value functions of the two political parties, P_L and P_R. We then provide the necessary and sufficient conditions for strategies to constitute a Markov perfect equilibrium.

State Space, Strategies and Value Functions

Fix a generic period t. We say that the polity, in period t, is in state $\widetilde{s}_L(\widetilde{s}_R)$ if party $P_L(P_R)$ is in power. We define $\widetilde{S}$, the collection of possible states, to be the state space of the model; thus, $\widetilde{S} \equiv \{\widetilde{s}_L, \widetilde{s}_R\}$.

Generic strategies of the two parties are represented by a mapping $g : \widetilde{S} \rightarrow [0, \overline{B}] \cup \{\text{“}DR\text{”}\}$, where $g(\widetilde{s}_L)$ $(g(\widetilde{s}_R))$ specifies the budgetary regime chosen by party $P_L(P_R)$ in state $\widetilde{s}_L(\widetilde{s}_R)$. $U_L(\widetilde{s}, r, \theta)$ $(U_R(\widetilde{s}, r, \theta))$ denotes the period payoff received by party $P_L(P_R)$ when: 1) the current state is $\widetilde{s} \in \widetilde{S}$; 2) the current budgetary regime is $r \in [0, \overline{B}] \cup \{\text{“}DR\text{”}\}$; and 3) the current demand shock is $\theta \in [0, \overline{\theta}]$. From section 3.4.1, the following expressions for $U_L(\widetilde{s}, r, \theta)$ and $U_R(\widetilde{s}, r, \theta)$ can be derived:

$$U_j(\widetilde{s}, \text{“}DR\text{”}, \theta) = b(\widetilde{s}, \text{“}DR\text{”}, \theta) \times (\theta - \lambda_j); \; j \in \{L, R\} \text{ and } \widetilde{s} \in \widetilde{S} \tag{3.21}$$

$$U_j(\widetilde{s}, r, \theta) = r \times (\theta - \lambda_j); \; j \in \{L, R\}, \; \widetilde{s} \in \widetilde{S} \text{ and } r \in [0, \overline{B}] \tag{3.22}$$

In equation (3.21), $b(s, \text{“}DR\text{”}, \theta)$ denotes the agency's budget when: 1) the current state is $\widetilde{s} \in \widetilde{S}$; 2) the current regime is the “discretion regime;” and 3) the current

demand shock is θ.[115] Since $(\theta - \lambda_j)$ is the per dollar benefit to party P_j, the total period benefit is the product of $b(s, \text{"}DR,\text{"}\theta)$ and $(\theta - \lambda_j)$. Consider now equation (3.22). Under the "b no discretion regime," the agency's budget is fixed at b. Once again, the total period payoff to party P_j is the product of the current agency budget, b, and the current per dollar net benefit, $(\theta - \lambda_j)$.

Given generic strategies g, $V_L(\widetilde{s})$ ($V_R(\widetilde{s})$) denotes the expected present discounted sum of period payoffs to party $P_L(P_R)$ over the infinite horizon when: 1) the current state is $\widetilde{s} \in \widetilde{S}$; and 2) the agency's services for the current period have already been paid for and consumed. By a standard recursion argument, the following two equations can be derived:

$$\begin{aligned} V_L(\widetilde{s}_L) \quad &= \quad \delta \times \pi_W \times [\int_0^{\overline{\theta}} U_L(\widetilde{s}_L, g(\widetilde{s}_L), \theta) \times \frac{1}{\overline{\theta}} d\theta \ + \ V_L(\widetilde{s}_L)] + \\ &\quad \delta \times (1 - \pi_W) \times [\int_0^{\overline{\theta}} U_L(\widetilde{s}_R, g(\widetilde{s}_L), \theta) \times \frac{1}{\overline{\theta}} d\theta \ + \ V_L(\widetilde{s}_R)] \end{aligned} \tag{3.23}$$

$$V_R(\widetilde{s}_R) \quad = \quad \delta \times \pi_W \times [\int_0^{\overline{\theta}} U_R(\widetilde{s}_R, g(\widetilde{s}_R), \theta) \times \frac{1}{\overline{\theta}} d\theta \ + \ V_R(\widetilde{s}_R)] + \tag{3.24}$$

115 In state $\widetilde{s}_L$, $b(\widetilde{s}_L, \text{"}DR\text{"}, \theta) = b(\theta, \lambda_L)$. In state $\widetilde{s}_R$, $b(\widetilde{s}_R, \text{"}DR\text{"}, \theta) = b(\theta, \lambda_R)$.

$$\delta \times (1 - \pi_W) \times [\int_0^{\overline{\theta}} U_R(\widetilde{s}_L, g(\widetilde{s}_R), \theta) \times \frac{1}{\overline{\theta}} d\theta \ + \ V_R(\widetilde{s}_L)]$$

Consider equation (3.23). In state $\widetilde{s}_L$, party P_L selects budgetary regime $g(\widetilde{s}_L)$ for the next period. Two possibilities now arise. With probability π_W, party P_L is reelected (i.e., the state next period remains $\widetilde{s}_L$). In state $\widetilde{s}_L$, party P_L's expected period payoff is $[\int_0^{\overline{\theta}} U_L(\widetilde{s}_L, g(\widetilde{s}_L), \theta) \times \frac{1}{\overline{\theta}} d\theta]$ while, over the remainder of the game, its expected discounted sum of period payoffs is $V_L(\widetilde{s}_L)$. Hence, conditional on reelection, the total discounted sum of period payoffs is: $[\int_0^{\overline{\theta}} U_L(\widetilde{s}_L, g(\widetilde{s}_L), \theta) \times \frac{1}{\overline{\theta}} d\theta$ $+ V_L(\widetilde{s}_L)]$. On the other hand, with probability $(1-\pi_W)$, party P_L is not re-elected (i.e., state next period is $\widetilde{s}_R$). An analogous argment establishes that conditional on not being re-elected, party P_L's total discounted sum of period payoffs is: $[\int_0^{\overline{\theta}} U_L(\widetilde{s}_R, g(\widetilde{s}_L), \theta) \times \frac{1}{\overline{\theta}} d\theta \ + \ V_L(\widetilde{s}_R)]$. Equation (3.23) indicates that from an ex ante perspective, $V_L(\widetilde{s}_L)$ is simply: $\delta \times$[probability{state next period is $\widetilde{s}_L$| current state is $\widetilde{s}_L$} $\times$ {total discounted sum of period payoffs for party P_L starting at $\widetilde{s}_L$} plus probability{state next period is $\widetilde{s}_R$| current state is $\widetilde{s}_L$} $\times$ {total discounted sum of period payoffs for party P_L starting at $\widetilde{s}_R$}]. Identical interpretation applies for equation (3.24).

Conditions for Markov Perfect Equilibrium

We let $V_L(\widetilde{s}_L, a)$ $(V_R(\widetilde{s}_R, a))$ denote the expected present discounted sum of

period payoffs for party $P_L(P_R)$ over the infinite horizon when: 1) the current state is $\tilde{s}_L(\tilde{s}_R)$; 2) the agency's services for the current period have already been paid for and consumed; 3) party P_L's (P_R's) choice of budgetary regime for next period is $a \in [0, \overline{B}] \cup \{\text{"}DR\text{"}\}$ (not necessarily that specified by g); and 4) that henceforth both parties play according to g. Following the logic of equations (3.23) and (3.24), the next two equations can be immediately derived:

$$\begin{aligned} V_L(\tilde{s}_L, a) &= \delta \times \pi_W \times [\int_0^{\overline{\theta}} U_L(\tilde{s}_L, a, \theta) \times \frac{1}{\overline{\theta}} d\theta \; + \; V_L(\tilde{s}_L)] + \\ & \quad \delta \times (1 - \pi_W) \times [\int_0^{\overline{\theta}} U_L(\tilde{s}_R, a, \theta) \times \frac{1}{\overline{\theta}} d\theta \; + \; V_L(\tilde{s}_R)] \end{aligned} \tag{3.25}$$

$$\begin{aligned} V_R(\tilde{s}_R, a) &= \delta \times \pi_W \times [\int_0^{\overline{\theta}} U_R(\tilde{s}_R, a, \theta) \times \frac{1}{\overline{\theta}} d\theta \; + \; V_R(\tilde{s}_R)] + \\ & \quad \delta \times (1 - \pi_W) \times [\int_0^{\overline{\theta}} U_R(\tilde{s}_L, a, \theta) \times \frac{1}{\overline{\theta}} d\theta \; + \; V_R(\tilde{s}_L)] \end{aligned} \tag{3.26}$$

We now provide the necessary and sufficient conditions for g to be a Markov perfect equilibrium. Using the unimprovability criterion of dynamic programming (see Bellman (1957)), g is a Markov perfect equilibrium if and only if one

shot deviations by parties P_L and P_R are unprofitable. Hence, the following two conditions ensure the optimality of g:

$$V_L(\tilde{s}_L) \geq V_L(\tilde{s}_L, a); \ \forall a \in [0, \overline{B}] \cup \{\text{"}DR\text{"}\} \tag{3.27}$$

$$V_R(\tilde{s}_R) \geq V_R(\tilde{s}_R, a); \ \forall a \in [0, \overline{B}] \cup \{\text{"}DR\text{"}\} \tag{3.28}$$

3.4.3. The Model's Solution and Implications

The construction of the Markov perfect equilibrium for the parliamentary system is analogous to that for the separation-of-powers system and is, hence, omitted. In this section, we simply present the main features of the model's solution, provide certain intuitions, and emphasize the principal implications.

A polity, in our model, is characterized by a triple $(\lambda_L, \lambda_R, \pi_W)$. A parliamentary system is defined to be the set of admissible polities — i.e., $\{(\lambda_L, \lambda_R, \pi_W)|\lambda_i \in [0, \overline{\theta}], \pi_W \in (\frac{1}{2}, 1]$ and $\lambda_R \geq \lambda_L\}$. With reelection rate π_W held fixed, the cross-section of admissible polities becomes the λ-space, $\{(\lambda_L, \lambda_R)|\lambda_i \in [0, \overline{\theta}]$ and $\lambda_R \geq \lambda_L\}$. In Figure 3 of Appendix C, triangle XYZ depicts this λ-space.

It turns out that the Markov perfect equilibrium of the model allows us to identify two qualitatively distinct regions of the λ-space: 1) A polity lying in

region R_{BR} (see Figure 3) exhibits rigid budgets. In such a polity, for each state $\widetilde{s} \in \widetilde{S}$, when party $\mathcal{P}(\widetilde{s})$ selects next period's budgetary regime it refuses to yield discretion. Instead, the budget is some fixed element of the set $[0, \overline{B}]$. 2) A polity lying in region R_{BF} (see Figure 3) exhibits flexible budgets. In such a polity, for each state $\widetilde{s} \in \widetilde{S}$, when party $\mathcal{P}(\widetilde{s})$ selects next period's budgetary regime it yields discretion ("DR"). The precise locations of regions R_{BR} and R_{BF} are detailed in result 2.[116,117]

Result 2: For a parliamentary system, fix the reelection parameter π_W and consider the λ-space, $\{(\lambda_L, \lambda_R) | \lambda_i \in [0, \overline{\theta}] \text{ and } \lambda_R \geq \lambda_L\}$. Then:

$$R_{BR} = \{(\lambda_L, \lambda_R) | \lambda_R \geq (\tfrac{1+j}{j}) \times \lambda_L \text{ and } \lambda_R \geq (\tfrac{\overline{\theta}}{1+j}) + (\tfrac{j}{1+j}) \times \lambda_L\}$$

$$R_{BF} = \{(\lambda_L, \lambda_R) | \lambda_R \leq (\tfrac{1+j}{j}) \times \lambda_L \text{ and } \lambda_R \leq (\tfrac{\overline{\theta}}{1+j}) + (\tfrac{j}{1+j}) \times \lambda_L\}$$

where: $j \equiv \sqrt{1 - \pi_W}$

Figure 3 illustrates an important observation: the parliamentary system generates multiple behavioral patterns; the budgetary regime of a specific polity

[116]The complete proofs are available upon request.

[117]Note that there are polities in the λ-space that do not belong in either R_{BR} or R_{BF}. These polities exhibit hybrid behavior: one of the two parties yields discretion while the other induces budget rigidity. For brevity, we do not consider such polities.

depends on its location in the λ-space.

We employ result 2 to derive predictions regarding the relationship between budget flexibility (or rigidity) and the level of polarization. Specifically, we hold fixed the reelection parameter, π_W, and consider the corresponding λ-space. As in the separation-of-powers system, the isopolarization curves in this λ-space are straight lines parallel to diagonal XY; the polarization level increases as the isopolarization curves move farther away from the diagonal. In Figure 3, we now consider two isopolarization curves, the A-line and the B-line.[118] Polities located on line A possess a higher polarization level than those located on line B. Observe also that a randomly sampled polity from line A(B) exhibits budget flexibility with probability equal to 0((length of line segment B_2B_3) $\div$ (length of line segment B_1B_4)).[119] Conclusion 2.1 summarizes the foregoing discussion.

Conclusion 2.1: In a parliamentary system, as the level of polarization increases, the probability of observing budget flexibility (rigidity) decreases (increases).

[118]The A-line refers to the line through points A_1 and A_4. The B-line refers to the line through points B_1 and B_4.

[119]Line segment B_2B_3 refers to the line segment with endpoints B_2 and B_3. Line segment B_1B_4 refers to the line segment with endpoints B_1 and B_4 (see Figure 3).

Result 2 also predicts how the regions of budget flexibility (R_{BF}) and budget rigidity (R_{BR}) change as the reelection parameter, π_W, is varied. Holding fixed the λ-space, two changes occur as π_W is increased: 1) line 1 rotates counter-clockwise about the point X; and 2) line 2 rotates clockwise about the point Y (see Figure 3).[120] Hence, region R_{BR} shrinks in size while region R_{BF} expands. The comparative statics of budgetary regimes with respect to π_W is summarized in conclusion 2.2.

<u>Conclusion 2.2:</u> In a parliamentary system, as the reelection rate of the chamber, π_W, is raised, budgetary rigidities are unambiguously reduced.

We now provide the intuition behind conclusions 2.1 and 2.2. The construction of a Markov perfect equilibrium (see equations (3.23) - (3.28)) demands that at each node $\tilde{s} \in \tilde{S}$, the budgetary regime selected by party $\mathcal{P}(\tilde{s})$ maximizes its expected next period payoff. Thus, despite the infinite-horizon structure of the model, optimality of party $\mathcal{P}(\tilde{s})$'s action is measured in terms of rewards in the immediate future.

[120] The equation of line 1 is: $\lambda_R = (\frac{1+j}{j}) \times \lambda_L$. The equation of line 2 is: $\lambda_R = (\frac{\bar{\theta}}{1+j}) + (\frac{j}{1+j}) \times \lambda_L$. To determine the rotation of the two lines, note that the derivative of j with respect to π_W is negative.

To fix ideas, consider a polity in which λ_L is less than $\frac{\overline{\theta}}{2}$ while λ_R exceeds $\frac{\overline{\theta}}{2}$.[121] Suppose, furthermore, that in generic period t, party P_L sets the budgetary regime for period $(t+1)$ — i.e., the polity is currently in state $\widetilde{s}_L$.[122] In an ideal world for party P_L, the period-$(t+1)$ budget follows the $b(\theta_{t+1}, \lambda_L)$-rule. Specifically, the budget is set at $\overline{B}(0)$ when the period-$(t+1)$ demand shock, θ_{t+1}, exceeds (is less than) λ_L. Given the structure of the model, however, the $b(\theta_{t+1}, \lambda_L)$-rule cannot be implemented. Recall that party P_L has only two budgetary options: 1) By selecting "DR", party P_L can cede discretion to the party in power in period $(t+1)$. 2) Alternatively, party P_L can rigidly fix the period $(t+1)$ budget at some level between 0 and $\overline{B}$.

Consider, now, what happens when party P_L opts to yield discretion. With probability $(1-\pi_W)$, the polity in period $(t+1)$ has party P_R in power. Since party P_R has the right to set the agency's period $(t+1)$ budget, it therefore follows the individually rational $b(\theta_{t+1}, \lambda_R)$-rule; i.e., the budget is set at $\overline{B}(0)$ when θ_{t+1} exceeds (is less than) λ_R. The behavior of party P_R differs from the ideal of party P_L: specifically, when $\theta_{t+1} \in (\lambda_L, \lambda_R)$, party P_R shuts down the agency while party P_L prefers that the budget be $\overline{B}$. This incongruence in behavior inflicts on

[121]Our intuitions do not depend on the locations of λ_L and λ_R relative to $\frac{\overline{\theta}}{2}$. We only require that λ_R weakly exceed λ_L.

[122]Our intuitions are unchanged if, instead, we consider state $\widetilde{s}_R$.

party P_L an expected welfare loss, denoted $\Delta W_P(\text{“}DR\text{”}, \widetilde{s}_L)$. The expression for $\Delta W_P(\text{“}DR\text{”}, \widetilde{s}_L)$ is as follows:[123]

$$\Delta W_P(\text{“}DR\text{”}, \widetilde{s}_L) = (1 - \pi_W) \times (\overline{B} \times \int_{\lambda_L}^{\lambda_R} (\theta - \lambda_L) \times \frac{1}{\overline{\theta}} d\theta) \tag{3.29}$$

The welfare loss, $\Delta W_P(\text{“}DR\text{”}, \widetilde{s}_L)$, is partially depicted in Figure 2. Note that $\Delta W_P(\text{“}DR\text{”}, \widetilde{s}_L)$ is proportional to the product of two terms: 1) the "total probability factor," $(1 - \pi_W)$; and 2) the "total preference factor," $\int_{\lambda_L}^{\lambda_R} (\theta - \lambda_L) d\theta$, equal to the area of triangle ABC.[124]

Two observations regarding $\Delta W_P(\text{“}DR\text{”}, \widetilde{s}_L)$ turn out to be important. First, as π_W is increased, the "total probability factor," $(1 - \pi_W)$, decreases. Therefore, ΔW_P $(\text{“}DR\text{”}, \widetilde{s}_L)$ is a decreasing function of π_W. Second, as the polarization level of a polity, $(\lambda_R - \lambda_L)$, rises, the area of triangle ABC (and, hence, the "total preference factor") increases. Therefore, $\Delta W_P(\text{“}DR\text{”}, \widetilde{s}_L)$ is an increasing function of a polity's polarization level.

We have discussed the consequences for party P_L, when in state $\widetilde{s}_L$, it chooses to yield discretion. However, party P_L has another option: it can set the budget for the next period (period $(t+1)$) at some level between 0 and $\overline{B}$. By assumption, λ_L

[123]The welfare loss $\Delta W_P(\text{“}DR\text{”}, \widetilde{s}_L)$ is relative to the first-best payoff of party P_L.
[124]The constant of proportionality is $\frac{\overline{B}}{\overline{\theta}}$.

is less than $\frac{\overline{\theta}}{2}$. Hence, on average, the agency's services in period $(t+1)$ are worth more than party P_L's estimate of the cost. The optimal rigid budget therefore involves precommitting the entire available funds, $\overline{B}$.

The fixed budget of $\overline{B}$ leads to an expected welfare loss for party P_L: specifically, when the demand shock for period $(t+1)$, θ_{t+1}, is less than λ_L, party P_L prefers ex post to shut down the agency but is instead committed to a funding level of $\overline{B}$. The welfare loss from rigid budgets, denoted $\Delta W_P(\overline{B}, \widetilde{s}_L)$, is as follows:[125]

$$\Delta W_P(\overline{B}, \widetilde{s}_L) = [\overline{B} \times \int_0^{\lambda_L} (\lambda_L - \theta) \times \frac{1}{\overline{\theta}} d\theta] \tag{3.30}$$

Observe, now, that welfare loss $\Delta W_P(\overline{B}, \widetilde{s}_L)$ is proportional to the area of triangle OAD in Figure 2.[126]

In sum, party P_L has essentially two budgetary options in state $\widetilde{s}_L$: "DR" and $\overline{B}$. Relative to its first-best, $\Delta W_P(\text{"}DR\text{"}, \widetilde{s}_L)$ $(\Delta W_P(\overline{B}, \widetilde{s}_L))$ measures the welfare loss to party P_L when it chooses discretion (a fixed budget of $\overline{B}$). The optimal strategy for party P_L is to select the budgetary option with the smaller welfare loss. Given this intuition, we now provide explanations for conclusions 2.1 and

[125]The welfare loss $\Delta W_P(\overline{B}, \widetilde{s}_L)$ is relative to the first-best payoff of party P_L.

[126]The constant of proportionality is $\frac{\overline{B}}{\overline{\theta}}$.

2.2.

Consider conclusion 2.1. Figure 2 illustrates that as the polarization level, $(\lambda_R - \lambda_L)$, rises, the area of triangle ABC (and, hence, $\Delta W_P(\text{“}DR\text{”}, \tilde{s}_L)$) increases as well. On the other hand, the area of triangle OAD (and, hence, $\Delta W_P(\overline{B}, \tilde{s}_L)$) is independent of $(\lambda_R - \lambda_L)$. Thus, as the level of polarization rises, there is greater incentive to introduce rigid budgetary rules. In sum, polarization level and budget flexibility (rigidity) are negatively (positively) correlated.

Consider conclusion 2.2. As the reelection rate of the chamber, π_W, is raised, the “total probability factor” $(1 - \pi_W)$ (and, hence, $\Delta W_P(\text{“}DR\text{”}, \tilde{s}_L)$) decreases. On the other hand, the area of triangle OAD (and, hence, $\Delta W_P(\overline{B}, \tilde{s}_L)$) is independent of π_W. Thus, an increase in π_W produces a greater incentive for party P_L to yield discretion. In sum, the reelection rate and budget flexibility (rigidity) are positively (negatively) correlated.

3.5. Comparison of the Two Electoral Systems

In sections 3.3 and 3.4, we analyzed in isolation the separation-of-powers system and the Westminster-style parliamentary arrangement. We now directly compare the two electoral systems in terms of the rigidity of the rules that emerge in equilibrium.

Our method of comparison is as follows. Associated with the separation-of-powers system are two reelection parameters, π_C and π_P, corresponding to chambers C and P. By contrast, associated with the parliamentary system is a single chamber and, hence, one reelection parameter, π_W. We let the three parameters — π_C, π_P and π_W — assume some fixed common value, denoted $\pi \in (\frac{1}{2}, 1]$. Then, we compare the λ-spaces corresponding to the two electoral systems to determine whether one cross-section generates more rigid rules than the other.

Recall that result 1(2) in section 3.3(3.4) permits us to divide the λ-space of the separation-of-powers (parliamentary) system into three subsets: 1) a region of rigid budgets, R_{BR}; 2) a region of flexible budgets, R_{BF}; and 3) a region of hybrid budgets. Result 3, which follows directly from results 1 and 2, compares the λ-spaces of the two electoral systems.

Result 3: Let the reelection parameters π_C, π_P and π_W assume some fixed common value, denoted $\pi \in (\frac{1}{2}, 1]$. For the two electoral systems, now consider the λ-spaces, $\{(\lambda_L, \lambda_R) | \lambda_i \in [0, \overline{\theta}] \text{ and } \lambda_R \geq \lambda_L\}$. Then:

1) The region of rigid budgets, R_{BR}, is identical across the two electoral systems.

2) The region of flexible budgets, R_{BF}, in the separation-of-powers system is a

strict subset of the corresponding region in the parliamentary system.

Figure 4 in Appendix C illustrates the above result. For both electoral systems, the λ-space is represented by triangle XYZ and the region of rigid budgets, R_{BR}, is depicted by area ZDEF. The region of flexible budgets, R_{BF}, is triangle XGY (XEY) in the separation-of-powers (parliamentary) system. Since triangle XGY is contained in triangle XEY, we derive a surprising conclusion: for every parameter value $\pi \in (\frac{1}{2}, 1]$, the separation-of-powers system generates uniformly more rigid budgetary rules than does the parliamentary system.

What is the intuition for result 3? Consider, first, why the region of rigid budgets, R_{BR}, is the same across the two electoral systems. To fix ideas, we focus on polities for which λ_L is less than $\frac{\overline{\theta}}{2}$ while λ_R exceeds $\frac{\overline{\theta}}{2}$. Suppose, furthermore, that in generic period t, party P_L is assigned the right to set the budgetary regime for period $(t+1)$.

In a separation-of-powers system, region R_{BR} is the subset of the λ-space in which party P_L prefers to set a rigid budget for period $(t+1)$ even though it currently controls both chambers, C and P.[127] Thus, for $s \in \{(s_L, s_L, 0), (s_L, s_L, 1)\}$, R_{BR} is the region of the λ-space in which the welfare loss to party P_L from setting a

[127]This observation has been discussed at length in section 3.3.3.

rigid budget ($\Delta W_S(\overline{B}, s)$) is less than that from ceding discretion ($\Delta W_S(\text{“}DR\text{”}, s)$). From equations (3.16) and (3.17), we obtain, respectively, expressions for $\Delta W_S($ “DR”, $s)$ and $\Delta W_S(\overline{B}, s)$. Using the two expressions, R_{BR} becomes the subset of the λ-space satisfying the following condition:[128]

$$[\overline{B} \times \int_0^{\lambda_L} (\lambda_L - \theta) \times \frac{1}{\overline{\theta}} d\theta] \leq (\rho_2(s) + \frac{\rho_3(s)}{2}) \times [\overline{B} \times \int_{\lambda_L}^{\lambda_R} (\theta - \lambda_L) \times \frac{1}{\overline{\theta}} d\theta] \quad (3.31)$$

Furthermore, when $s \in \{(s_L, s_L, 0), (s_L, s_L, 1)\}$ (i.e., the polity exhibits "unified party P_L control") and the two reelection rates, π_C and π_P, are each equal to π, the total probability factor, $(\rho_2(s) + \frac{\rho_3(s)}{2})$, associated with $\Delta W_S(\text{“}DR\text{”}, s)$ assumes the value $(1 - \pi)$.[129] In sum:

$$(\rho_2(s) + \frac{\rho_3(s)}{2}) = (1 - \pi); \text{ for } s \in \{(s_L, s_L, 0), (s_L, s_L, 1)\} \quad (3.32)$$

Now consider the parliamentary system. Region R_{BR} is the region of the λ-space

[128] For ease of exposition, we only consider the perspective of party P_L. With two political parties to consider, R_{BR} is the region of the λ-space in which: 1) $\Delta W_S(\text{“}DR\text{”}, s)$ weakly exceeds $\Delta W_S(\overline{B}, s)$ for $s \in \{(s_L, s_L, 0), (s_L, s_L, 1)\}$; and 2) $\Delta W_S(\text{“}DR\text{”}, s)$ weakly exceeds $\Delta W_S(0, s)$ for $s \in \{(s_R, s_R, 0), (s_R, s_R, 1)\}$.

[129] When $s \in \{(s_L, s_L, 0), (s_L, s_L, 1)\}$, we have: 1) $\rho_2(s)$ (the probability of "unified party P_R control" in period $(t + 1)$) equal to $[(1\text{-}\pi_C).(1\text{-}\pi_P)]$; and 2) $\rho_3(s)$ (the probability of "divided government" in period $(t + 1)$) equal to $[\pi_C.(1\text{-}\pi_P) + (1\text{-}\pi_C).\pi_P]$. Thus, $(\rho_2(s) + \frac{\rho_3(s)}{2})$ is equal to: $(1\text{-}\frac{\pi_C}{2}\text{-}\frac{\pi_P}{2})$. When $\pi_C = \pi_P = \pi$, $(\rho_2(s) + \frac{\rho_3(s)}{2})$ assumes the value: $(1\text{-}\pi)$.

in which party P_L, when establishing budgetary rules, prefers to yield discretion to the party assuming office in period $(t+1)$. Thus in region R_{BR}, the welfare loss to party P_L from setting a rigid budget $(\Delta W_P(\overline{B}, \tilde{s}_L))$ is less than that from yielding discretion $(\Delta W_P(\text{"}DR\text{"}, \tilde{s}_L))$. Equations (3.29) and (3.30) provide expressions for, respectively, $\Delta W_P(\text{"}DR\text{"}, \tilde{s}_L)$ and $\Delta W_P(\overline{B}, \tilde{s}_L)$.[130] Using the two expressions, R_{BR} becomes the subset of the λ-space satisfying the following condition:

$$[\overline{B} \times \int_0^{\lambda_L} (\lambda_L - \theta) \times \frac{1}{\overline{\theta}} d\theta] \leq (1-\pi) \times [\overline{B} \times \int_{\lambda_L}^{\lambda_R} (\theta - \lambda_L) \times \frac{1}{\overline{\theta}} d\theta] \tag{3.33}$$

Given condition (3.32), constraints (3.31) and (3.33) are identical. Therefore, for the two electoral systems, the regions of rigid budgets coincide.

Why, then, is the region of budget flexibility, R_{BF}, smaller in the separation-of-powers system than in the parliamentary system? Recall that in a separation-of-powers system, R_{BF} is the subset of the λ-space in which party P_L prefers to cede discretion even though it currently controls only the weakest institution of power, i.e., chamber P.[131] Thus, for $s = (s_R, s_L, 1)$, R_{BF} is the region of the λ-space

[130] For ease of exposition, we only consider the perspective of party P_L. With two political parties to consider, R_{BR} is the subset of the λ-space in which: 1) $\Delta W_P(\text{"}DR\text{"}, \tilde{s}_L)$ weakly exceeds $\Delta W_P(\overline{B}, \tilde{s}_L)$; and 2) $\Delta W_P(\text{"}DR\text{"}, \tilde{s}_R)$ weakly exceeds $\Delta W_P(0, \tilde{s}_R)$.

[131] This observation has been discussed at length in section 3.3.3.

in which the welfare loss to party P_L from setting a rigid budget $(\Delta W_S(\overline{B}, s))$ is more than that from ceding discretion $(\Delta W_S(\text{“}DR\text{”}, s))$. Using the expressions for $\Delta W_S(\text{“}DR\text{”}, s)$ and $\Delta W_S(\overline{B}, s)$ (see equations (3.16) and (3.17)), R_{BF} becomes the subset of the λ-space satisfying the following condition:[132]

$$(\rho_2(s) + \frac{\rho_3(s)}{2}) \times [\overline{B} \times \int_{\lambda_L}^{\lambda_R} (\theta - \lambda_L) \times \frac{1}{\theta} d\theta] \leq [\overline{B} \times \int_0^{\lambda_L} (\lambda_L - \theta) \times \frac{1}{\theta} d\theta] \quad (3.34)$$

Furthermore, when $s = (s_R, s_L, 1)$ (i.e., the polity currently exhibits “divided government” with party $P_R(P_L)$ controlling chamber $C(P)$) and the two reelection rates, π_C and π_P, are each equal to π, the total probability factor, $(\rho_2(s) + \frac{\rho_3(s)}{2})$, associated with $\Delta W_S(\text{“}DR,\text{”} s)$ assumes the value $\frac{1}{2}$.[133] In sum:

$$(\rho_2(s) + \frac{\rho_3(s)}{2}) = \frac{1}{2}; \text{ for } s = (s_R, s_L, 1) \quad (3.35)$$

Now consider region R_{BF} in the parliamentary system. In region R_{BF}, the welfare

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[132] For ease of exposition, we only consider the perspective of party P_L. With two political parties to consider, R_{BF} is the subset of the λ-space in which: 1) $\Delta W_S(\overline{B}, s)$ weakly exceeds $\Delta W_S(\text{“}DR\text{”}, s)$ for $s = (s_R, s_L, 1)$; and 2) $\Delta W_S(0, s)$ weakly exceeds $\Delta W_S(\text{“}DR\text{”}, s)$ for $s = (s_L, s_R, 1)$.

[133] When $s = (s_R, s_L, 1)$, we have: 1) $\rho_2(s)$ (the probability of “unified party P_R control” in period $(t + 1)$) equal to $[\pi_C.(1\text{-}\pi_P)]$; and 2) $\rho_3(s)$ (the probability of “divided government” in period $(t+1)$) equal to $[\pi_C.\pi_P + (1\text{-}\pi_C).(1\text{-}\pi_P)]$. Thus, $(\rho_2(s) + \frac{\rho_3(s)}{2})$ is equal to: $(\frac{1}{2} + \frac{\pi_C}{2} - \frac{\pi_P}{2})$. When $\pi_C = \pi_P = \pi$, $(\rho_2(s) + \frac{\rho_3(s)}{2})$ assumes the value: $\frac{1}{2}$.

loss to party P_L from setting a rigid budget ($\Delta W_P(\overline{B}, \tilde{s}_L)$) is more than that from ceding discretion ($\Delta W_P(\text{“}DR\text{”}, \tilde{s}_L)$).[134] Using the expressions for $\Delta W_P(\text{“}DR\text{”}, \tilde{s}_L)$ and $\Delta W_P(\overline{B}, \tilde{s}_L)$ (see equations (3.29) and (3.30)), R_{BF} becomes the subset of the λ-space satisfying the following condition:

$$(1-\pi) \times [\overline{B} \times \int_{\lambda_L}^{\lambda_R} (\theta - \lambda_L) \times \frac{1}{\overline{\theta}} d\theta] \leq [\overline{B} \times \int_0^{\lambda_L} (\lambda_L - \theta) \times \frac{1}{\overline{\theta}} d\theta] \tag{3.36}$$

By assumption, π exceeds $\frac{1}{2}$. Given condition (3.35), we now note that constraint (3.34) is more stringent than constraint (3.36). Therefore, the region of budget flexibility in the separation-of-powers system is a proper subset of the corresponding region in the parliamentary system.

In brief, the message of this section is as follows. In a separation-of-powers system, when a political party — say, party P_L — cedes discretion in generic period t, there are two potential sources of welfare loss: 1) that under “divided government” in period $(t+1)$; and 2) that under “unified party P_R government” in period $(t+1)$. By contrast, in a parliamentary system, when party P_L cedes

[134]For ease of exposition, we only consider the perspective of party P_L. With two political parties to consider, R_{BF} is the subset of the λ-space in which: 1) $\Delta W_S(\overline{B}, \tilde{s}_L)$ weakly exceeds $\Delta W_S(\text{“}DR\text{”}, \tilde{s}_L)$; and 2) $\Delta W_S(0, \tilde{s}_R)$ weakly exceeds $\Delta W_S(\text{“}DR\text{”}, \tilde{s}_R)$.

discretion in generic period t, there is only one potential source of welfare loss: that under "party P_R control" in period $(t+1)$. Somewhat surprisingly, for every parameter value $\pi \in (\frac{1}{2}, 1]$, the probability weighted welfare loss from granting discretion is weakly larger in a separation-of-powers system than in a parliamentary system. Given the relative costliness of discretion, budget rules tend to be more flexible (rigid) in a parliamentary (separation-of-powers) system.

3.6. Conclusion

In this paper, a polity has the following basic structure. There is an agency that employs public funds to provide a service valued by citizens. There are two political parties, with different preferences, that jointly establish the budgetary rules to which the agency is subjected. Polities, however, are differentiated by the electoral arrangement in place. Certain polities have a bicameral legislature and, hence, are considered members of a separation-of-powers system. Other polities possess a unicameral legislature and, hence, are considered members of a parliamentary system. Throughout, we ask one question: what determines the nature of the budgetary rules — flexible or rigid — that emerge in equilibrium?

Our models generate four predictions regarding the nature of budgetary rules. First, in both electoral systems, as the level of polarization increases — i.e., as

the two political parties move farther apart in preference — budgetary rules become rigid. Second, in the parliamentary system, as incumbency becomes more profitable — i.e., as the reelection rate of the unicameral chamber increases — budgetary rules become flexible. Third, in the separation-of-powers system, the relationship between the reelection rates of the two chambers and the nature of the budgetary rules is asymmetrical (conclusions 1.2 and 1.3 make this precise). Fourth, budgetary rules in the separation-of-powers system are, on average, more rigid than that in the parliamentary system. While all of our four predictions generate precise empirical hypotheses, we view the comparative result (prediction 4) to be the most surprising.

Our analysis of equilibrium budget rules is far from exhaustive. Several extensions to this paper seem especially worthwhile. In an attempt to obtain closed-form solutions that can be readily interpreted, we have consistently employed simple functional forms (linear utility for political parties, demand shocks that are i.i.d. and uniformly distributed, etc.). It is now desirable to ascertain whether the principal predictions of this paper are robust to more realistic functional form specifications.

This paper only addresses the implications of coalitional drift for equilibrium budget rules — for analytical tractability, we have simply assumed away bu-

reaucratic drift. Specifically, note that the agency never misreports the demand-related information to its political overseer(s). This explicit assumption of agency honesty is at odds with the traditional notion (see, e.g., Niskanen 1971, 1975) that agency executives strategically manipulate private information so as to receive larger funds from politicians. Our paper will be considerably strengthened should the agency be modeled as a strategic player engaged in budget maximization. Results from this modified three-player game will shed light on how the two drift forms (coalitional and bureaucratic) interact in the formation of equilibrium budget rules. Preliminary work on this topic is in progress.

Finally, our paper considers polities with only two political parties. Most democracies, however, possess multiple parties. Hence, extending our results to multi-party polities should prove challenging but worthwhile.

3.7. Formal Proof of Result 1

In this section, we formally prove result 1. To reduce inessential details, we consider polities for which both λ_L and λ_R are different from $\frac{\overline{\theta}}{2}$. The restrictions are without loss of generality; all proofs can be extended to include these "knife-edge cases." Throughout, the notation used is that of section 3.3.

[Step 1] Consider equations (3.10) - (3.15). The equations indicate that g is a Markov perfect equilibrium if and only if the following two conditions are satisfied. First, for all $a \in [0, \overline{B}] \cup \{\text{“}DR\text{”}\}$ and for all $s \in S_L$, we require:

$$\delta \times \sum_{s' \in S} \varphi(s, s') \times \int_0^{\overline{\theta}} U_L(s', g(s), \theta) d\theta \geq \delta \times \sum_{s' \in S} \varphi(s, s') \times \int_0^{\overline{\theta}} U_L(s', a, \theta) d\theta. \quad (3.37)$$

Second, for all $a \in [0, \overline{B}] \cup \{\text{“}DR\text{”}\}$ and for all $s \in S_R$, we require:

$$\delta \times \sum_{s' \in S} \varphi(s, s') \times \int_0^{\overline{\theta}} U_R(s', g(s), \theta) d\theta \geq \delta \times \sum_{s' \in S} \varphi(s, s') \times \int_0^{\overline{\theta}} U_R(s', a, \theta) d\theta. \quad (3.38)$$

Thus, g is a Markov perfect equilibrium if at node $s \in S$, budgetary regime $g(s)$ maximizes the expected next period payoff of party $\mathcal{P}(s)$.

[Step 2] Suppose that in generic period t, a polity is in state $s \in S$; i.e., party $\mathcal{P}(s)$ is in office. In the phase where party $\mathcal{P}(s)$ selects the budgetary regime for period $(t+1)$, assume that the "discretion regime" ("DR") option is exogenously excluded. Let $\tilde{g}(s) \in [0, \overline{B}]$ now be the fixed budget level that maximizes party

$\mathcal{P}(s)$'s ex ante expected payoff in period $(t+1)$.

The average demand shock in period $(t+1)$ is the expectation of the random variable, θ; i.e., $\frac{\overline{\theta}}{2}$. Given the risk neutral preferences of the two parties, it is immediate that $\tilde{g}(s)$ is as follows:

$$\tilde{g}(s) = \begin{cases} 0 & \text{if } \frac{\overline{\theta}}{2} < \lambda\text{-value of party } \mathcal{P}(s) \\ \overline{B} & \text{if } \frac{\overline{\theta}}{2} > \lambda\text{-value of party } \mathcal{P}(s) \end{cases} \tag{3.39}$$

We describe the $\tilde{g}$-mapping graphically. Corresponding to a polity is a specific pair (λ_L, λ_R). Since $\lambda_L \leq \lambda_R$ and $\lambda_i \in [0, \overline{\theta}]$, the collection of possible polities is represented by the λ-space: $\{(\lambda_L, \lambda_R) |\ \lambda_L \leq \lambda_R \text{ and } \lambda_i \in [0, \overline{\theta}]\}$. In Figure 5 of Appendix C, the λ-space is the triangle ACF. Triangle ACF is subdivided into three regions: A polity is placed in region 1 (triangle ABD) if its (λ_L, λ_R)-value satisfies: 1) $\lambda_L < \frac{\overline{\theta}}{2}$ and 2) $\lambda_R < \frac{\overline{\theta}}{2}$. A polity is placed in region 2 (square DBEF) if its (λ_L, λ_R)-value satisfies: 1) $\lambda_L < \frac{\overline{\theta}}{2}$ and 2) $\lambda_R > \frac{\overline{\theta}}{2}$. A polity is placed in region 3 (triangle BCE) if its (λ_L, λ_R)-value satisfies: 1) $\lambda_L > \frac{\overline{\theta}}{2}$ and 2) $\lambda_R > \frac{\overline{\theta}}{2}$.

The $\tilde{g}$-mapping in each of the three regions is as follows: 1) In region 1, $\tilde{g}(s) = \overline{B}, \forall s \in S$. 2) In region 2, $\tilde{g}(s) = 0$ for $s \in S_R$ and $\tilde{g}(s) = \overline{B}$ for $s \in S_L$. 3) In region 3, $\tilde{g}(s) = 0, \forall s \in S$.

[Step 3] Suppose that in generic period t, a polity is in state $s \in S$. By the construction in step 2, it is clear that when party $\mathcal{P}(s)$ selects a budgetary rule for period $(t+1)$, the choice is between $\widetilde{g}(s)$ and "DR". Thus, $g(s) \in \{\widetilde{g}(s), \text{“}DR\text{”}\}$. Furthermore, step 1 indicates that in deciding between $\widetilde{g}(s)$ and "DR", party $\mathcal{P}(s)$ picks the option that maximizes its expected payoff in period $(t+1)$.

[Step 4] Suppose that in generic period t, a polity is in state $s \in S$ and that party $\mathcal{P}(s)$ chooses budgetary regime $\widetilde{g}(s)$. Given $\widetilde{g}(s)$, we now compute the expected payoff to party $\mathcal{P}(s)$ in period $(t+1)$, denoted $\overline{V}(\widetilde{g}(s), s)$. To compute $\overline{V}(\widetilde{g}(s), s)$, we shall consider two subcases: 1) the λ-value of party $\mathcal{P}(s)$ is less than $\frac{\overline{\theta}}{2}$ (i.e., $\widetilde{g}(s) = \overline{B}$) and 2) the λ-value of party $\mathcal{P}(s)$ exceeds $\frac{\overline{\theta}}{2}$ (i.e., $\widetilde{g}(s) = 0$).

Subcase 1: λ-value of party $\mathcal{P}(s)$ less than $\frac{\overline{\theta}}{2}$.— In an ideal world, party $\mathcal{P}(s)$ desires a period $(t+1)$ budget of $\overline{B}(0)$ when θ_{t+1} exceeds (is less than) its λ-value. Thus, for $s \in S_L$ ($s \in S_R$) the first-best expected payoff for party $P_L(P_R)$ is: $[\overline{B} \times \int_{\lambda_L}^{\overline{\theta}} (\theta - \lambda_L) \times \frac{1}{\overline{\theta}} d\theta]$ $([\overline{B} \times \int_{\lambda_R}^{\overline{\theta}} (\theta - \lambda_R) \times \frac{1}{\overline{\theta}} d\theta])$. This first-best expected payoff for party $P_L(P_R)$ is denoted as $\overline{V}_L^{\max}(\overline{V}_R^{\max})$.

However, given the rigid $\widetilde{g}(s)$-regime, the flexible budgets of the ideal world cannot be enforced. When the λ-value of party $\mathcal{P}(s)$ is less than $\frac{\overline{\theta}}{2}$, step 2 indicates that $\tilde{g}(s) = \overline{B}$ — i.e., the budget for period $(t+1)$ is set at $\overline{B}$. The fixed budget induces a welfare loss for party $\mathcal{P}(s)$: specifically, when θ_{t+1} is less than the λ-value of party $\mathcal{P}(s)$, party $\mathcal{P}(s)$ prefers ex post to shut down the agency but is instead committed to a funding level of $\overline{B}$.

In sum, when $s \in S_L$ ($s \in S_R$), the budget rigidity inflicts on party $P_L(P_R)$ an expected loss of: $[\overline{B} \times \int_0^{\lambda_L} (\lambda_L - \theta) \times \frac{1}{\overline{\theta}} d\theta]$ $([\overline{B} \times \int_0^{\lambda_R} (\lambda_R - \theta) \times \frac{1}{\overline{\theta}} d\theta])$. Given this expected welfare loss relative to the first-best, the following two conditions are immediate:

$$\overline{V}(\tilde{g}(s), s) = \overline{V}_L^{\max} - \overline{B} \times \int_0^{\lambda_L} (\lambda_L - \theta) \times \frac{1}{\overline{\theta}} d\theta; \; s \in S_L \text{ and } \lambda_L < \frac{\overline{\theta}}{2} \tag{3.40}$$

$$\overline{V}(\tilde{g}(s), s) = \overline{V}_R^{\max} - \overline{B} \times \int_0^{\lambda_R} (\lambda_R - \theta) \times \frac{1}{\overline{\theta}} d\theta; \; s \in S_R \text{ and } \lambda_R < \frac{\overline{\theta}}{2} \tag{3.41}$$

Subcase 2: λ-value of party $\mathcal{P}(s)$ exceeds $\frac{\overline{\theta}}{2}$.— Step 2 indicates that $\tilde{g}(s) = 0$ — i.e., the budget for period $(t+1)$ is set at 0. The fixed budget induces a welfare loss for party $\mathcal{P}(s)$: specifically, when θ_{t+1} is more than the λ-value of party $\mathcal{P}(s)$, party $\mathcal{P}(s)$ prefers ex post to let the agency's budget be $\overline{B}$ but is instead committed to a funding level of 0.

In sum, when $s \in S_L$ ($s \in S_R$), the budget rigidity inflicts on party $P_L(P_R)$ an expected loss of: $[\overline{B} \times \int_{\lambda_L}^{\overline{\theta}}(\theta - \lambda_L) \times \frac{1}{\overline{\theta}} d\theta]$ ($[\overline{B} \times \int_{\lambda_R}^{\overline{\theta}}(\theta - \lambda_R) \times \frac{1}{\overline{\theta}} d\theta]$). Given this expected welfare loss relative to the first-best, the following two conditions are immediate:

$$\overline{V}(\tilde{g}(s), s) = \overline{V}_L^{\max} - \overline{B} \times \int_{\lambda_L}^{\overline{\theta}} (\theta - \lambda_L) \times \frac{1}{\overline{\theta}} d\theta; \; s \in S_L \text{ and } \lambda_L > \frac{\overline{\theta}}{2} \tag{3.42}$$

$$\overline{V}(\tilde{g}(s), s) = \overline{V}_R^{\max} - \overline{B} \times \int_{\lambda_R}^{\overline{\theta}} (\theta - \lambda_R) \times \frac{1}{\overline{\theta}} d\theta; \; s \in S_R \text{ and } \lambda_R > \frac{\overline{\theta}}{2} \tag{3.43}$$

[Step 5] Suppose that in generic period t, a polity is in state $s \in S$ and that party $\mathcal{P}(s)$ chooses the "discretion" regime, "DR". Given the "DR"-regime, we now compute the expected payoff to party $\mathcal{P}(s)$ in period $(t+1)$, denoted $\overline{V}(\text{"}DR\text{"}, s)$. First, we introduce additional notation.

We divide the state space S into four subsets. $S_{LL}(S_{RR})$ denotes the set of states in which party $P_L(P_R)$ controls both chambers. $S_{LR}(S_{RL})$ denotes the set of states in which party $P_L(P_R)$ controls chamber C while party $P_R(P_L)$ controls chamber P. Given our theory of elections, characterized by reelection rates (π_C, π_P), the transition probabilities between the (above) four subsets of S are given by the matrix Π.

$\Pi =$

	S_{LL}	S_{LR}	S_{RL}	S_{RR}
S_{LL}	$\pi_C.\pi_P$	$\pi_C.(1\text{-}\pi_P)$	$(1\text{-}\pi_C).\pi_P$	$(1\text{-}\pi_C).(1\text{-}\pi_P)$
S_{LR}	$\pi_C.(1\text{-}\pi_P)$	$\pi_C.\pi_P$	$(1\text{-}\pi_C).(1\text{-}\pi_P)$	$(1\text{-}\pi_C).\pi_P$
S_{RL}	$(1\text{-}\pi_C).\pi_P$	$(1\text{-}\pi_C).(1\text{-}\pi_P)$	$\pi_C.\pi_P$	$\pi_C.(1\text{-}\pi_P)$
S_{RR}	$(1\text{-}\pi_C).(1\text{-}\pi_P)$	$(1\text{-}\pi_C).\pi_P$	$\pi_C.(1\text{-}\pi_P)$	$\pi_C.\pi_P$

The (i, j)'th element of Π denotes the probability of transiting (in one step) from a state represented by the i'th row of Π to a state represented by the j'th column of Π. For example, $\Pi_{(1,1)}$ denotes the probability that the state next period is an element of S_{LL} when the current state is an element of S_{LL}. Since this requires the incumbent party P_L to win elections in both chambers, $\Pi_{(1,1)} = \pi_C \times \pi_P$.

Given Π, for each state $s \in S$ we construct a three-element vector $\rho(s)$ where: 1) the first element $(\rho_1(s))$ represents the probability of "unified P_L government" next period; 2) the second element $(\rho_2(s))$ represents the probability of "unified

P_R government" next period; and 3) the third element ($\rho_3(s)$) represents the probability of "divided government" next period. The following four conditions can be readily derived from the elements of Π.

$$\rho(s) = (\pi_C.\pi_P,\ (1\text{-}\pi_C).(1\text{-}\pi_P),\ \pi_C.(1\text{-}\pi_P) + (1\text{-}\pi_C).\pi_P);\ \ s \in S_{LL} \tag{3.44}$$

$$\rho(s) = (\pi_C.(1\text{-}\pi_P),\ (1\text{-}\pi_C).\pi_P,\ \pi_C.\pi_P + (1\text{-}\pi_C).(1\text{-}\pi_P));\ \ s \in S_{LR} \tag{3.45}$$

$$\rho(s) = ((1\text{-}\pi_C).\pi_P,\ \pi_C.(1\text{-}\pi_P),\ \pi_C.\pi_P + (1\text{-}\pi_C).(1\text{-}\pi_P));\ \ s \in S_{RL} \tag{3.46}$$

$$\rho(s) = ((1\text{-}\pi_C).(1\text{-}\pi_P),\ \pi_C.\pi_P,\ \pi_C.(1\text{-}\pi_P) + (1\text{-}\pi_C).\pi_P);\ \ s \in S_{RR} \tag{3.47}$$

Consider, now, $\overline{V}(\text{“}DR\text{”}, s)$, $s \in S_L$. Three cases arise: 1) With probability

$\rho_1(s)$, party P_L controls both chambers in period $(t+1)$ and fixes the agency's budget at a level that is first-best for party P_L — i.e., the budget is $\overline{B}(0)$ if θ_{t+1} exceeds (is less than) λ_L. 2) With probability $\rho_2(s)$, party P_R controls both chambers in period $(t+1)$ and fixes the agency's budget at $\overline{B}(0)$ if θ_{t+1} exceeds (is less than) λ_R. The behavior of party P_R differs from the ideal rule of party P_L; specifically, when $\theta_{t+1} \in (\lambda_L, \lambda_R)$, party P_R shuts down the agency while party P_L prefers that the budget be $\overline{B}$. This incongruence in behavior inflicts on party P_L an expected welfare loss of $[\overline{B} \times \int_{\lambda_L}^{\lambda_R}(\theta - \lambda_L) \times \frac{1}{\theta} d\theta]$. 3) With probability $\rho_3(s)$, there is "divided government" in period $(t+1)$. Under divided government, the agency's budget is set at: a) 0 if $\theta_{t+1} \leq \lambda_L$, b) $\frac{\overline{B}}{2}$ if $\theta_{t+1} \in (\lambda_L, \lambda_R)$, and c) $\overline{B}$ if $\theta_{t+1} \geq \lambda_R$. The decision rule under divided government is suboptimal for party P_L in the region $\theta_{t+1} \in (\lambda_L, \lambda_R)$; specifically, party P_L prefers a budget of $\overline{B}$ but obtains only half that amount. This incongruence in behavior inflicts on party P_L an expected welfare loss of $[\frac{\overline{B}}{2} \times \int_{\lambda_L}^{\lambda_R}(\theta - \lambda_L) \times \frac{1}{\theta} d\theta]$. By a standard conditioning argument, the following expression for $\{\overline{V}(\text{"}DR\text{"}, s) | s \in S_L\}$ can be derived:

$$\overline{V}(\text{"}DR\text{"}, s) = \overline{V}_L^{\max} - (\rho_2(s) + \frac{\rho_3(s)}{2}) \times (\overline{B} \times \int_{\lambda_L}^{\lambda_R} (\theta - \lambda_L) \times \frac{1}{\theta} d\theta); \; s \in S_L \quad (3.48)$$

By an argument identical to that given above, the following expression for $\{\overline{V}$ $(\text{"}DR\text{"}, s) | s \in S_R\}$ can also be established:

$$\overline{V}(\text{"}DR\text{"}, s) = \overline{V}_R^{\max} - (\rho_1(s) + \frac{\rho_3(s)}{2}) \times (\overline{B} \times \int_{\lambda_L}^{\lambda_R} (\lambda_R - \theta) \times \frac{1}{\overline{\theta}} d\theta); \; s \in S_R \quad (3.49)$$

[Step 6] For brevity, we only provide the necessary and sufficient conditions for the Markov perfect equilibrium to exhibit complete budget rigidity or complete budget flexibility. Thus, we compute: 1) the subset of the λ-space, denoted R_{BR}, for which $g(s) = \tilde{g}(s), \forall s \in S$ (i.e., the region of budget rigidity); and 2) the subset of the λ-space, denoted R_{BF}, for which $g(s) = \text{"}DR\text{"}, \forall s \in S$ (i.e., the region of budget flexibility).

[Step 7] Consider, now, R_{BR}. By step 1, R_{BR} is the region: $\{(\lambda_L, \lambda_R) | \overline{V}(\tilde{g}(s), s) \geq \overline{V}(\text{"}DR\text{"}, s); \forall s \in S\}$.

Consider, first, $s \in S_L$. Given the transition matrix Π and equations (3.44) - (3.46), simple algebra reveals that $(\rho_2(s) + \frac{\rho_3(s)}{2})$ has the smallest value when $s \in S_L \cap S_{LL}$. (The comparison is across three subsets of $S_L : S_L \cap S_{LL}$, $S_L \cap S_{LR}$

and $S_L \cap S_{RL}$. Note also that $S_L \cap S_{LL} = S_{LL}$.) From equation (3.48), it therefore follows that $\overline{V}(\text{``}DR,\text{''} s)$ has the largest value when $s \in S_{LL}$. Finally, observe that equations (3.40) and (3.42) jointly imply that the value of $\overline{V}(\tilde{g}(s), s)$ does not vary across states $s \in S_L$.

Consider, now, $s \in S_R$. Given the transition matrix Π and equations (3.45) - (3.47), simple algebra reveals that $(\rho_1(s) + \frac{\rho_3(s)}{2})$ has the smallest value when $s \in S_R \cap S_{RR}$. (The comparison is across three subsets of S_R : $S_R \cap S_{RR}$, $S_R \cap S_{LR}$ and $S_R \cap S_{RL}$. Note also that $S_R \cap S_{RR} = S_{RR}$.) From equation (3.49), it therefore follows that $\overline{V}(\text{``}DR\text{''}, s)$ has the largest value when $s \in S_{RR}$. Finally, observe that equations (3.41) and (3.42) jointly imply that the value of $\overline{V}(\tilde{g}(s), s)$ does not vary across states $s \in S_R$.

Given the observations in the above two paragraphs, R_{BR} is as follows:

$$R_{BR} = R_{BR}(S_{LL}) \cap R_{BR}(S_{RR}) \tag{3.50}$$

$$\text{where} : R_{BR}(S_{LL}) = \{(\lambda_L, \lambda_R) | \overline{V}(\tilde{g}(s), s) \geq \overline{V}(\text{``}DR\text{''}, s); \forall s \in S_{LL}\} \tag{3.51}$$

$$R_{BR}(S_{RR}) = \{(\lambda_L, \lambda_R)|\overline{V}(\tilde{g}(s), s) \geq \overline{V}(\text{“}DR\text{”}, s); \forall s \in S_{RR}\} \tag{3.52}$$

We begin by characterizing $R_{BR}(S_{LL})$. To characterize $R_{BR}(S_{LL})$, we shall consider two subcases: 1) $\lambda_L < \frac{\overline{\theta}}{2}$ (regions 1 and 2 of Figure 5) and 2) $\lambda_L > \frac{\overline{\theta}}{2}$ (region 3 of Figure 5).

Subcase 1: λ_L less than $\frac{\overline{\theta}}{2}$.— Figure 5 indicates that $\tilde{g}(s) = \overline{B}$. From equations (3.40), (3.44) and (3.48), $\overline{V}(\overline{B}, s) \geq \overline{V}(\text{“}DR\text{”}, s)$ if and only if:

$$(1 - \frac{\pi_C}{2} - \frac{\pi_P}{2}) \times \overline{B} \times \int_{\lambda_L}^{\lambda_R} (\theta - \lambda_L) \times \frac{1}{\overline{\theta}} d\theta \geq \overline{B} \times \int_0^{\lambda_L} (\lambda_L - \theta) \times \frac{1}{\overline{\theta}} d\theta \tag{3.53}$$

Simplifying the above expression, $\overline{V}(\tilde{g}(s), s) \geq \overline{V}(\text{“}DR\text{”}, s)$ if and only if:

$$\lambda_R \geq (\frac{1 + j'}{j'}) \times \lambda_L; \text{ where } j' \equiv \sqrt{(1 - \frac{\pi_C}{2} - \frac{\pi_P}{2})} \tag{3.54}$$

Subcase 2: λ_L exceeds $\frac{\overline{\theta}}{2}$.— Figure 5 indicates that $\tilde{g}(s) = 0$. From equations (3.42), (3.44) and (3.48), $\overline{V}(0, s) \geq \overline{V}(\text{“}DR\text{”}, s)$ if and only if:

$$(1-\frac{\pi_C}{2}-\frac{\pi_P}{2})\times\overline{B}\times\int_{\lambda_L}^{\lambda_R}(\theta-\lambda_L)\times\frac{1}{\overline{\theta}}d\theta\geq\overline{B}\times\int_{\lambda_L}^{\overline{\theta}}(\theta-\lambda_L)\times\frac{1}{\overline{\theta}}d\theta \quad (3.55)$$

Condition (3.55) is violated for all parameter configurations.

Combining equations (3.54) and (3.55), $R_{BR}(S_{LL})$ is as follows:

$$R_{BR}(S_{LL})=\{(\lambda_L,\lambda_R)|\lambda_R\geq(\frac{1+j'}{j'})\times\lambda_L \text{ and } \lambda_L<\frac{\overline{\theta}}{2}\} \quad (3.56)$$

We now characterize region $R_{BR}(S_{RR})$. To characterize $R_{BR}(S_{RR})$, we shall consider two subcases: 1) $\lambda_R<\frac{\overline{\theta}}{2}$ (region 1 of Figure 5) and 2) $\lambda_R>\frac{\overline{\theta}}{2}$ (regions 2 and 3 of Figure 5).

Subcase 1: λ_R less than $\frac{\overline{\theta}}{2}$.— Figure 5 indicates that $\tilde{g}(s)=\overline{B}$. From equations (3.41), (3.47) and (3.49), $\overline{V}(\overline{B},s)\geq\overline{V}(\text{"}DR\text{"},s)$ if and only if:

$$(1-\frac{\pi_C}{2}-\frac{\pi_P}{2})\times\overline{B}\times\int_{\lambda_L}^{\lambda_R}(\lambda_R-\theta)\times\frac{1}{\overline{\theta}}d\theta\geq\overline{B}\times\int_{0}^{\lambda_R}(\lambda_R-\theta)\times\frac{1}{\overline{\theta}}d\theta \quad (3.57)$$

Condition (3.57) is violated for all parameter configurations.

Subcase 2: λ_R exceeds $\frac{\overline{\theta}}{2}$.— Figure 5 indicates that $\tilde{g}(s)=0$. From equations

(3.43), (3.47) and (3.49), $\overline{V}(0,s) \geq \overline{V}(\text{``}DR\text{''},s)$ if and only if:

$$(1 - \frac{\pi_C}{2} - \frac{\pi_P}{2}) \times \overline{B} \times \int_{\lambda_L}^{\lambda_R} (\lambda_R - \theta) \times \frac{1}{\overline{\theta}} d\theta \geq \overline{B} \times \int_{\lambda_R}^{\overline{\theta}} (\theta - \lambda_R) \times \frac{1}{\overline{\theta}} d\theta \qquad (3.58)$$

Simplifying the above expression, $\overline{V}(\tilde{g}(s),s) \geq \overline{V}(\text{``}DR\text{''},s)$ if and only if:

$$\lambda_R \geq (\frac{\overline{\theta}}{1+j'}) + (\frac{j'}{1+j'}) \times \lambda_L \qquad (3.59)$$

Combining equations (3.57) and (3.59), $R_{BR}(S_{RR})$ is as follows:

$$R_{BR}(S_{RR}) = \{(\lambda_L, \lambda_R) | \lambda_R \geq (\frac{\overline{\theta}}{1+j'}) + (\frac{j'}{1+j'}) \times \lambda_L \text{ and } \lambda_R > \frac{\overline{\theta}}{2}\} \qquad (3.60)$$

Finally, equations (3.50), (3.56) and (3.60) yield, after simple manipulations, a characterization of R_{BR}. R_{BR} is the subset of the λ-space satisfying the following two requirements:

$$\lambda_R \geq (\frac{1+j'}{j'}) \times \lambda_L \qquad (3.61)$$

$$\lambda_R \geq (\frac{\overline{\theta}}{1+j'}) + (\frac{j'}{1+j'}) \times \lambda_L \tag{3.62}$$

[Step 8] We now compute R_{BF} (the region of budget flexibility). By step 1, R_{BF} is the region: $\{(\lambda_L, \lambda_R) | \overline{V}(\text{"}DR\text{"}, s) \geq \overline{V}(\tilde{g}(s), s); \forall s \in S\}$.

Consider, first, $s \in S_L$. Given the transition matrix Π and equations (3.44) - (3.46), simple algebra reveals that $(\rho_2(s) + \frac{\rho_3(s)}{2})$ has the largest value when $s \in S_L \cap S_{RL}$. (The comparison is across three subsets of $S_L : S_L \cap S_{LL}$, $S_L \cap S_{LR}$ and $S_L \cap S_{RL}$.) From equation (3.48), it therefore follows that $\overline{V}(\text{"}DR\text{"}, s)$ has the smallest value when $s \in S_L \cap S_{RL}$. Observe, also, that equations (3.40) and (3.42) jointly imply that the value of $\overline{V}(\tilde{g}(s), s)$ does not vary across states $s \in S_L$.

Consider, now, $s \in S_R$. Given the transition matrix Π and equations (3.45) - (3.47), simple algebra reveals that $(\rho_1(s) + \frac{\rho_3(s)}{2})$ has the largest value when $s \in S_R \cap S_{LR}$. (The comparison is across three subsets of $S_R : S_R \cap S_{RR}$, $S_R \cap S_{LR}$ and $S_R \cap S_{RL}$.) From equation (3.49), it therefore follows that $\overline{V}(\text{"}DR\text{"}, s)$ has the smallest value when $s \in S_R \cap S_{LR}$. Observe, also, that equations (3.41) and (3.43) jointly imply that the value of $\overline{V}(\tilde{g}(s), s)$ does not vary across states $s \in S_R$.

Given the observations in the above two paragraphs, R_{BF} can be expressed as follows:

$$R_{BF} = R_{BF}(S_L \cap S_{RL}) \cap R_{BF}(S_R \cap S_{LR}) \tag{3.63}$$

$$\text{where}: R_{BF}(S_L \cap S_{RL}) = \{(\lambda_L, \lambda_R) | \overline{V}(\text{“}DR\text{”}, s) \geq \overline{V}(\tilde{g}(s), s); \forall s \in S_L \cap S_{RL}\} \tag{3.64}$$

$$R_{BF}(S_R \cap S_{LR}) = \{(\lambda_L, \lambda_R) | \overline{V}(\text{“}DR\text{”}, s) \geq \overline{V}(\tilde{g}(s), s); \forall s \in S_R \cap S_{LR}\} \tag{3.65}$$

We begin by characterizing $R_{BF}(S_L \cap S_{RL})$. Two subcases need to be considered: 1) $\lambda_L < \frac{\overline{\theta}}{2}$ (regions 1 and 2 of Figure 5) and 2) $\lambda_L > \frac{\overline{\theta}}{2}$ (region 3 of Figure 5).

Subcase 1: λ_L less than $\frac{\overline{\theta}}{2}$.— Figure 5 indicates that $\tilde{g}(s) = \overline{B}$. From equations (3.40), (3.46) and (3.48), $\overline{V}(\text{“}DR\text{”}, s) \geq \overline{V}(\overline{B}, s)$ if and only if:

$$(\frac{1}{2} + \frac{\pi_C}{2} - \frac{\pi_P}{2}) \times \overline{B} \times \int_{\lambda_L}^{\lambda_R} (\theta - \lambda_L) \times \frac{1}{\overline{\theta}} d\theta \leq \overline{B} \times \int_0^{\lambda_L} (\lambda_L - \theta) \times \frac{1}{\overline{\theta}} d\theta \tag{3.66}$$

Simplifying the above expression, $\overline{V}(\text{"}DR\text{"}, s) \geq \overline{V}(\tilde{g}(s), s)$ if and only if:

$$\lambda_R \leq (\frac{1+j''}{j''}) \times \lambda_L; \text{ where } j'' \equiv \sqrt{(\frac{1}{2} + \frac{\pi_C}{2} - \frac{\pi_P}{2})} \tag{3.67}$$

Subcase 2: λ_L exceeds $\frac{\overline{\theta}}{2}$.— Figure 5 indicates that $\tilde{g}(s) = 0$. From equations (3.42), (3.46) and (3.48), $\overline{V}(\text{"}DR\text{"}, s) \geq \overline{V}(0, s)$ if and only if:

$$(\frac{1}{2} + \frac{\pi_C}{2} - \frac{\pi_P}{2}) \times \overline{B} \times \int_{\lambda_L}^{\lambda_R} (\theta - \lambda_L) \times \frac{1}{\overline{\theta}} d\theta \leq \overline{B} \times \int_{\lambda_L}^{\overline{\theta}} (\theta - \lambda_L) \times \frac{1}{\overline{\theta}} d\theta \tag{3.68}$$

Condition (3.68) is satisfied for all parameter configurations.

Combining equations (3.67) and (3.68), $R_{BF}(S_L \cap S_{RL})$ is as follows:

$$R_{BF}(S_L \cap S_{RL}) = \{(\lambda_L, \lambda_R) | \lambda_R \leq (\frac{1+j''}{j''}) \times \lambda_L \text{ and } \lambda_L < \frac{\overline{\theta}}{2}\} \cup \{(\lambda_L, \lambda_R) | \ \lambda_L > \frac{\overline{\theta}}{2}\} \tag{3.69}$$

We now characterize $R_{BF}(S_R \cap S_{LR})$. Two subcases need to be considered: 1) $\lambda_R < \frac{\overline{\theta}}{2}$ (region 1 of Figure 5) and 2) $\lambda_R > \frac{\overline{\theta}}{2}$ (regions 2 and 3 of Figure 5).

Subcase 1: λ_R less than $\frac{\overline{\theta}}{2}$.— Figure 5 indicates that $\tilde{g}(s) = \overline{B}$. From equations (3.41), (3.45) and (3.49), $\overline{V}(\text{"}DR\text{"}, s) \geq \overline{V}(\overline{B}, s)$ if and only if:

$$(\frac{1}{2}+\frac{\pi_C}{2}-\frac{\pi_P}{2})\times\overline{B}\times\int_{\lambda_L}^{\lambda_R}(\lambda_R-\theta)\times\frac{1}{\overline{\theta}}d\theta\leq\overline{B}\times\int_{0}^{\lambda_R}(\lambda_R-\theta)\times\frac{1}{\overline{\theta}}d\theta \quad (3.70)$$

Condition (3.70) is satisfied for all parameter configurations.

Subcase 2: λ_R exceeds $\frac{\overline{\theta}}{2}$.— Figure 5 indicates that $\tilde{g}(s)=0$. From equations (3.43), (3.45) and (3.49), $\overline{V}(\text{“}DR\text{”},s)\geq\overline{V}(0,s)$ if and only if:

$$(\frac{1}{2}+\frac{\pi_C}{2}-\frac{\pi_P}{2})\times\overline{B}\times\int_{\lambda_L}^{\lambda_R}(\lambda_R-\theta)\times\frac{1}{\overline{\theta}}d\theta\leq\overline{B}\times\int_{\lambda_R}^{\overline{\theta}}(\theta-\lambda_R)\times\frac{1}{\overline{\theta}}d\theta \quad (3.71)$$

Simplifying the above expression, $\overline{V}(\text{“}DR\text{”},s)\geq\overline{V}(0,s)$ if and only if:

$$\lambda_R\geq(\frac{\overline{\theta}}{1+j''})+(\frac{j''}{1+j''})\times\lambda_L \quad (3.72)$$

Combining equations (3.70) and (3.72), $R_{BF}(S_R\cap S_{LR})$ is as follows:

$$\begin{aligned} R_{BF}(S_R\cap S_{LR}) &= \{(\lambda_L,\lambda_R)|\lambda_R<\frac{\overline{\theta}}{2}\}\cup\{(\lambda_L,\lambda_R)| \\ \lambda_R &\leq (\frac{\overline{\theta}}{1+j''})+(\frac{j''}{1+j''})\times\lambda_L\text{and }\lambda_R>\frac{\overline{\theta}}{2}\} \end{aligned} \quad (3.73)$$

Finally, equations (3.63), (3.69) and (3.73) yield, after simple manipulations, a characterization of R_{BF}. R_{BF} is the subset of the λ-space satisfying the following two requirements:

$$\lambda_R \leq (\frac{1+j''}{j''}) \times \lambda_L \tag{3.74}$$

$$\lambda_R \leq (\frac{\overline{\theta}}{1+j''}) + (\frac{j''}{1+j''}) \times \lambda_L \tag{3.75}$$

[Step 9] The locations of the two regions (R_{BR} and R_{BF}) in λ-space are depicted in Figure 1 of Appendix C. The location of $R_{BR}(R_{BF})$ is derived from equations (3.61) - (3.62) ((3.74) - (3.75)).

APPENDICES

APPENDIX A

TABLES FOR CHAPTER 1

Table 1: Parameter Values (in francs) for the Experiment

Treatment #	B	k	π_L	π_H
Treatment 1	7425	1	0.0	1.0
Treatment 2	7425	1	0.2	0.8
Treatment 3	5000	1	0.0	1.0
Treatment 4	5000	1	0.2	0.8
Treatment 5	7425	1	0.5	0.5
Treatment 6	5000	1	0.5	0.5

Table 2: Summary of Observations for Repeated-Interactions Sessions

Treatment #	# of Trials	Average Effort	Std. Dev. of Effort	Realized Output	Reelection Probability
Treatment 1	6	67.43	18.66	(67, 134)	(.08, 1.0)
Treatment 2	5	44.42	19.44	(93, 77)	(.10, 1.0)
Treatment 3	5	48.72	15.43	(86, 76)	(.21, 1.0)
Treatment 4	5	32.27	14.75	(100, 54)	(.57, .98)
Treatment 5	5	5.24	12.16	(79, 73)	(.40, 1.0)
Treatment 6	2	2.51	11.16	(25, 36)	(.08, 1.0)

Table 3: Regression-based Analysis of Candidates' Effort

Variable	(1) OLS	(2) OLS-FE	(3) OLS-RE
Constant	30.46	-	27.31
	(1.19)		(3.15)
Highb	15.60	16.88	16.82
	(1.33)	(1.78)	(1.72)
Highprod	19.98	19.59	19.65
	(1.33)	(1.27)	(1.26)
Fixed Effects	No	Yes	No
R-squared	0.35	0.33	0.33
n = 687			

Notes: OLS-FE refers to the fixed effects estimates of equation (1.3). OLS-RE refers to the random-effects estimates of equation (1.3). The numbers in parentheses are standard errors.

Table 4: Analysis of Voters' Behavior

Treatment #	# of Trials	# of Election Pds.	Error Rate, APM	Error Rate, DAPM
Treatment 1	6	201	10.75	14.23
Treatment 2	5	170	13.06	22.59
Treatment 3	5	162	18.77	23.09
Treatment 4	5	154	26.37	27.67
Treatment 5	5	152	23.95	23.42
Treatment 6	2	61	15.73	21.64

Table 5: Analysis of Voter Heterogeneity

Treatment #	Avg., Error Rates	Std. Dev., Error Rates	Avg., $\hat{\rho}_i$'s	Std. Dev., $\hat{\rho}_i$'s
Treatment 1	10.75	6.70	.35	.28
Treatment 2	13.06	5.58	.22	.23
Treatment 3	18.77	7.31	.32	.29
Treatment 4	26.37	11.56	.13	.18
Treatment 5	23.95	7.23	.32	.29
Treatment 6	15.73	8.49	.22	.09

Table 6: Predicted and Observed Candidates' Effort Levels

Treatment #	Average Effort	Std. Dev. of Effort	Average Predicted Effort	Std. Dev. of Predicted Effort
Treatment 1	67.43	18.66	66.53	18.65
Treatment 2	44.42	19.44	32.75	5.78
Treatment 3	48.72	15.43	33.04	5.06
Treatment 4	32.27	14.75	17.87	3.31
Treatment 5	5.24	12.16	0	0
Treatment 6	2.51	11.16	0	0

Table 7: Regression-based Analysis of Effort Discrepancy

Variable	(1) OLS	(2) OLS-FE	(3) OLS-RE
Constant	20.10	-	19.34
	(1.08)		(1.64)
Highb	1.82	2.15	2.08
	(0.91)	(1.31)	(1.21)
Highprod	0.85	0.78	0.79
	(0.91)	(0.93)	(0.92)
Exper	-0.25	-0.30	-0.28
	(0.08)	(0.07)	(0.08)
Fixed Effects	No	Yes	No
R-squared	0.02	0.02	0.02
n = 687			

Notes: OLS-FE refers to the fixed-effects estimates of equation (1.12). OLS-RE refers to the random-effects estimates of equation (1.12). The numbers in parentheses are standard errors.

Table 8: Relative Efficiency of Experimental Elections

Treatment #	Effort Upper Bound	Average Effort	Relative Efficiency
Treatment 1	70.36	67.43	95.84%
Treatment 2	70.36	44.42	63.13%
Treatment 3	57.74	48.72	84.38%
Treatment 4	57.74	32.27	55.89%
Treatment 5	0	5.24	-
Treatment 6	0	2.51	-

Table 9: Summary of Observations for One-Shot Sessions

Treatment #	# of Trials	Average Effort	Std. Dev. of Effort
Treatment 1	2	8.58	16.39
Treatment 2	2	8.75	12.08
Treatment 3	2	9.42	16.45
Treatment 4	2	7.91	13.05

APPENDIX B

TABLES FOR CHAPTER 2

Table 10: Parameter Values (in francs) for the Experiment

Treatment #	W	k	π	I_L (C_L)	I_H (C_H)	$R(\_,_L)$	$R(\_,_H)$
Treatment 1	600	100	0.5	1	10	1	10
Treatment 2	600	20	0.5	1	10	1	10
Treatment 3	1300	20	0.5	1	10	1	10

Table 11: Equilibrium Set for One-Shot Experimental Elections

Treatment #	Pooling Equilibria	Efficient Pooling	Separating Equilibria	Efficient Separating
Treatment 1	(0, 0), (0, 1)	(0, 0), (0, 1)	(0, 3, 0, 1), (0, 6, 0, 1)	(0, 3, 0, 1)
Treatment 2	(0, 0), (0, 1), (3, 1)	(0, 0), (0, 1)	(0, 6, 0, 1), (0, 9, 0, 1)	(0, 6, 0, 1)
Treatment 3	(0, 0), (0, 1), (3, 1), (6, 1)	(0, 0), (0, 1)	(0, 9, 0, 1)	(0, 9, 0, 1)

Table 12: Equilibrium Set for Repeated-Interactions Experimental Elections

Treatment #	Pooling Equilibria	Efficient Pooling	Separating Equilibria	Efficient Separating
Treatment 1	(0, 0), (0, 1), (3, 1)	(0, 0), (0, 1)	(0, 3, 0, 1), (0, 6, 0, 1)	(0, 3, 0, 1)
Treatment 2	(0, 0), (0, 1), (3, 1), (6, 1)	(0, 0), (0, 1)	(0, 3, 0, 1), (0, 6, 0, 1), (0, 9, 0, 1), (3, 6, 0, 1), (3, 9, 0, 1), (6, 9, 0, 1)	(0, 3, 0, 1)
Treatment 3	(0, 0), (0, 1), (3, 1), (6, 1), (9, 1)	(0, 0), (0, 1)	Same as in Treatment 2	(0, 3, 0, 1)

Table 13: Summary of Observations for FI-OS and II-OS Sessions

Session Characteristic	Policy Outcome (I_L)	Policy Outcome (I_H)	Reelection Probability
<u>FI-OS:</u> Treatment 1 Treatment 2 Treatment 3	(27, 0, 0, 0) (9, 6, 0, 0) (13, 1, 2, 1)	(1, 12, 0, 0) (2, 6, 16, 1) (1, 1, 1, 20)	(.14, 1.0, _, _) (0.0, .33, 1.0, 1.0) (0.0, 0.0, 0.0, 1.0)
<u>II-OS:</u> Treatment 1 Treatment 2 Treatment 3	(42, 1, 0, 0) (27, 12, 0, 0) (16, 8, 21, 0)	(2, 40, 5, 0) (1, 8, 30, 2) (0, 7, 22, 6)	(.07, .93, 1.0, _) (.18, .50, 1.0, 1.0) (.07, .33, .84, 1.0)

Table 14: Rationality of Candidates and Voters in FI-OS and II-OS Sessions

Session Characteristic	Optimal Policy Choice	Modal Policy Choice	Reelection Probability	Conditional Probability of I_H
FI-OS:				
Treatment 1	(0, 3)	(0, 3)	(.14, 1.0, _, _)	(.04, 1.0, _, _)
Treatment 2	(3, 6)	(0, 6)	(0.0, .33, 1.0, 1.0)	(.18, .50, 1.0, 1.0)
Treatment 3	(0, 9)	(0, 9)	(0.0, 0.0, 0.0, 1.0)	(.07, .50, .33, .95)
II-OS:				
Treatment 1	(0, 3)	(0, 3)	(.07, .93, 1.0, _)	(.05, .98, 1.0, _)
Treatment 2	(3, 6)	(0, 6)	(.18, .50, 1.0, 1.0)	(.04, .40, 1.0, 1.0)
Treatment 3	(6, 6)	(6, 6)	(.07, .33, .84, 1.0)	(0.0, .47, .51, 1.0)

Table 15: Equilibrium Selection for One-Shot Elections (Consistent Responses)

Session Characteristic	Equilibrium Ranked 1	Equilibrium Ranked 2	Equilibrium Ranked 3
FI-OS:			
Treatment 1	((0, 3, 0, 1), s, 90%)	((0, 6, 0, 1), s, 60%)	((0, 0), p, 10%)
Treatment 2	((0, 6, 0, 1), s, 63%)	((0, 9, 0, 1), s, 25%)	((3, 1), p, 10%)
Treatment 3	((0, 9, 0, 1), s, 83%)	((0, 0), p, 33%)	All Others
II-OS:			
Treatment 1	((0, 3, 0, 1), s, 86%)	((0, 6, 0, 1), s, 50%)	((3, 1), p, 42%)
Treatment 2	((0, 6, 0, 1), s, 65%)	((0, 9, 0, 1), s, 30%)	((3, 1), p, 31%)
Treatment 3	((6, 1), p, 45%)	((0, 9, 0, 1), s, 26%)	((0, 0), p, 19%)

Notes: "All Others" includes the three pooling equilibria: (0,1), (3,1) and (6,1).

Table 16: Equilibrium Selection for One-Shot Elections (Likelihood Methods)

Session Characteristic	Equilibrium Ranked 1	Equilibrium Ranked 2	Equilibrium Ranked 3	$(\hat{\epsilon}_I, \hat{\epsilon}_E)$ Best Equilibrium
<u>FI-OS:</u>				
Treatment 1	((0, 3, 0, 1), s)	((0, 6, 0, 1), s)	((0, 1), p)	(.04, .14)
Treatment 2	((0, 6, 0, 1), s)	((3, 1), p)	((0, 1), p)	(.15, .18)
Treatment 3	((0, 9, 0, 1), s)	((6, 1), p)	((3, 1), p)	(.07, .05)
<u>II-OS:</u>				
Treatment 1	((0, 3, 0, 1), s)	((0, 6, 0, 1), s)	((0, 1), p)	(.07, .11)
Treatment 2	((0, 6, 0, 1), s)	((0, 1), p)	((3, 1), p)	(.13, .19)
Treatment 3	((6, 1), p)	((3, 1), p)	((0, 1), p)	(.17, .21)

Table 17: Summary of Observations for the FI-RI and II-RI Sessions

Session Characteristic	Policy Outcome (I_L)	Policy Outcome (I_H)	Reelection Probability
<u>FI-RI:</u>			
Treatment 1	(100, 4, 1, 0)	(6, 98, 0, 0)	(.14, .99, 0.0, _)
Treatment 2	(98, 30, 3, 1)	(8, 92, 37, 0)	(.07, .85, 1.0, 1.0)
Treatment 3	(81, 25, 1, 0)	(9, 73, 17, 16)	(.18, .78, .95, 1.0)
<u>II-RI:</u>			
Treatment 1	(113, 3, 1, 0)	(7, 66, 50, 1)	(.17, .64, 1.0, 1.0)
Treatment 2	(89, 28, 0, 0)	(1, 38, 53, 16)	(.08, .76, 1.0, 1.0)
Treatment 3	(64, 38, 18, 0)	(2, 52, 65, 10)	(.06, .75, .92, 1.0)

Table 18: Equilibrium Selection for Repeated Elections (Consistent Responses)

Session Characteristic	# Trials	# Trials (With Separation)	# Trials (With Efficient Separation)	# Trials (With Pooling)
<u>FI-RI:</u>				
Treatment 1	9	9	9	0
Treatment 2	12	11	6	1
Treatment 3	10	8	6	2
<u>II-RI:</u>				
Treatment 1	11	10	4	1
Treatment 2	11	10	2	1
Treatment 3	11	6	2	5

Table 19: Informational Efficiency of Experimental Elections

Session Characteristic	Treatment 1 (%)	Treatment 2 (%)	Treatment 3 (%)
FI-OS	92.50	80.00	90.00
II-OS	92.22	85.00	63.75
FI-RI	87.56	84.76	81.98
II-RI	79.25	88.44	74.69

APPENDIX C

FIGURES FOR CHAPTER 3

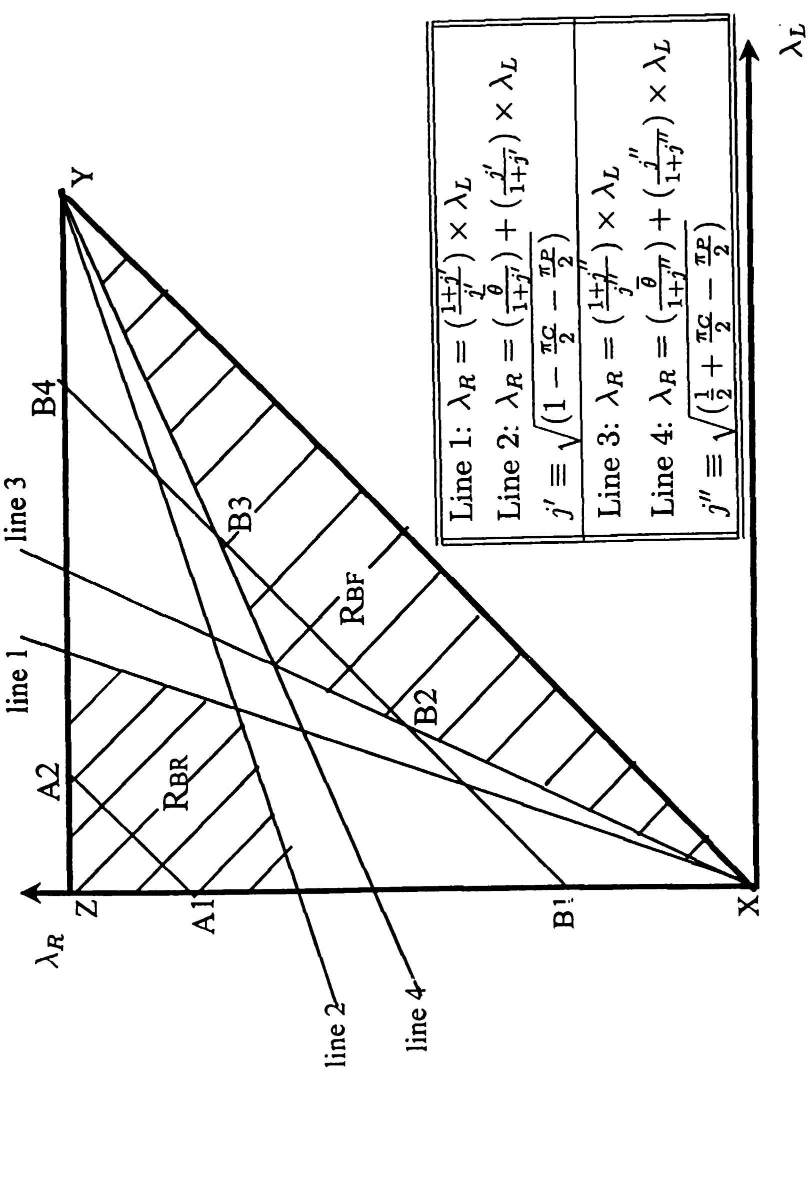

Figure 1: Solution for the Separation-of-Powers System

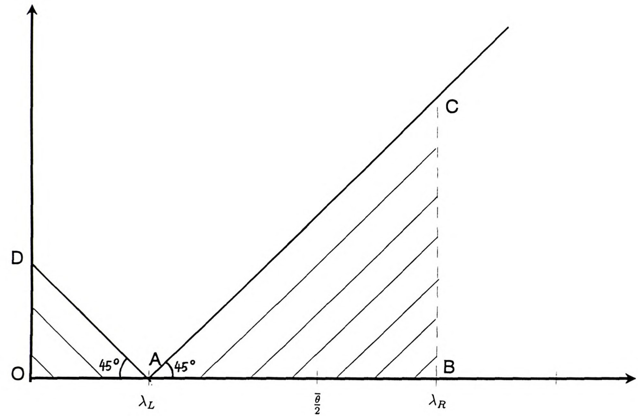

Figure 2: Welfare Loss Triangles for Party P_L

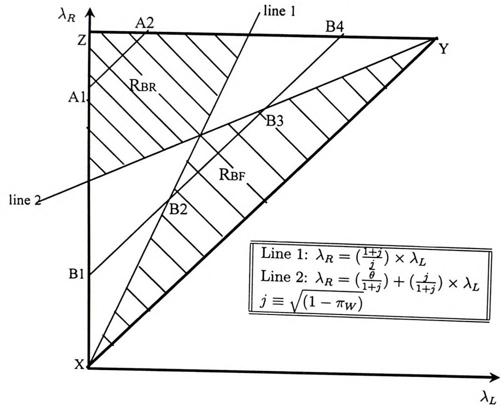

Figure 3: Solution for the Parliamentary System

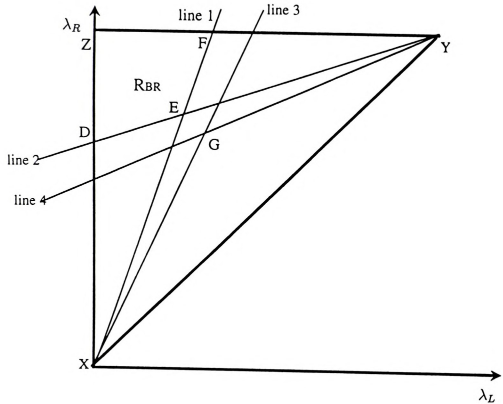

Figure 4: Comparison of the Two Electoral Systems

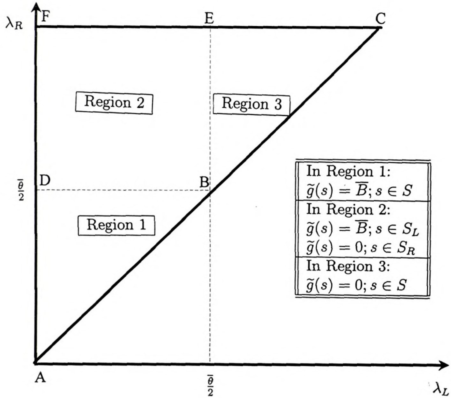

Figure 5: g-(wiggle) Mapping for Lambda-space

LIST OF REFERENCES

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[1] Abramowitz, Alan. 1980. "A Comparison of Voting for U.S. Senators and Representatives in 1978." *American Political Science Review* 74: 633-640

[2] Abreu, Dilip, David Pearce, and Ennio Stachetti. 1986. "Optimal Cartel Equilibrium with Imperfect Monitoring." *Journal of Economic Theory* 50: 251-269.

[3] Alesina, Alberto and Alex Cukierman. 1990. "The Politics of Ambiguity." *The Quarterly Journal of Economics* 105: 829-850.

[4] Alesina, Alberto and Guido Tabellini. 1990. "A Positive Theory of Fiscal Deficits and Government Debt." *The Review of Economic Studies* 57: 403-414.

[5] Amemiya, Takeshi. 1985. *Advanced Econometrics*. Cambridge: Harvard University Press.

[6] Arnold, R. Douglas. 1987. "Political Control of Administrative Officials." *Journal of Law, Economics and Organization* 3: 279-286.

[7] Austen-Smith, David and Jeffrey S. Banks. 1989. "Electoral Accountability and Incumbency." In *Models of Strategic Choice in Politics*, ed. Peter C. Ordeshook. Ann Arbor: The University of Michigan Press.

[8] Banks, Jeffrey S. 1989. "Agency Budgets, Cost Information, and Auditing." *American Journal of Political Science* 50: 670-699.

[9] Banks, Jeffrey S. 1990. "A Model of Electoral Competition with Incomplete Information." *Journal of Economic Theory* 50: 309-325.

[10] Banks, Jeffrey S. 1991. *Signaling Games in Political Science*. New York: Harwood Academic Publishers.

[11] Banks, Jeffrey S. and Barry R. Weingast. 1992. "The Political Control of Bureaucracies under Asymmetric Information." *American Journal of Political Science* 36: 509-524.

[12] Banks, Jeffrey S. and Rangarajan K. Sundaram. 1993. "Adverse Selection and Moral Hazard in a Repeated Elections Model." In *Political Economy: Institutions, Competition, and Representation; Proceedings of the Seventh International Symposium in Economic Theory and Econometrics*, ed. William A. Barnett. Cambridge: Cambridge University Press.

[13] Baron, David P. 1996. "A Dynamic Theory of Collective Goods Programs." *American Political Science Review* 90: 316-330.

[14] Barro, Robert. 1973. "The Control of Politicians: An Economic Model." *Public Choice* 14: 19-42.

[15] Bawn, Kathleen. 1995. "Police Control versus Expertise: Congressional Choices about Administrative Procedures." *American Political Science Review* 89: 62-73.

[16] Bellman, Richard, 1957. *Dynamic Programming.* Princeton, N.J.: Princeton University Press.

[17] Bendor, Jonathan, Serge Taylor and Roland Van Gaalen. 1985. "Bureaucratic Expertise versus Legislative Authority: A Model of Deception and Monitoring in Budgeting." *American Political Science Review* 79: 1041-1060.

[18] Besley, Timothy J. and Anne C. Case. 1995a. "Does Electoral Accountability Affect Economic Policy Choices? Evidence from Gubernatorial Term Limits." *The Quarterly Journal of Economics* 110: 769-798.

[19] Besley, Timothy J. and Anne C. Case. 1995b. "Incumbent Behavior: Vote-Seeking, Tax-Setting, and Yardstick Competition." *American Economic Review* 85: 25-45.

[20] Calvert, Randall L., Matthew D. McCubbins and Barry R. Weingast. 1989. "A Theory of Political Control and Agency Discretion." *American Journal of Political Science* 33: 588-611.

[21] Chamberlain, Gary. 1984. "Panel Data." In *Handbook of Econometrics*, Vol. 2, eds. Zvi Griliches and Michael D. Intriligator. Amsterdam: North-Holland.

[22] Collier, Kenneth E., Richard D. McKelvey, Peter C. Ordeshook, and Kenneth C. Williams. 1987. "Retrospective Voting: An Experimental Study." *Public Choice* 54: 101-130.

[23] Conover, W.J. 1980. *Practical Nonparametric Statistics*. New York: John Wiley and Sons.

[24] Cukierman, Alex, Sebastian Edwards, and Guido Tabellini. 1992. "Seigniorage and Political Instability." *American Economic Review* 82: 537-555.

[25] Davis, Douglas O. and Charles A. Holt. 1994. "Equilibrium Cooperation in Three-Person, Choice-of-Partner Games." *Games and Economic Behavior* 7: 39-53.

[26] Downs, Anthony. 1957. *An Economic Theory of Democracy.* New York: Harper and Row.

[27] Epstein, David and Sharyn O'Halloran. 1994. "Administrative Procedures, Information, and Agency Discretion." *American Journal of Political Science* 38: 697-722.

[28] Epstein, David and Sharyn O'Halloran. 1996. "Divided Government and the Design of Administrative Procedures: A Formal Model and Empirical Tests." *Journal of Politics* xx: 373-397.

[29] Feinberg, Robert M. and Thomas A. Husted. 1993. "An Experimental Test of Discount-rate on Collusive Behavior in Duopoly Markets." *Journal of Industrial Economics* 41: 153-160.

[30] Ferejohn, John A. 1986. "Incumbent Performance and Electoral Control." *Public Choice* 14: 19-42.

[31] Ferejohn, John A. 1990. "Information and the Electoral Process." In *Information and Democratic Processes*, eds. John A. Ferejohn and James W. Kuklinski, Urbana: University of Illinois Press.

[32] Ferejohn, John A. and Charles Shipan. 1990. "Congressional Influence on the Bureaucracy." *Journal of Law, Economics and Organization* 6: 1-20.

[33] Fiorina, Morris P. 1986. "Legislator Uncertainty, Legislator Control, and the Delegation of Legislative Power." *Journal of Law, Economics and Organization* 2: 33-51.

[34] Fudenberg, Drew and Jean Tirole. 1991. *Game Theory.* Cambridge, M.A.: MIT Press.

[35] Grossman, Sanford and Oliver D. Hart. 1983. "An Analysis of the Principal-Agent Problem." *Econometrica* 51: 7-45.

[36] Harless, David W., and Colin F. Camerer. 1995. "An Error Rate Analysis of Experimental Data Testing Nash Refinements." *European Economic Review* 39: 649-660.

[37] Harrington, Joseph E. 1993. "Economic Policy, Economic Performance, and Elections." *American Economic Review* 83: 27-42.

[38] Hausman, Jerry A. 1978. "Specification Tests in Econometrics." *Econometrica* 46: 1251-1272.

[39] Hey, John D. 1995. "Experimental Investigations of Errors in Decision Making Under Risk." *European Economic Review* 39: 633-640.

[40] Hill, Jeffrey S. 1985. "Why So Much Stability? The Impact of Agency Determined Stability." *Public Choice* 46: 275-289.

[41] Holmstrom, Bengt R. 1979. "Moral Hazard and Observability." *Bell Journal of Economics* 10: 74-91.

[42] Horn, Murray J. and Kenneth A. Shepsle. 1989. "Commentary on `Administrative Arrangements and the Political Control of Agencies.'" *Virginia Law Review* 75: 431-482.

[43] Kalt, Joseph P. and Mark A. Zupan. 1990. "The Apparent Ideological Behavior of Legislators: Testing for Principal-Agent Slack in Political Institutions." *Journal of Law and Economics* 33: 103-131.

[44] Kreps, David M. and Robert B. Wilson. 1982. "Sequential Equilibria." *Econometrica* 50: 863-894.

[45] Laffont, Jean-Jacques and Jean Tirole. 1990. "The Politics of Government Decision Making: Regulatory Institutions." *Journal of Law, Economics and Organization* 9: 9-42.

[46] Laffont, Jean-Jacques and Jean Tirole. 1991. "The Politics of Government Decision Making: A Theory of Regulatory Capture." *Quarterly Journal of Economics* 106: 1089-1127.

[47] Ledyard, John O. 1984. "The Pure Theory of Large Two-Candidate Elections." *Public Choice* 44: 7-41.

[48] Lott, John R. and Michael L. Davis. 1992. "A Critical Review and an Extension of the Political Shirking Literature." *Public Choice* 74: 461-484.

[49] Lott, John R. and Stephen G. Bronars. 1993. "Time Series Evidence on Shirking in the U.S. House of Representatives." *Public Choice* 76: 125-149.

[50] Macey, Jonathan R. 1992. "Organizational Design and Political Control of Administrative Agencies." *Journal of Law, Economics and Organization* 8: 93-110.

[51] Malaith, George. 1987. "Incentive Compatibility in Signaling Games with a Continuum of Types." *Econometrica* 55: 1349-1365.

[52] Maskin, Eric and Jean Tirole. 1988. "A Theory of Dynamic Oligopoly, I: Overview and Quantity Competition with Large Fixed Costs." *Econometrica* 56: 549-569.

[53] Maskin, Eric and Jean Tirole. 1994. "Markov Perfect Equilibrium." Harvard University. Typescript.

[54] McCubbins, Matthew D. and Thomas Schwartz. 1984. "Congressional Oversight Overlooked: Police Patrol versus Fire Alarms." *American Journal of Political Science* 28: 165-179.

[55] McCubbins, Matthew D., Roger G. Noll, and Barry R. Weingast. 1987. "Administrative Procedures as Instruments of Political Control." *Journal of Law, Economics and Organization* 3: 243-277.

[56] McCubbins, Matthew D., Roger G. Noll, and Barry R. Weingast. 1989. "Structure and Process, Politics and Policy: Administrative Arrangements and the Political Control of Agencies." *Virginia Law Review* 75: 431-482.

[57] Milgrom, Paul R. 1981. "Good News and Bad News: Representation Theorems and Applications." *Bell Journal of Economics* 12: 380-391.

[58] Miller, Gary J. and Terry M. Moe. 1983. "Bureaucrats, Legislators, and the Size of Government." *American Political Science Review* 77: 297-322.

[59] Moe, Terry M. 1990a. "Political Institutions: The Neglected Side of the Story." *Journal of Law, Economics and Organization* 6: 213-253.

[60] Moe, Terry M. 1990b. "The Politics of Structural Choice: Toward a Theory of Public Bureaucracy." In *Organization Theory: From Chester Bernard to the Present and Beyond*, ed. Oliver E. Williamson. New York: Oxford University Press.

[61] Moe, Terry M. and Michael Caldwell. 1994. "The Institutional Foundation of Democratic Government: A Comparison of Presidential and Parliamentary Systems." *Journal of Institutional and Theoretical Economics* 150: 171-195.

[62] Moe, Terry M. and Scott A. Wilson. 1994. "Presidents and the Politics of Structure." *Law and Contemporary Problems* 57: 1-44.

[63] Niskanen, William. 1971. *Bureaucracy and Representative Government*. Chicago: Aldine-Atherton.

[64] Niskanen, William. 1975. "Bureaucrats and Politicians." *Journal of Law and Economics* 18: 617-644.

[65] Palfrey, Thomas R. and Howard Rosenthal. 1985. "Voter Participation and Strategic Uncertainty." *American Political Science Review* 79: 62-78.

[66] Palfrey, Thomas R. and Howard Rosenthal. 1992. "Repeated Play, Cooperation, and Coordination: An Experimental Study." California Institute of Technology. Typescript.

[67] Peltzman, Sam. 1976. "Toward a More General Theory of Regulation." *Journal of Law and Economics* 19: 211-240.

[68] Posner, Richard A. 1974. "Theories of Economic Regulation." *Bell Journal of Economics* 5: 335-358.

[69] Reed, Robert W. 1989. "Information in Political Markets: A Little Knowledge Can Be a Dangerous Thing." *Journal of Law, Economics and Organization* 5: 355-373.

[70] Rogoff, Kenneth S. and Anne C. Sibert. 1988. "Elections and Macroeconomic Policy Cycles." *Review of Economic Studies* 55: 1-16.

[71] Rogoff, Kenneth S. 1990. "Equilibrium Political Budget Cycles." *American Economic Review* 80: 21-36.

[72] Roth, Alvin E. 1991. "Game Theory As Part of Empirical Economics." *The Economic Journal* 101: 107-114.

[73] Shepsle, Kenneth A. 1992. "Bureaucratic Drift, Coalitional Drift, and Time Consistency: A Comment on Macey." *Journal of Law, Economics and Organization* 8: 111-118.

[74] Spence, Michael. 1973. "Job Market Signaling." *Quarterly Journal of Economics* 87: 355-374.

[75] Stigler, George. 1971. "The Economic Theory of Regulation." *Bell Journal of Economics* 2: 3-21.

[76] Stokes, Donald and Warren Miller. 1962. "Party Government and the Saliency of Congress." *Public Opinion Quarterly* 26: 531-546.

[77] Tirole, Jean. 1986. "Hierarchies and Bureaucracies." *Journal of Law, Economics and Organization* 2: 181-214.