Equilibrium Political Budget Cycles

By KENNETH ROGOFF*

Political business cycle theories generally rely on nominal rigidities and voter myopia. This paper offers an equilibrium theory which preserves some basic insights from earlier models, though with significant refinements. The "political budget cycle" emphasized here is in fiscal policy rather than output and inflation; it arises via a multidimensional signal process. One can consider the welfare implications of proposals to mitigate the cycle, and the effects of altering the electoral structure. (JEL 131)

Economists and political scientists have long been intrigued by the coincidence of elections and economic policy cycles.[1] During election years, governments at all levels often engage in a consumption binge, in which taxes are cut, transfers are raised, and government spending is distorted toward projects with high immediate visibility. The proximate cause of the "political budget cycle" does not seem difficult to identify. Any incumbent politician, regardless of his ideological stripes, wants to convince voters that he is doing an efficient job running the government. The deeper question is why rational voters might allow their expectations about postelection performance to be influenced by preelection budget antics.[2]

In this paper, I offer a dynamic, multidimensional signaling model in which both voters and politicians are rational, utility-maximizing agents. A political budget cycle arises here due to temporary information asymmetries about the incumbent leader's "competence" in administering the public goods production process. The incumbent leader has an incentive to bias preelection fiscal policy toward easily observed consumption expenditures, and away from government investment. In equilibrium, however, voters can deduce the leader's current competency by the degree to which he distorts tax and expenditure policies.[3]

Perhaps the most important reason for trying to develop a fully articulated equilibrium model of political budget cycles is to enable one to analyze the welfare implications of alternative electoral regimes, and of various proposals for tempering election year budget distortions.[4] For example, the popu-

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[1] Important contributions to the modern literature on political business cycles include William D. Norhaus (1975), Assar Lindbeck (1976), and Edward R. Tufte (1978). For a broad survey of the more recent literature on politics and macroeconomic policy, see Alberto Alesina (1988); see also Thomas D. Willet (1989).

[2] Kenneth Rogoff and Anne Sibert (1988) show that political budget cycles can be given an equilibrium signaling interpretation. Their model is not sufficiently articulated, however, to address the normative issues raised here.

[3] The rationale for political budget cycles here is very different from the one underlying the "partisan" models of Douglas A. Hibbs (1977) and Alesina (1987). In partisan models, two parties with very different preferences over inflation and unemployment compete for office. Consequently, private nominal wage setters have great difficulty predicting postelection monetary policy. For empirical evidence on this approach, see Alesina (1988), (1989), Daniel Cohen (1988) and Steven M. Sheffrin (1988). In principle, it should be possible to generalize the present analysis to incorporate partisan factors.

[4] A number of authors have previously addressed normative aspects of political business cycles; see Lindbeck (1976), Henry Chappell and William Keech (1983),

lar perception is that political budget cycles are a bad thing. But a central conclusion here is that they may be a socially efficient mechanism for diffusing up-to-date information about the incumbent's administrative competence. Efforts to curtail the cycle can easily reduce welfare, either by impeding the transmission of information or by inducing politicians to select more socially costly ways of signaling.[5]

In Section I, I present the model, including the constitutionally constrained election structure. Section II gives the equilibrium under full information, and Sections III–V characterize the fiscal policy distortions which occur under asymmetric information. There are multiple sequential equilibria to the model, but after applying some standard refinements, one obtains a unique equilibrium. In Section VI, I explore some possible approaches to mitigating the cycle, including a constitutional limit on the legislature's ability to undertake new fiscal initiatives directly prior to elections. One interesting alternative electoral structure, common to many countries, gives the incumbent the option of calling for an early election. Finally, I consider whether there are ways for society to channel preelection signaling into dimensions that primarily impact on the incumbent and not on society at large. In the conclusions, the predictions of the equilibrium political budget cycle theory are compared with those of its Keynesian predecessor, the political business cycle theory.

I. The Model

A. *The Preferences of a Representative Citizen*

The economy is composed of a large number of (*ex ante*) identical citizens, each of whom derives utility both from public goods and from a private consumption good. The representative voter is concerned with the expected value of his utility function, $E_t^P(\Gamma_t)$, where subscripts denote time, E^P denotes expectations based on the general public's information set, and

$$(1) \quad \Gamma_t = \sum_{s=t}^{T} [U(c_s, g_s) + V(k_s) + \eta_s] \beta^{s-t}.$$

In equation (1), c is a representative citizen's consumption of the private good, g is the public "consumption" good (per capita), and k is the public "investment" good (per capita). (Population will be held constant throughout). U and V are both regular strictly concave functions, with $U_1, U_2, V' > 0$. In addition to the usual Inada conditions, I make the further assumption that $\lim_{k \to 0} V(k) = -\infty$ [for example, $V(k) = \log k$]. This condition is sufficient to ensure an interior solution in the asymmetric information case. $\beta < 1$ is the representative citizen's discount rate, and T is his time horizon, which may be infinite. The term η is a random shock, which will later be identified with non-pecuniary leader-specific factors such as the leader's looks.

B. *Technology*

At the beginning of each period, all citizens exogenously receive y units of a nonstorable good, which can either be privately consumed or used as an input into the production of public goods. Lump-sum taxes in period t are given by τ_t, so that

$$(2) \quad c_t = y - \tau_t.$$

In addition to taxes, the production of public goods also requires a (single) "leader" whose administrative competency is indexed by ε. A competent administrator (high ε) is able to provide a given level of public goods at a lower level of taxes than an incompetent one can. Specifically, I assume that the pub-

Keech and Carl Simon (1985), Alex Cukierman and Allan H. Meltzer (1986), and Willett (1989). None of these analyses, however, are based on fully specified equilibrium models.

[5] Tufte (1978, p. 149) also suggests that political business cycles may have socially beneficial aspects. He argues that the government tends to distribute income more equitably prior to elections than at other times.

lic goods production function takes the form[6]

$$g_t + k_{t+1} = \tau_t + \varepsilon_t. \tag{3}$$

Note that whereas the relative cost of producing g and k is unity, the timing of their production differs. To have the public "investment" good k in period $t+1$, the government must invest in period t.

C. *Stochastic Structure*

All agents are capable of serving as the country's leader. However, at any point in time they differ according to their innate administrative ability. For each agent i, (potential) leadership competency evolves according to the serially correlated stochastic process

$$\varepsilon_t^i = \alpha_t^i + \alpha_{t-1}^i, \tag{4}$$

where each α is an independent drawing from a Bernoulli distribution with $\rho \equiv \text{prob}(\alpha = \alpha^H)$ and $1-\rho \equiv \text{prob}(\alpha = \alpha^L)$, $\alpha^H > \alpha^L > 0$. The α shocks are independent across agents as well as across time. One reason why competency might realistically be thought to vary across time is that leadership abilities well-suited to dealing with the one set of historical circumstances may become outmoded as the problems facing the country change. Also, even if the same leader stays in power, there may be turnover among his key advisors.

In this model, competency is not a choice variable for a leader but an individual characteristic. One may think of competency as administrative IQ.[7] The assumption that competency follows a first-order moving average process simplifies the analysis below considerably, by effectively breaking structural links between elections. However, the main qualitative results here should carry over to more general stochastic processes.

In addition to the competency shock, each agent i experiences a "looks" shock η, which also follows a moving average process:

$$\eta_t^i = q_t^i + q_{t-1}^i, \tag{5}$$

where each q is a continuously distributed i.i.d. random variable on $[-\bar{q}, \bar{q}]$, with q_t^i and q_s^j independent for all $s \neq t$, $i \neq j$. The random variable η is intended to capture factors relevant to an agent's leadership ability but uncorrelated with his competence in administering the public goods production function; for example, his "looks." Neither ε^i nor η^i matter for anything when agent i is a private citizen. Throughout, whenever ε, η, α, or q are written without a superscript, they refer to the incumbent.

D. *The Leader's Utility Function*

The country's leaders are drawn from the ranks of ordinary citizens and as such, they derive utility from public and private consumption goods in the same way as other citizens. However, because the position of chief administrator is considered a great honor, the leader receives additional "ego rents" of X per period in office. Thus, for an incumbent leader, expected utility is given by[8]

$$E_t^I(\Gamma_t) + \sum_{s=t}^{T} \beta^{s-t} X \pi_{s,t}, \tag{6}$$

where I denotes the incumbent and Γ is given by (1). E_t^I denotes expectations based on the incumbent's information set at time t,

[6]The analysis would be similar in most respects if ε entered the production function multiplicatively, either multiplying $g+k$ or k alone. There would be some differences since a change in ε then has price effects as well as income effects, but the welfare results in Section VI would not be affected.

[7]It is tempting to stretch the paradigm here to interpret competency as reflecting the efficacy of a particular political party's general philosophical approach toward managing the government.

[8]Implicit in (6) is the assumption that the leader cares just as much about his own "looks" shock as private agents do. The results below would be the same, however, if η did not enter the leader's objective function. Another assumption implicit in (6) is that the leader is not legally allowed to tax himself differently from other individuals; there is no graft.

and $\pi_{s,t}$ is the incumbent's time t estimate of his probability of being in office in period s; π will be derived later on. Prospective ego rents (X) do not enter explicitly into the objective function of an ordinary citizen, $E^P(\Gamma)$, only because the population is sufficiently large that the probability of his ever being elected is infinitesimal.

I have motivated the leader's utility function without any appeal to altruism. But it should later be apparent that the analysis would be similar in most respects under a more generous interpretation of the leader's aims. Specifically, one can interpret equation (6) as saying that the leader puts some weight on social welfare, Γ, and some weight on the rents he receives from being in office.

E. *The Structure of Elections*

In order to determine which citizen is awarded the honor of administering the production of public goods, the country's constitution specifies that elections be held every other period. The incumbent leader is allowed to run an indefinite number of times,[9] whereas the opposition candidate is chosen at random from the rest of the population. Note that under the information structure specified below, the fundamental difference between the incumbent leader and his opponent is that the public can infer something about the incumbent's most recent competency shock, but it has no way of inferring anything about the opponent's competency. For voters, the choice is essentially between reelecting the incumbent or selecting an agent from the population at large, all of whom appear identical *ex ante*.[10]

[9]If the incumbent can only run for reelection a finite number of times, then the model predicts that there will be no political budget cycle in the last period. One can also interpret the model along the lines of Rogoff and Sibert (1988), in which electoral competitions match two political parties.

[10]The stochastic structure of the model is consistent with Ray C. Fair's (1978) finding that for U.S. presidential elections, voters do not take into account the opposition party's economic performance when last in power; see also Sam Peltzman (1987).

F. *The Information Structure and the Timing of Events*

Voters observe taxes τ_t and government consumption spending g_t contemporaneously, and employ this information to form *inferences* concerning government investment spending k_{t+1} and the incumbent's competency shock α_t. However, they cannot directly confirm these inferences until the following period. In period $t+1$, the government's period t investment comes on line and voters also directly observe α_t. Thus the incumbent has a temporary information "advantage" over voters in the sense that he sees his competency shock contemporaneously. I use the word "advantage" in quotation marks because it will turn out that *in equilibrium* voters are always able to deduce the incumbent's private information.

The information structure assumed here is plausible since it is costly for an individual to closely monitor and evaluate a government's performance. Moreover, there is little private incentive for an individual to undertake such monitoring since in equilibrium, he can infer α_t costlessly using his information on g_t and τ_t. Taxes and government consumption spending are variables which individuals need to know and can observe relatively easily. On the other hand, if k represents investment in national defense, there may be national security reasons for not making it public. More broadly, k may be thought of as vesting of public pension funds, off-budget loan guarantees, or any type of government expenditure whose effects are only observed by the representative voter with a lag.

Of course, if some group were able to monitor the government and *credibly* transmit information in a way that would not be too costly for the average citizen to process, then there would be no political budget cycle in the analysis below. Clearly, neither the opposition candidate nor the incumbent can provide this service, since their statements cannot be trusted. The results below should go through in a more general setting in which some voters monitor α_t, as long as there is a sufficient pool of uninformed voters.

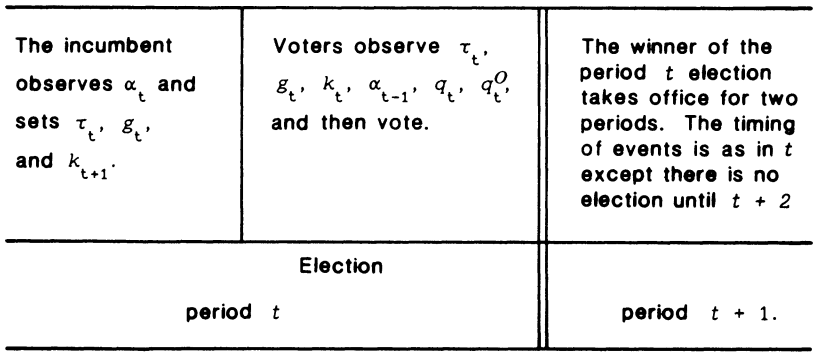

FIGURE 1. THE TIMING OF EVENTS

The public, of course, has no way of inferring α_t^O, where "O" superscripts denote the opponent. All voters know about the opponent is the probability distribution of α. (The incumbent has no way of knowing α_t^O either until he actually tries his hand at running the government.) Prior to voting, voters do observe both q_t and q_t^O, the "looks" shocks.

The incumbent must set g and τ prior to observing the q's. The rationale for this assumption is that it takes time for the government to collect taxes and to make purchases. The q shocks, on the other hand, might capture information revealed in election-eve debates or uncertainty about a last-minute scandal concerning one of the candidates. In a slightly different version of the model in which voters have heterogeneous preferences over looks, q can represent uncertainty about election-day weather, and thus about the composition of voters who come to the polls.[11] Figure 1 illustrates the timing of events.

In deciding his vote, the representative voter compares his expected utility under each of the two candidates. If $v=1$ denotes a vote for the incumbent and $v=0$ a vote for his opponent, then

$$(7)\quad v_t=\begin{cases}1 & \text{if } E_t^P(\Gamma_{t+1})\geq E_t^P(\Gamma_{t+1}^O)\\ 0, & \text{otherwise.}\end{cases}$$

II. Equilibrium Under Full Information

Before proceeding, it is useful to analyze the equilibrium which would arise if voters could directly observe α_t prior to voting. In this case, the incumbent's preelection fiscal policy cannot possibly affect voter's expectations abut his postelection competency, and thus can have no effect on his chances of remaining in office. With the π terms in (6) exogenous, the incumbent's decision problem becomes equivalent to maximizing the welfare of the representative agent. Given the simple production and storage technology, this problem can be broken down into a sequence of static maximization problems:

$$(8)\quad \max_{\tau_t,c_t,g_t,k_{t+1}} U(c_t,g_t)+\beta V(k_{t+1}),\qquad \forall\, t\geq T$$

subject to (2), (3), and $k, c, g\geq 0$; $k_{T+1}=\bar{k}$.[12]

[11] The analysis below is quite similar when voters have heterogeneous tastes concerning "looks," except that elections are no longer unanimous.

[12] Note that τ is allowed to take on negative values (the government can make net transfers). This assumption is not qualitatively important and the analysis is easily generalized to the case where taxes are constrained to be nonnegative.

It is convenient to rewrite the above maximization problem by substituting (2) and (3) into (8):

$$(9)\quad \max_{\tau,g} W(g,\tau,\varepsilon) \equiv U(y-\tau,g) + \beta V(\tau+\varepsilon-g)$$
$$\text{s.t. } g,\ y-\tau,\ \tau+\varepsilon-g \geq 0.$$

(Time subscripts will henceforth be omitted where the meaning is obvious.) The first-order conditions for an interior solution to (9) imply

$$(10)\quad U_1(y-\tau,g) = U_2(y-\tau,g),$$

$$(11)\quad U_1(y-\tau,g) = \beta V'(\tau+\varepsilon-g).$$

One can readily confirm that there is a unique $[g^*(\varepsilon), \tau^*(\varepsilon)]$ which satisfies (10) and (11), and that this point is a global maximum. (Note that U and V are strictly concave and that the constraint set is convex.) Clearly

$$W^*(\varepsilon) = W^*[g^*(\varepsilon), \tau^*(\varepsilon), \varepsilon]$$

is strictly increasing in ε and, if all goods are normal, then $c^*(\varepsilon)$, $g^*(\varepsilon)$, and $k^*(\varepsilon)$ are also increasing. By (2), $\tau^*(\varepsilon)$ must be decreasing in ε.

If t is an election period, then by equations (1), (4), (5), (7), and (9), the incumbent will be reelected ($v=1$) if

$$(12)\quad E_t^P[W^*(\varepsilon_{t+1})] - E_t^P[W^*(\varepsilon_{t+1}^O)] + q_t - q_t^O \geq 0.$$

Because ε and η follow first-order moving average processes, voters' expected utility is the same under either candidate for periods $t+2$ and beyond, and thus only expectations over $t+1$ enter into (12). (Recall from Figure 1 that voters observe the q shocks prior to the election.)

If voters directly observe the incumbent's most recent competency shock prior to voting, then the first term in (12) is given by

$$(13)\quad E_t^P[W^*(\varepsilon_{t+1})|\alpha_t = \alpha^i] \equiv \Omega^i = \rho W^*(\alpha^i+\alpha^H) + (1-\rho)W^*(\alpha^i+\alpha^L); \quad i=H,L.$$

Voters have no observations on the opponent's competency; hence

$$(14)\quad E_t^P[W^*(\varepsilon_{t+1}^O)] \equiv \Omega^O = \rho^2 W^*(2\alpha^H) + 2\rho(1-\rho)W^*(\alpha^H+\alpha^L) + (1-\rho)^2 W^*(2\alpha^L).$$

Clearly, $\Omega^H > \Omega^O > \Omega^L$.

III. Voters' and Leaders' Optimization Problems Under Asymmetric Information

I now return to the asymmetric information structure summarized in Figure 1. Although the public cannot observe α_t until period $t+1$, they can form "beliefs" about α_t given their observations on g_t and τ_t. These beliefs can be parameterized as $\hat{\rho}(g,\tau)$, where $\hat{\rho}$ is the probability weight the public attaches to the possibility that $\alpha_t = \alpha_H$. (Since α_{t-1} is a fixed, known parameter throughout this section, I abbreviate $\hat{\rho}(\alpha_t, \tau_t; \alpha_{t-1})$ as $\hat{\rho}(\alpha,\tau)$).

We will initially focus on the final election period, $t=T-2$. Since the winner will not be running for reelection, he has no incentive to distort fiscal policy in periods $T-1$ or T. Thus $E_t^P[W(\varepsilon_{T+1})] = E_t^P[W^*(\varepsilon_{T+1})]$ if the incumbent wins and similarly for his opponent. By equations (12)–(14), if voters have priors $\hat{\rho}(g,\tau)$, the incumbent will be reelected ($v=1$) if

$$(15)\quad \hat{\rho}\Omega^H + (1-\hat{\rho})\Omega^L - \Omega^O + q - q^O \geq 0.$$

The incumbent does not know $q - q^O$ when setting his election-year fiscal policy. However, for any choice of (g, τ), he can infer $\hat{\rho}(g, \tau)$ and thus calculate the probability that $q - q^O$ will be high enough for him to win:

$$(16) \quad \pi[\hat{\rho}(g,\tau)] \equiv E^I(\nu|g,\tau) = 1 - G[\Omega^O - \hat{\rho}\Omega^H - (1-\hat{\rho})\Omega^L],$$

where G is the probability distribution function of $q - q^O$. The possibility for signaling arises here because there is a limit to how much an incumbent would be willing to distort fiscal policy in order to fool the public about his competency. As a representative agent, he too cares about the mix of consumption and investment; see (6) above.

It is convenient to define $\varepsilon^H = \alpha_{t-1} + \alpha^H$, and $\varepsilon^L = \alpha_{t-1} + \alpha^L$. The incumbent will be described as a "type H" (or "competent type") if $\varepsilon_t = \varepsilon^H$, and a "type L" (or "incompetent type") if $\varepsilon_t = \varepsilon^L$. Using equations (1), (4)–(6), (9), and (16), one can then write an incumbent of type i's maximization problem as

$$(17) \quad \max_{g,\tau} Z[g, \tau, \hat{\rho}(g,\tau), \varepsilon^i]$$

$$\text{s.t. } g,\ y - \tau,\ \tau + \varepsilon^i - g \geq 0; \quad i = H, L,$$

where

$$(18) \quad Z[g, \tau, \hat{\rho}(g,\tau), \varepsilon^i] \equiv \chi^i \pi[\hat{\rho}(g,\tau)] + W(g, \tau, \varepsilon^i)],$$

$$(19) \quad \chi^i \equiv \beta[X(1+\beta) + \Omega^i - \Omega^O].$$

The first term on the RHS of (18) is the incumbent's expected chance of winning, π, multiplied by his surplus from winning, χ^i. This surplus is broken down in (19), where the term $X(\beta + \beta^2)$ captures the discounted ego rents for the two postelection periods, and the term $\beta(\Omega^i - \Omega^o)$ is the amount by which the representative citizen's expected utility is higher if the incumbent wins instead of his opponent. I assume $\chi^L > 0$.

Two features distinguish the objective function of a competent type from that of an incompetent type. First, the competent type knows that expected social welfare will be higher if he is reelected than if his unknown opponent wins. The second difference is that for any (g, τ), a type H is investing $\alpha^H - \alpha^L$ more units into k_{t+1} than a type L is, by equation (3). An important implication is that since $V'' < 0$, a type H can cut back on government investment at lower *marginal* cost that can a type L.

IV. Sequential Equilibria

The interaction between incumbent politicians and rational voters here can be viewed as a multidimensional signaling problem, with g and τ as signals of the incumbent's (contemporaneously) unobserved competency. As is typically the case in such models, there is a multiplicity of sequential equilibria, including both *separating* and *pooling* equilibria. In a separating equilibrium, the incumbent's choice of fiscal policy perfectly reveals his competency type. In a pooling equilibrium, the incompetent type might mimic the competent type. However, by requiring that voters' beliefs reflect a certain minimal level of sophistication (by excluding "dominated" strategies),[13] it is possible to rule out all but one of the separating equilibria. By further refining the equilibrium concept, using the "intuitive" criterion of In-Koo Cho and David Kreps (1987), one can also rule out pooling equilibria. In the unique equilibrium which survives both refinements, competent types set taxes too low and government spending too high before elections, whereas incompetent types pursue their full information policy. On average, there is a political budget cycle.[14]

In the main text, I will restrict attention to equilibria in pure strategies. For $i = L, H$, let

[13] See Hervé Moulin (1981). The general approach here draws on Paul Milgrom and John Roberts (1986), and Kyle Bagwell and Garey Ramey (1988).

[14] The analysis can be generalized to allow for a continuum of types along the lines of Rogoff and Sibert (1988). In their analysis, very competent and very incompetent types distort the least.

(g^i, τ^i) describe a strategy for the incumbent leader, and let $\nu[\hat{\rho}(g,\tau), q-q^O]$ describe a strategy for voters. Then the pair $\{(g^i,\tau^i), i=L,H;\ \nu[\hat{\rho}(g,\tau), q-q^O]\}$ describes a sequential equilibrium if: (a) Voters set ν according to (15); (b) the incumbent chooses (g^i,τ^i) according to (17); and (c) voters' beliefs are *Bayes-consistent*: If $(g^L,\tau^L)\neq(g^H,\tau^H)$, then $\hat{\rho}(g^L,\tau^L)=0$ and $\hat{\rho}(g^H,\tau^H)=1$. If $(g^L,\tau^L)=(g^H,\tau^H)$, then $\hat{\rho}(g^L,\tau^L)=\rho$. Henceforth, I will use the term "equilibrium" as an abbreviation for "sequential equilibrium."

A. *Separating Equilibria*

In a separating equilibrium $(g^L,\tau^L)\neq(g^H,\tau^H)$. Note that in any separating equilibrium a type L must be choosing his full-information fiscal policy

$$(20)\quad (g^L,\tau^L)=\left[g^*(\varepsilon^L),\tau^*(\varepsilon^L)\right],$$

since otherwise

$$Z\left\{g^*(\varepsilon^L),\tau^*(\varepsilon^L),\hat{\rho}\left[g^*(\varepsilon^L),\tau^*(\varepsilon^L)\right],\varepsilon^L\right\} - Z\left(g^L,\tau^L,0,\varepsilon^L\right)>0,$$

which is inconsistent with the requirement that (g^L,τ^L) maximize (17). An incompetent incumbent gains nothing by choosing a level of fiscal policy which is distortionary and yet fails to prevent the public from deducing his type.

I will initially assume that voters' "off-the-equilibrium-path" beliefs are governed simply by $\hat{\rho}(g,\tau)=0\ \forall\ (g,\tau)\neq(g^H,\tau^H)$. Given these beliefs, a type L will not benefit by mimicking a type H as long as $(g^H,\tau^H)\in\mathcal{A}$ where

$$(21)\quad \mathcal{A}\equiv\left\{(g,\tau)\,|\,Z\left(g,\tau,1,\varepsilon^L\right) - Z\left[g^*(\varepsilon^L),\tau^*(\varepsilon^L),0,\varepsilon^L\right] \leq 0\right\}.$$

In Figure 2, point I corresponds to $[g^*(\varepsilon^L),\tau^*(\varepsilon^L)]$, and set $\mathcal{A}$ consists of all points on or outside the dashed ellipse. A

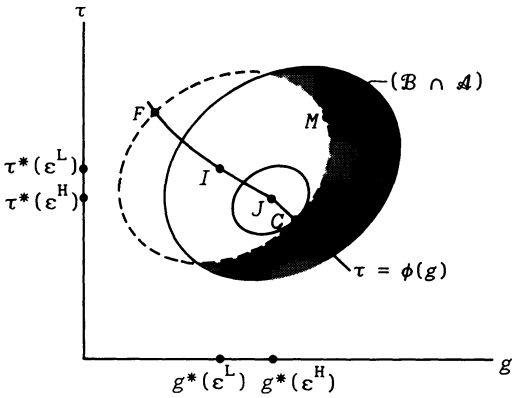

FIGURE 2. UNDOMINATED SEPARATING EQUILIBRIUM

type L would be willing to choose any point *within* the dashed ellipse over point I if by doing so, he could fool the public into thinking he is a type H. (The assumption that U and V obey Inada conditions together with the assumption $V(0)=-\infty$ assure that the ellipse is contained within the boundaries $g>0$, $y-\tau>0$, and $k^L=\tau+\varepsilon^L-g>0$. The set of points contained within the ellipse is necessarily convex as drawn, since W is strictly concave in τ and g).

Point J in Figure 2 corresponds to $[g^*(\varepsilon^H),\tau^*(\varepsilon^H)]$. Because all goods are normal, J must lie southeast of I. Whether J lies within the dashed ellipse (in which case it cannot be a separating equilibrium strategy for a type H) depends on a number of factors. It is more likely to be interior the larger X (ego rents), the smaller $\varepsilon^H-\varepsilon^L$, and the lower the variance of $q-q^O$. Thus if the high type is sufficiently more competent than the low type, he can choose his first-best fiscal policy and still separate himself.

Another necessary condition for a separating equilibrium is that $(g^H,\tau^H)\in\mathcal{B}$, where

$$(22)\quad \mathcal{B}\equiv\left\{(g,\tau)\,|\,Z\left(g,\tau,1,\varepsilon^H\right) - Z\left[g^*(\varepsilon^H),\tau^*(\varepsilon^H),0,\varepsilon^H\right] \geq 0\right\}.$$

The large solid ellipse in Figure 2 contains

the convex set $\mathscr{B}$. The shaded region is $\mathscr{B} \cap \mathscr{A}$; it contains all the possible separating equilibrium strategies for a type H. It is easy to prove that $\mathscr{B} \cap \mathscr{A}$ is nonempty by virtue of the fact $\chi^H > \chi^L$ and $V'' < 0$. Thus

PROPOSITION 1: *The set of all separating equilibria is nonempty and is characterized by* $(g^L, \tau^L) = [g^*(\varepsilon^L), \tau^*(\varepsilon^L)]$, *and* $(g^H, \tau^H) \in \mathscr{B} \cap \mathscr{A}$.

B. *Undominated Separating Equilibria*

The range of separating equilibria can be drastically reduced (to a single point) by requiring that $\hat{\rho} = 1$ for all $(g, \tau) \in \mathscr{B} \cap \mathscr{A}$ and not just at (g^H, τ^H). This restriction on voters' beliefs is plausible since there are no circumstances under which a type L might benefit by choosing a point in the shaded region in Figure 2. Provided voters' beliefs reflect this minimal level of sophistication, a competent incumbent is essentially free to choose the separating strategy which is most favorable to him, that is, the one which entails the least distortions. In an *undominated* separating equilibrium, (g^H, τ^H) solves[15]

$$\max_{g,\tau} W(g, \tau, \varepsilon^H) \tag{23}$$

$$\text{s.t. } g,\ y - \tau,\ \tau + \varepsilon^H - g \geq 0,$$

$$\text{and} \quad (g, \tau) \in \mathscr{A}.$$

PROPOSITION 2: *There exists a unique undominated separating equilibrium, and in this equilibrium* $U_1(y - \tau, g) = U_2(y - \tau, g)$.

Note that the condition $U_1 = U_2$ is precisely the same as one of the first-order conditions for a full-information optimum, equation (10). Equation (10) implicitly defines the income expansion path $\tau = \phi(g)$, which passes through points I and J in Figure 2; $\phi' < 0$ since both c and g are normal goods. The unique undominated equilibrium is given by point C in Figure 2, where $g > g^*(\varepsilon^H)$ and $\tau < \tau^*(\varepsilon^H)$. This equilibrium has the property that signaling is "efficient" in the sense that no reallocation of expenditures between the private and public consumption goods can yield voters higher welfare.

C. *Pooling Equilibria*

Restricting attention to undominated equilibria is not sufficient to rule out all pooling equilibria. For example, if ρ is large enough, then $(g^L, \tau^L) = (g^H, \tau^H) = [g^*(\varepsilon^H), \tau^*(\varepsilon^H)]$; $\hat{\rho}(g^H, \tau^H) = \rho$, can be an equilibrium. To rule out all pooling equilibria (in pure and mixed strategies), it is necessary to further refine the equilibrium concept. Following Cho and Kreps (1987), an equilibrium $\{(g^L, \tau^L), (g^H, \tau^H)\}$ is *unintuitive* if there exists a point $(\bar{g}, \bar{\tau})$ such that[16]

$$Z(\bar{g}, \bar{\tau}, 1, \varepsilon^H) - Z[g^H, \tau^H, \hat{\rho}(g^H, \tau^H), \varepsilon^H] > 0, \tag{24}$$

and

$$Z(\bar{g}, \bar{\tau}, 1, \varepsilon^L) - Z[g^L, \tau^L, \hat{\rho}(g^L, \tau^L), \varepsilon^L] < 0. \tag{25}$$

PROPOSITION 3: *All pooling equilibria are unintuitive.*

One can easily confirm that the unique undominated separating equilibrium is also an intuitive equilibrium (i.e., not unintuitive). Henceforth, the term "equilibrium" refers to this equilibrium.

[15] Formally, a point $(\bar{g}, \bar{\tau})$ is dominated for a type i if $Z[g^*(\varepsilon^i), \tau^*(\varepsilon^i), 0, \varepsilon^i] - Z(\bar{g}, \bar{\tau}, 1, \varepsilon^i) > 0$. Dominated equilibria are ruled out by requiring that $\hat{\rho} = 1$ at points dominated for L but not H. (As a minor technical point, $\mathscr{B} \cap \mathscr{A}$ includes points weakly dominated for L but not dominated for H).

[16] Condition (24) states that a type H would prefer to select $(\bar{g}, \bar{\tau})$ over (g^H, τ^H) if, by doing so, he could convince the public of his true type. Condition (25) states that a type L would prefer to select (g^L, τ^L) and elicit voters' equilibrium response $\hat{\rho}(g^L, \tau^L)$, than to choose $(\bar{g}, \bar{\tau})$ even if $\hat{\rho}(\bar{g}, \bar{\tau}) = 1$.

V. Multiple Elections

The extension to the case of finitely many election periods is straightforward. In off-election years, the incumbent always follows his full-information fiscal policy. Voters are able to monitor the government perfectly with a one-period lag, so there is no incentive to distort in an off-election year. During election years, the signaling problem is the same as above, except that the gain to the incumbent of reelection, χ, becomes larger as the incumbent's expected term in office increases. The prospect of being able to run for reelection again in the future raises the temptation to distort fiscal policy, and thus tends to exacerbate the political budget cycle.

The equilibrium studied here remains an equilibrium when the time horizon is infinite. It is also possible, however, to have "reputational" equilibria in which there is little or no political budget cycle if (a) the leader's rate of time preference is close to one, (b) exogenous uncertainty (here the variance of q) is not too large, and (c) the time between elections is short.[17] In most countries, though, elections are typically spaced many years apart and there is considerable uncertainty over what factors will govern distant elections. Thus incumbents are not likely to place great weight on maintaining a reputation for not engaging in political budget cycles.[18]

VI. Alternative Approaches to Mitigating the Political Budget Cycle

If preelection signaling is truly a central cause of the political budget cycle, is there any way for society to mitigate the problem?

A. *A Constitutional Amendment to Restrain Election-Year Fiscal Policy*

One natural alternative is to reform the budget process so that the government cannot alter its fiscal policy rule just prior to an election. Edward Tufte (1978, p. 152), for example, suggests instituting a change in the timing of the congressional budget cycle. Let us consider a constitutional amendment which forces the government to set fiscal policy on a biennial basis, so that both (g_t, τ_t) and (g_{t-1}, τ_{t-1}) must be set in off-election year $t-1$. (The only relevant source of uncertainty here is the α shock but in interpreting the analysis below, one can think of the government as being allowed to index its fiscal policy rule to any publicly observable shock.) If forced to bind himself in $t-1$ to (g_t, τ_t), the incumbent would solve

$$(26)\quad \max_{g,\tau} E_{t-1}[W(g,\tau,\varepsilon_t)]$$
$$= \rho W(g,\tau,\alpha_{t-1}+\alpha^H)$$
$$+ (1-\rho)W(g,\tau,\alpha_{t-1}+\alpha^L).$$

Note that the incumbent is prevented from signaling because he does not have any information about his postelection competency type when setting election-year fiscal policy. The budget process reform thus mitigates the political budget cycle, but there are two costs. First, the public no longer has any way of distinguishing between H and L types when voting. If for simplicity we ignore the q shock, the mean cost of this lost information is $\rho\beta(\Omega^H - \Omega^O)$. The other cost is that the leader cannot employ his private information on α_t in setting period t fiscal policy.

The relative costs and benefits of the constitutional amendment are transparent in two extreme cases. If ego rents (X) are small, then the election-year fiscal policy distortions will be minor and the proposed budget process reform makes little sense. At the opposite extreme, as X becomes large, the political budget cycle takes on catastrophic

[17] Alesina (1987) has analyzed how reputation effects can mitigate partisan political business cycles, and John Ferejohn (1986) has considered how they can provide officeholders with incentives for taking into a account the wishes of the electorate; see also Rogoff and Sibert (1988), and Gregory D. Hess (1988).

[18] A caveat is that the government's reputation for engaging in political budget cycles may be intertwined with its general reputation for conducting a stable macroeconomic policy; see Rogoff (1989) for a survey of reputational models of macroeconomic policy.

dimensions. Indeed, the public may actually enjoy higher welfare during the election year itself when the incumbent is an incompetent type, since it is the competent type who distorts fiscal policy to signal his type. Nevertheless, a competent type is more likely to win reelection, since citizens vote for the candidate who offers them higher expected future welfare.

The preceding analysis, if anything, overstates the efficacy of trying to legislate away the political budget cycle. In practice, an incumbent has a wide array of fiscal actions with which he can signal, and it is not realistically possible to constrain him in all dimensions. If this is the case, then attempts to block signaling in one set of fiscal policy instruments will tend to exacerbate distortion in others. Indeed, attempts to suppress the political budget cycle may actually reduce the welfare of the representative citizen by inducing competent types to signal inefficiently.

As a simple example, consider a "balanced budget" constraint of the form

$$\tau = \Psi(g), \qquad \Psi' > 0. \tag{27}$$

Let us initially assume that $\Psi(g)$ passes through point I in Figure 2 and also through point M. Since $\Psi(g)$ passes through $[g^*(\varepsilon^L), \tau^*(\varepsilon^L)]$, this point remains the separating equilibrium choice of a type L. The undominated separating equilibrium strategy for a type H is now found by maximizing (23) subject to the *additional* constraint (27). At the solution point, labeled M in Figure 2, the welfare of the representative voter is unambiguously lower than at C, the equilibrium in the absence of the constraint.[19]

Suppose now that $\Psi(g)$ does not pass through point I, so that the constraint (27) also distorts the choice of a type L. Denote a type L's solution to his full-information problem (9), subject to the additional constraint (27), as $[g^{**}(\varepsilon^L), \tau^{**}(\varepsilon^L)]$, and define the set $\mathscr{A}^A$ as

$$\mathscr{A}^A \equiv \{(g,\tau) | Z(g,\tau,1,\varepsilon^L) - Z[g^{**}(\varepsilon^L), \tau^{**}(\varepsilon^L), 0, \varepsilon^L] \leq 0\}. \tag{28}$$

The separating equilibrium strategy for a type H is again found by maximizing (23) subject to the additional constraint (27), but now with the constraint $(g,\tau) \in \mathscr{A}^A$ in place of $(g,\tau) \in \mathscr{A}$. Note that $\mathscr{A}^A$ is a subset of $\mathscr{A}$; a type L is willing to distort further to convince the public he is a type H when his best alternative is the constitutionally constrained $[g^{**}(\varepsilon^L), \tau^{**}(\varepsilon^L)]$ than when it is the unconstrained $[g^*(\varepsilon^L), \tau^*(\varepsilon^L)]$. Thus the separating strategy for a type H will generally be at some point where voter welfare is even lower than at point M.

To summarize, if a budget process reform forces a pooling equilibrium, voters may or may not be better off, depending on the costs of the lost information versus the benefits of mitigating the political budget cycle. If, however, the incumbent can still find a way to use fiscal policy to signal, the budget process reform is likely to prove counterproductive. One interesting implication of this analysis is that having an independent central bank does not necessarily reduce the *welfare* costs of political budget cycles, even if it insulates monetary policy from election-year pressures.

B. *Endogenous Elections*

Until now, I have treated the timing of elections as immutable. In principle, the framework developed here can be extended to compare social welfare under different electoral structures. For example, in a regime with very short intervals between elections, incompetent leaders can be quickly removed from office. The drawback, of course, is that the political budget cycle will occur at correspondingly high frequencies (though it may be damped since fewer years of ego rents will be at stake in each election).

[19] For some specifications of $\Psi(g)$ there may not exist any separating equilibrium. Of course, no pure strategy pooling equilibrium can yield higher social welfare than the solution to (26).

An especially important alternative class of electoral structures involves giving the incumbent the *option* of calling for an early election. Indeed, many modern industrialized countries, including Canada, the United Kingdom, and Japan, have systems in which the timing of elections is endogenous. In practice, early elections are sometimes forced upon a ruling party after it loses its working majority in parliament. In some instances, however, an incumbent government opportunistically decides to risk its remaining time in office in hopes of winning a fresh new term. For opportunistic early elections, the model suggests that preelection fiscal policy distortions are likely to be less severe than for end-of-term elections. The basic reason is that the call for an early election can serve as an additional (non-distorting) signal.[20]

Recall from Figure 2 that the dashed ellipse bounds the fiscal policy distortions a type L would be willing to undertake to fool the public into thinking he is a type H. Of course, this curve is drawn under the assumption that a type L's best alternative is to choose his full information policy (point I), and hope that a very favorable looks shock carries him through the election. If a type L has the superior option of waiting a period before standing for reelection, then the option of calling for an early election and mimicking the fiscal policy of a type H becomes less attractive. By waiting to call an election, a type L not only gets to enjoy a certain extra period of ego rents, but also buys time to wait for a more favorable competency shock. As a result, a competent incumbent does not need to distort fiscal policy as much to separate himself when calling an early election. Indeed, he may not need to distort at all. To assess the overall welfare implications of allowing for early elections, one must trade off the benefits of having smaller distortions with the costs of having more frequent elections.

[20] For an interesting formal development of the case of endogenous elections, see Marco Terrones (1989a). Terrones shows that in the unique undominated equilibrium, the budget distortions accompanying early elections are damped.

Most cross-country empirical studies of political business cycles do not systematically distinguish between opportunistic early elections and end-of-term elections, but the above discussion suggests that the distinction may be important.[21]

C. *Self-Denial as a Signal of Competency*

Thus far I have been implicitly restricting the incumbent to signals which adversely affect all citizens and not just the incumbent himself. It is reasonable to ask whether the analysis thereby exaggerates the extent to which the incumbent will use socially destructive fiscal policy distortions to signal his competency.

Suppose, for example, that the incumbent can also signal by publicly destroying σ units of his own personal endowment of the private consumption good.[22] In this case, the incumbent's consumption is given by $c^I = y - \tau - \sigma$, and W in his objective function becomes

$$(29)\quad W^I(g,\tau,\sigma,\varepsilon) = U(y-\tau-\sigma, g) + \beta V(\tau+\varepsilon-g),$$

where $\sigma \geq 0$. Under full information, $\sigma^* = 0$, while g^* and τ^* are governed by (10) and (11) as before. Let $\tilde{Z}(g,\tau,\sigma,\hat{\rho},\varepsilon^i)$ be the same as Z in equation (18), except with W and $\hat{\rho}(g,\tau)$ replaced by W^I and $\hat{\rho}(g,\tau,\sigma)$.

It is straightforward to show that there exist equilibria in which a competent incumbent, by setting $\sigma^H > 0$, is able to sepa-

[21] Two important exceptions are Takatoshi Ito and Jin Hyuk Park (1988), and Terrones (1989b). In their study of Japan, Ito and Park find that the event of an early election does not seem to significantly impact monetary and fiscal policy. Instead, their results suggest that an incumbent government is more likely to call for an early election when recent growth and inflation performance have been strong.

[22] Milgrom and Roberts (1986) and Bagwell and Ramey (1988) model advertising by firms in a related fashion. In Bagwell and Ramey's setup, advertising is used in an undominated equilibrium only if it would have a direct positive effect on demand under full information.

rate himself without distorting fiscal policy as much as in any of the separating equilibria where $\sigma^H = 0$. In the (unique) *undominated* separating equilibrium, however, a type H sets (g^H, τ^H, σ^H) to solve

$$(30) \qquad \max_{g,\tau,\sigma} W^I(g,\tau,\sigma,\varepsilon^H)$$

$$\text{s.t. } g, \sigma, y - \tau - \sigma, \tau + \varepsilon^H - g \geq 0,$$

$$\text{and} \qquad (g,\tau,\sigma) \in \tilde{\mathscr{A}},$$

where

$$\tilde{\mathscr{A}} \equiv \{(g,\tau,\sigma) | \tilde{Z}(g,\tau,\sigma,1,\varepsilon^L) - \tilde{Z}[g^*(\varepsilon^L), \tau^*(\varepsilon^L), 0, 0, \varepsilon^L] \leq 0\}.$$

PROPOSITION 4: *In an undominated separating equilibrium,* $\sigma^H = 0$, *and* (g^H, τ^H) *solves* (23).

A type H incumbent could set $\sigma > 0$ to help signal his type, but by Proposition 4 he will always prefer to do it using fiscal policy alone. It is inefficient for a competent incumbent to signal by dissipating his personal resources, because he has no comparative advantage in that dimension.

Society could *force* the leader to dissipate $\bar{\sigma} > 0$ by requiring any incumbent who wants to run for reelection to pay a fee. It is easily shown that such a scheme can be welfare improving, but not by enough to attain the full-information equilibrium. A fee tends to distort a (selfish) leader's choice of tax policy, because it gives him a different tradeoff between private and public goods expenditure than the representative voter. But the most conspicuous drawback to this approach is that it would be very difficult in practice to find a rule for setting $\bar{\sigma}$, since incumbents differ greatly in wealth and future earning power.

Of course, if there were some way to reduce the leader's rents without causing him to distort fiscal policy, this would lead to the first-best outcome. Unfortunately, massive ego rents seem an inevitable by-product of the public goods production function.

VII. Conclusions

The present analysis preserves some of the basic insights of the Keynesian political business cycle model, albeit with significant refinements. Underlying the cycle in the model (for example, William Nordhaus, 1975) is a Keynesian Phillips curve and voter myopia. By increasing money supply growth in the year prior to an election, an incumbent national leader is able to temporarily raise output and employment.[23] Voters respond positively, not recognizing that after the election inflation will rise while output and employment will return to their natural rates. This story has two conspicuous failings. First, elections are perfectly anticipated events, so any systematic accompanying rise in money growth should not have any real effects. Second, preelection macroeconomic policy is a given by the time of the election, and voters' decisions should be governed only by which candidate offers them higher expected postelection welfare.

The Keynesian theory has generated a plethora of empirical studies aimed at testing for electoral cycles in national output, unemployment, and inflation. In light of the theoretical weaknesses of the underlying model, perhaps it should not be too surprising that the results have been mixed.[24] The equilibrium political budget cycle theory suggests that it would be more promising to focus empirical research on testing for electoral

[23] It may be possible to extend the present model to generate electoral cycles in employment. If taxes distort the labor-leisure decision, then one might expect labor supply to rise during election years when tax rates are low.

[24] Bennett T. McCallum (1978), David G. Golden and James Poterba (1980), and Nathaniel Beck (1987), among others, have suggested that there is little empirical evidence of a political business cycle in U.S. inflation and unemployment. Recently, however, Kevin B. Grier (1987), and Stephen E. Haynes and Joe A. Stone (1989) have offered a very different interpretation of the data. They argue that if one does not place arbitrary restrictions on the economy's dynamic structure, then one finds significant evidence of political business cycles. Haynes and Stone note that their test cannot discriminate between the classical political business cycle theory and the equilibrium political budget cycle theory.

cycles in taxes, transfers, and government consumption spending.[25] For these variables, one can also look at data for state and local elections, instead of concentrating solely on the small number of observations available for national elections.

In addition to focusing on different variables, the present model also offers sharper prediction concerning the dynamic structures of the cycle. Here the pre- and postelection values of observable fiscal policy variables tend to be *positively* correlated (when variables are measured in deviations from pre- and postelection means). Competent incumbents, who have greater leeway to cut taxes and raise government consumption spending prior to elections, are more likely to be able to do so after elections as well. The model here also has concrete implications for the nature of political budget cycles under alternative electoral structures. For example, in countries where the incumbent has the option of calling for early elections, the budget distortions which accompany opportunistic early elections tend to be damped compared to those accompanying end-of-term elections.

Does the political budget cycle theory have any bearing on countries such as Mexico and Japan, in which a single party dominates political life? Even in dominant-party systems, the country's leaders still generally care about their party's margin of victory. Its plurality not only affects the leaders' ability to govern the populace, but also their ability to contain internal dissent within the party. (The formal model above is easily extended to the case where plurality matters). The model should also retain some relevance in situations where competing parties share power (for example, if the majority party in the legislature is Democratic and the President is Republican). Although each of the parties may care about increasing its representation in the government, individual legislators have a strong common interest in their own reelection.

[25] Tufte (1978) finds that in the United States, transfers rise significantly prior to presidential elections; see also Alesina (1988) and Eric Ghysels (1988). In their study of U.S. federal taxes for the years 1879–1986, Bizer and Durlouf (1989) conclude that taxes are typically reduced two years prior to successful presidential reelection attempts. Using data from twelve industrialized countries., Alesina (1989) presents evidence that federal government budget deficits tend to rise prior to elections.

Appendix

This Appendix provides the proofs of Propositions 2, 3, and 4.

Proof of Proposition 2. Given the Inada conditions on U and V, any solution to (23) must have $c, g, k > 0$. Thus the Kuhn-Tucker conditions reduce to

$$\text{(A1)} \qquad U_1 - \beta V_H' = \lambda(U_1 - \beta V_L'),$$

$$\text{(A2)} \qquad U_2 - \beta V_H' = \lambda(U_2 - \beta V_L'),$$

$$\text{(A3)} \quad \chi^L \pi(0) + W^*(\varepsilon^L) - \chi^L \pi(1) - U(y - \tau, g) - \beta V(\tau + \varepsilon^L - g) \geq 0, \quad (= 0 \text{ if } \lambda > 0),$$

where $V_i' \equiv V'(\tau + \varepsilon^i - g)$. (A1) and (A2) imply that $U_1 = U_2$. This equation governs the downward-sloping income extension path $\tau = \phi(g)$ in Figure 2. (A3) is the constraint $(g, \tau) \in \mathscr{A}$, the set of points on or outside the dashed ellipse. Assume that $\lambda > 0$ so that (A3) is binding. Equations (A1)–(A3) are then satisfied at exactly two points. At point C in Figure 2, $\beta V_i' > U_1$, $i = H, L$, and $\lambda = (U_1 - \beta V_H')/(U_1 - \beta V_L') < 1$. At point F, $\beta V_i' < U_1$ and $\lambda > 1$. One can show that the second-order conditions hold if

$$\text{(A4)} \quad (1 - \lambda)[2U_{12} - U_{11} - U_{22}](U_1 - \beta V_L')^2 > 0.$$

Since all goods are normal, $2U_{12} - U_{11} - U_{22} > 0$. Thus (A4) holds only at point C.

Proof of Proposition 3. Suppose (g^z, τ^z) is any point selected with positive probability by both types. Let

$$R^i(g, \tau) \equiv Z(g, \tau, 1, \varepsilon^i) - Z[g^z, \tau^z, \hat{\rho}(g^z, \tau^z), \varepsilon^i], \qquad i = L, H.$$

Select the pair $[\bar{g}, \phi(\bar{g})]$ such that (a) $\phi(\bar{g}) - \bar{g} < \tau^*(\varepsilon^H) - g^*(\varepsilon^H)$, and (b) $R^H[\bar{g}, \phi(\bar{g})] = 0$. Given that $V(0) = -\infty$ and $\pi(1) > \pi(\hat{\rho})$, such a pair exists and is feasible. Note that $\phi(\bar{g}) - \bar{g} < \tau^z - g^z$ since $U[y - \phi(g), g] \geq U(y - \tau^z, g^z)$ if $\phi(g) - g = \tau^z - g^z$. Then since $V'' < 0$, it follows that $R^L[\bar{g}, \phi(\bar{g})] < 0$. Thus by the continuity of R^i, $\exists\ \delta > 0$ such that $R^H[\bar{g} - \delta, \phi(\bar{g} - \delta)] > 0$ and $R^L[\bar{g} - \delta, \phi(\bar{g} - \delta)] < 0$.

The geometric intuition is that there must always exist some point on $\tau = \phi(g)$ sufficiently far southeast of J in Figure 2 such that both (24) and (25) hold. (Note in the absence of the q shock, $\pi(1)$ is not necessarily greater than $\pi(\hat{\rho})$, and the intuitive criterion is not generally sufficient to rule out all pooling equilibria).

Proof of Proposition 4. Any solution to (30) satisfies Kuhn-Tucker conditions analogous to (A1)–(A3), plus the additional conditions

$$(A5) \qquad (\lambda - 1)U_1 + \mu \leq 0 \quad (= 0 \text{ if } \sigma > 0),$$

$$(A6) \qquad \sigma \geq 0 \quad (= 0 \text{ if } \mu > 0).$$

Assume in contradiction to the proposition that $\sigma > 0$. Then $\mu = 0$, (A5) must hold with equality and hence $\lambda = 1$. But then (A1) and (A2) require that

$$V'(\tau + \varepsilon^H - g) = V'(\tau + \varepsilon^L - g),$$

which is impossible. Thus $\sigma = 0$ and the solution to (30) is the same as to (23).

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