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Incorporating Policymaker Costs and Political Competition into Rent-Seeking Games

R. Kenneth Godwin,* Edward J. López,† and Barry J. Seldon‡

We incorporate policymaker costs of supplying rents and variable intensities of competition among rent seekers into the standard rent-seeking game. By incorporating these aspects, the game has greater verisimilitude to the lobbying process. The first aspect captures the fact that in rent-seeking contests there is a positive probability that neither firm will obtain the rent. The second aspect captures the fact that firms seeking different rents still must compete for policymakers' resources. We find that lobbying expenditures, rent-seeking profits, and rent dissipation depend on the intensity of competition and the value of the rent relative to policymaker costs. For example, if the value of the rent is sufficiently high relative to policymakers' costs, an increase in the intensity of political competition will increase lobbying expenditures; otherwise, expenditures fall as competitive intensity increases. In addition, the model establishes pure-strategy equilibria with underdissipation where only mixed-strategy equilibria exist in the standard model.

JEL Classification: D72, H42, L51

1. Introduction

Rent seeking in politics involves agents who lobby policymakers for potential benefits. In a seminal contribution, Tullock (1980) modeled rent seeking as a lottery game. A major weakness of Tullock's game was that it lacked verisimilitude to actual rent seeking because it omitted politics. The absence of politics meant that the game essentially assumed that there are no costs to the policymakers of supplying rents. But as Tollison (1997) and others have pointed out, these costs are not zero, and the politics surrounding the policy decision influence the pattern of lobbying and the rent-seeking outcome. In this paper we address two aspects of those politics: the costs to policymakers of supplying rents and the variable intensity of political competition among a given number of rent seekers. Including these aspects increases the similarity of the game to actual rent-seeking situations and makes clearer the incentives to rent seekers.

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Costs to supplying rents arise due to various constraints. Legislators must build coalitions, acquire parliamentary rights, maintain a positive image, and service constituent interests. Policymakers in agencies must follow procedural rules, submit to congressional oversight and budgeting, pass OMB reviews, and so forth. Lower policymaker costs should increase the effectiveness of lobbying, and this should attract greater lobbying efforts among rent seekers.¹ Increasing policymaker costs makes lobbying less effective. Indeed, because of these costs policymakers often turn away lobbies empty-handed. In short, policymakers have constraints that affect the policies they design, and this affects lobbying expenditures (Dougan and Snyder 1993). This paper introduces policymaker costs in monetary units, such that they are comparable to the value of the rent and rent-seeking expenditures.

Political competition among rent seekers also influences the rent-seeking outcome. Competition traditionally has been modeled by varying the number of rent-seeking agents (actual or potential) or their relative lobbying expenditures (e.g., Posner 1975; Rogerson 1982; Sun and Ng 1999). Competition can vary, however, even among a given number of rent seekers and for a given profile of expenditures. For example, two agents may lobby a policymaker for the same unique and exclusive political good. Then one agent directly opposes the other and only one agent can win the good. Alternatively, the same two agents may lobby a policymaker for two separate political goods. In that case, the agents oppose each other only indirectly. This situation is frequent in politics as rent-seeking agents compete for space on the political agenda, for policymakers' time, and for portions of a particular government budget. In this situation, success by one agent does not necessarily result in failure by the other, but it does lower the probability that the other agent will succeed. Competition is more intense in the first example, even though the examples involve the same number of firms. Industrial organization economists have shown that a single parameter can determine incumbent firms' competition in price and quantity regardless of the number of firms present.² This paper introduces rent-seeking competition analogously, allowing a parameter to alter the competitiveness of the rent-seeking game among a fixed number of firms.

We incorporate monetized policymaker costs and the political competition parameter into the success probabilities of the standard rent-seeking game. The resulting model is a game in which the agents' simultaneous maximization of expected net returns (or profits) determines a Nash equilibrium in their expenditures. Incorporating politics into the standard game makes the game more accurate because equilibrium and comparative statics depend in part on the politics of the rent-seeking contest. More specifically, increasing political competition decreases rent-seeking expenditures unless the value of the rent is sufficiently large relative to policymaker costs; and dissipation rates are lower than in previous research because of policymaker costs. Furthermore, under increasing returns to expenditures there is a unique pure-strategy equilibrium with underdissipation of rents, unlike the standard game, which has stochastic mixed-strategy equilibria with overdissipation occurring about half the time.

Intuitively, in the model incorporating politics, rent seekers will avoid competition with each other, search for low-cost providers of political goods, and generally avoid overdissipation. With such implications, our model extends the Tullock game in a political-economic sense, reaching more empirically reasonable results than previous models.

¹ Organized interests concentrate campaign contributions on legislators with greater parliamentary power over their issue set (Grier and Munger 1991; Kroszner and Stratmann 1998).

² The magnitude of a single variable, the conjectural variation, determines whether two firms act as if they are competitive firms, pricing at marginal cost, or if they act as a cartel, maximizing their profits as would a multiplant monopolist (see Waterson 1984 for a concise discussion).

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2. The Standard Rent-Seeking Model³

Following Tullock (1980), consider two agents competing for a private good with expenditures R_1 and R_2 and success probabilities

$$P_1 = \frac{R_1^\sigma}{R_1^\sigma + R_2^\sigma} \quad \text{and} \quad P_2 = \frac{R_2^\sigma}{R_1^\sigma + R_2^\sigma},$$

where $P_1 + P_2 = 1$, which implies that one agent must win. σ indicates "returns to scale" in expenditures; for example, if $\sigma > 1$, then an increase in R_i , *ceteris paribus*, causes a more than proportionate increase in agent i 's probability of winning.⁴ If σ is the same for both agents, then the game is "unbiased": the agents are equally suited to rent seeking. Tullock reasoned that if $\sigma = 2$ and $n = 2$ in an unbiased game, then combined symmetric expenditures would equal the value of the prize. Following convention, we call this "exact dissipation." But if $\sigma > 2$ for two agents (or $\sigma > n/(n-1)$ for n agents), Tullock reasoned that total spending in an unbiased game will always exceed the value of the rent, and this usually will occur in biased games. This result is "overdissipation" and forms the basis of Tullock's social waste argument.

Many game theorists were attracted to Tullock's curious result, and most of the rent-seeking models that followed attempted to rule out overdissipation in equilibrium. New contributions emerged with increasing complexities, such as open-ended sequential games, uncertain prizes, risk-averse rent seekers, budget constraints, entry conditions, and various sharing rules for groups of winners. As a consequence, this literature formalized and generalized Tullock's reasoning.⁵ By incorporating policymaker costs and political competition into the basic model, this paper formalizes the idea that rent seeking takes place within a political context that influences patterns of rent seeking and the outcomes observed (Tollison 1997). The model suggests a more politically realistic solution to overdissipation.

3. Rent Seeking with Policymaker Costs and Political Competition

In previous formulations of rent-seeking contests, players' success probabilities are related *only* to their relative lobbying expenditures, regardless of the value of σ . It has been noted in several places (e.g., Baye, Kovenock, and de Vries 1994; Che and Gale 1997) that if σ is finite, then the game is a lottery; and if $\sigma \rightarrow \infty$, then the game is an all-pay auction. For any finite value of σ , the chances of player i 's success increase directly with expenditures R_i . In the lottery, the winner is selected according to probabilities; in the all-pay auction the winner is the highest bidder. Such an approach assumes a costless political process. In contrast, define $N \in (0, \infty)$ as the monetized disutility to the policymaker of providing the rent. Thus conceived, the policymakers' costs may be influenced by any number of institutional factors. For instance, N may depend on the political body that is lobbied. For middle-level regulatory waivers, there may be a small number of policymakers involved, little formal oversight, and negligible lobbying opposition—in this case N may be close to zero. Alternatively, for major legislative changes in which a winning coalition must form against powerful opposition and

³ We refer to the class of games that follow the approach based on Tullock's (1980) lottery game as the "standard model." We do not intend to implicate other branches of the literature that have incorporated politics such as the theory of regulation (Stigler 1971; Peltzman 1976; McCormick and Tollison 1981; Becker 1983) or various empirical approaches that are too numerous to list here (Tollison 1997 provides an up-to-date survey).

⁴ σ does not indicate returns to scale as usually defined, but we maintain this terminology of the literature.

⁵ For a compilation of this literature, see Lockard and Tullock (2001).

re-election constraints, N may be very high. Policymaker costs also could depend on the selection of a voting rule—majority rule would have a lower N than would a supermajority rule. Stronger checks and balances also affect policymaker costs: for U.S. style judicial review, N may be moderate, but for Swiss style legislative referendum, N may be much higher (Moser 2000; Spindler and de Vanssay 2003). Individual policymakers can have different values of N , depending on their regulatory/parliamentary power over a policy (Denzau and Munger 1986; Grier and Munger 1991). Public perception may help to determine N if it involves a policy that would attract substantial negative media attention to the policymaker(s).

Consider next the nature of competition among rent seekers. It may depend on the number of rent seekers and entry conditions, as demonstrated in many contributions to both the empirical and theoretical rent-seeking literature. However, political competition can also emerge among a given number of rent seekers. For example, two firms may compete for a single contract to produce tires for government vehicles. If only one firm can receive the contract, the success of a firm completely precludes the success of its rival. In this case, political competition is high. In contrast, suppose two defense contractors are lobbying to increase the price each receives for weapons sold to the government. If one firm's success in obtaining a price increase has little impact on the probability that the other firm will also obtain an increase, then political competition is low. If, however, policymakers face a tight budget constraint, then one firm's success can significantly affect the other firm's probability of obtaining its objective, and the competition between them is higher. Nevertheless, competition would be less than between firms bidding for the same rent if only one can succeed. To introduce this concept of political competition into the model, we define $\alpha \in (0, 1]$ as an index of competition that increases with the degree of competition in the contest.

For the moment, suppose that there are two players, Firm 1 and Firm 2, which incur expenditures R_1 and R_2 in lobbying to acquire a rent of value V to each firm, and that $\sigma = 1$.⁶ We express the probabilities of success or failure for Firm i , where $i = 1, 2$ and, in the following, $i \neq j$, as

$$P_i = \frac{R_i}{R_i + \alpha R_j + N} = \text{probability that Firm } i \text{ receives the good;} \quad (1)$$

$$1 - P_i = \frac{\alpha R_j + N}{R_i + \alpha R_j + N} = \text{probability that Firm } i \text{ fails to receive the good,} \quad (2)$$

where it is possible that *neither* firm will succeed, and where α represents the degree of competition between the rent seekers. If $\alpha < 1$, there are four possible ex-post states of the world: (1) both firms may succeed in their lobbying; (2) both firms may fail; (3) Firm 1 may succeed and Firm 2 may fail; and (4) Firm 1 may fail and Firm 2 may succeed. The competition parameter α signifies the importance to Firm i of Firm j 's lobbying expenditures. The higher α is, the more Firm j 's expenditure reduces Firm i 's probability of success. At the upper bound, if $\alpha = 1$ and Firm i succeeds, then Firm j will fail. Here there are three possible outcomes: (1) Firm 1 may win, in which case Firm 2 fails; (2) Firm 2 may win, so Firm 1 fails; and (3) both firms may fail.⁷ When $\alpha = 1$, the expenditure of a firm that increases its probability of success has a very deleterious effect on the other firm's probability of winning. In contrast, if one firm's success does not preclude the other firm's success, α takes a value

⁶ Different valuations of the rent to the two firms are plausible but would not change our main results. We discuss the implications of different valuations below. Similarly, we consider different values of σ below.

⁷ If $\alpha = 1$, we have an extension of the standard game because, in that case, probability (2) is the sum of the probability that Firm j receives the good, expressed as $R_j/(R_i + R_j + N)$, and the probability that neither firm receives the rent, expressed as $N/(R_i + R_j + N)$. Adding the probability that Firm i receives the rent, expressed as $R_i/(R_i + R_j + N)$, we have three probabilities that sum to one. Alternatively, if $\alpha < 1$, each firm has a probability of success and a probability of failure. In this case, there are four probabilities.

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less than 1. For lower values of α , the probability of Firm i 's success is higher for any given R_j . At the lower bound, if $\alpha = 0$, there is no effect at all of one firm's expenditures on the other firm's success probability: because $\alpha = 0$ the rival's term disappears from the probability equations. Because we are interested in rent-seeking competition, however, we bound α away from 0.

Obviously, Probabilities (1) and (2) sum to one and each firm's success probability increases as the firm spends more. These features carry over from the standard game. For any $N > 0$, P_i and P_j are less than one; thus there is a positive probability that neither firm wins the rent. For an increase in N , there is a decrease in the probability of each firm's success and, therefore, an increase in the probability that neither wins. Finally, the standard game is a special case of our model, in which $\alpha = 1$ and $N = 0$.

4. The Model

We model two agents (viz., firms) in a simultaneous game. The firms maximize expected net returns from lobbying, which we refer to simply as "profits." Let $V > 0$ be the value of the rent to the firm. For now, we assume these benefits to be equal for both firms so that their problems are identical. We also assume that the firms are equally adept at lobbying. Thus, for $i, j = 1, 2$ each firm maximizes expected profits, the difference between expected returns and the cost of lobbying, by

$$\max_{R_i} \Pi_i = \left[\frac{R_i}{R_i + \alpha R_j + N} \right] V - R_i, \tag{3}$$

where the expenditure terms are linear. We need only include the probability of the firm succeeding in lobbying in expected profits. Thus Equation 3 expresses the expected profit in the less competitive case, where $\alpha \in (0, 1)$, as well as in the highly competitive case, where $\alpha = 1$, so $\alpha \in (0, 1]$, despite the different numbers of ex-post states of the world. The first-order condition equates marginal expected returns to marginal cost, so

$$\frac{\partial \Pi_i}{\partial R_i} = \left[\frac{\alpha R_j + N}{(R_i + \alpha R_j + N)^2} \right] V - 1 = 0. \tag{4}$$

The second derivative is negative, so the solution to Equation 4 maximizes profits.⁸ Of course, if the value of V were small enough relative to political costs N , then firms would not lobby. We make the following

ASSUMPTION 1: $V > N$.

This will be sufficient to ensure that the firms have the incentive to make expenditures in seeking the rent.

Equation 4 implicitly yields the profit-maximizing level of R_i ; and defining the set containing any $R_i \geq 0$ that satisfies profit maximization as the firm's best reply, ρ_i , results in the best reply function

$$\rho_i = \begin{cases} \sqrt{(\alpha R_j + N)V} - \alpha R_j - N & \text{for } 0 \leq R_j \leq \frac{(V-N)}{\alpha} \\ 0 & \text{for } \frac{(V-N)}{\alpha} < R_j \end{cases} \tag{5}$$

The proof that Equation 5 is the best reply function is in Appendix A. There, we show that $\Pi_i \geq 0$ on Equation 5, so the profit-maximizing firm does not incur an expected loss on the best reply function,

⁸ The second derivative is $-2(\alpha R_j + N)/[(R_i + \alpha R_j + N)^3]V < 0$ because $R_j \geq 0$ and V, α, N are all positive.

and that the best reply function is strictly concave over $R_j \leq (V - N)/\alpha$, which is useful later in establishing equilibrium.

In Appendix B we show that the exact shape of Firm i 's best reply function depends on the value of V relative to N . For $V \leq 4N$ (so the value of the rent is relatively small compared with policymakers' costs), ρ_i is monotonically decreasing in R_j , and the firm would reduce lobbying expenditures as its rival's expenditures increase; in essence acquiescing to its rival because the rent is not worth the fight. But if $V > 4N$, then ρ_i has an interior maximum at $R_j = (V/4 - N)/\alpha$, so if the rent is relatively valuable there is a range over lower levels of the rival's expenditures in which the firm's expenditures increase with that of its rival's. The firm is willing to challenge the rival to gain the relatively valuable rent.⁹

Because the shape of ρ_i depends on the relative values of V to N , equilibrium also depends on the relative values. In Appendix C, we provide existence and uniqueness proofs for the equilibrium when $V \leq 4N$.¹⁰ For all $V > 4N$, there likely exists a unique equilibrium, but we can only prove uniqueness for $4[(1 + \alpha)/\alpha]^2 N > V > 4N$. It is possible that three equilibria might exist if V is even larger than $4[(1 + \alpha)/\alpha]^2 N$, but we have been unable to construct a numerical example of such a game, and we doubt that one exists. Examples of best reply functions and equilibria are shown in Figure 1, where Figure 1A has $V < 4N$, Figure 1B has $4[(1 + \alpha)/\alpha]^2 N > V > 4N$, and Figure 1C has $V > 4[(1 + \alpha)/\alpha]^2 N > 4N$, with a unique equilibrium. Stability is indicated by the directional arrows in the figures. Figure 1D shows the possibility of multiple equilibria, but the arrows indicate that the symmetrical equilibrium is the only stable equilibrium.

In Appendix D, we show that Firm i 's lobbying expenditure in a symmetrical equilibrium is

$$\rho_e = \frac{\sqrt{4(1 + \alpha)NV + \alpha^2 V^2} + \alpha V - 2(1 + \alpha)N}{2(1 + \alpha)^2}, \tag{6}$$

where the e subscript denotes equilibrium. By substituting Equation 6 into the profit Equation 3, we can express equilibrium firm profit as

$$\Pi_i^e = \left[\frac{\rho_e}{\rho_e + \alpha\rho_e + N} \right] V - \rho_e, \tag{7}$$

where $\rho_e = \rho_e(V, N, \alpha)$ for both firms.

5. Comparative Statics

We next consider the comparative statics of expenditures and profits with respect to competition. First, we show the effect of competition on equilibrium lobbying expenditures. In Appendix E we prove

THEOREM 1: (1) If $V/4 \leq N$, then $\partial\rho_e/\partial\alpha < 0$ at all levels of $\alpha \in (0,1]$. (2) If $V/4 > N$, then $\partial\rho_e/\partial\alpha$ is greater than, equal to, or less than 0 as α is less than, equal to, or greater than $(V - 4N)/V$ or, equivalently, as $(1 - \alpha)V/4$ is greater than, equal to, or less than N .

This suggests that if the value of the rent is sufficiently small relative to N , then equilibrium

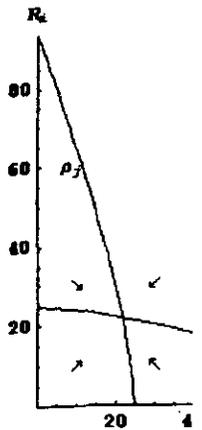


Figure 1A: where $V = 10$

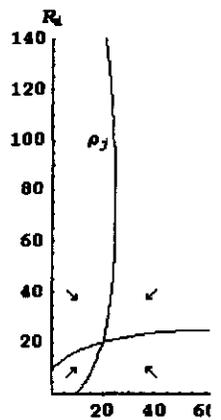


Figure 1C: where $V = 10$

Figure 1. The shape of

lobbying expenditure then there is a range of competition increases and in Figure 1B, (these figures, lobby Figure 1C, (1 - alpha) equilibrium, the eq Intuitively, on expenditures. This entry conditions to however, predicts

⁹ These changes in the firm's expenditures are hypothetical, being based on its rival's action. The equilibrium is static, but the intuition concerning the shape of the reaction function seems reasonable and lends credence to the model.

¹⁰ We cannot use the existence and uniqueness proofs from Esteban and Ray (1999), which depend on a thrice continuously differentiable, strictly concave cost function. In this section, cost is linear.

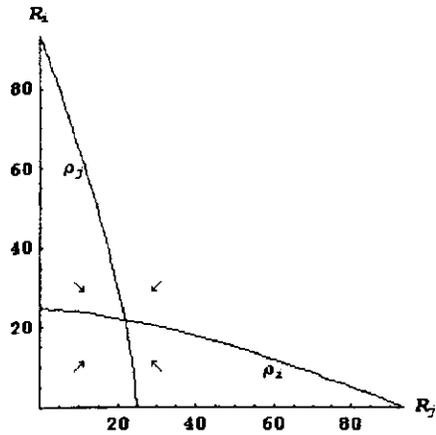


Figure 1A: Case of $V < 4N$
where $V = 100$; $N = 30$; $\alpha = 3/4$

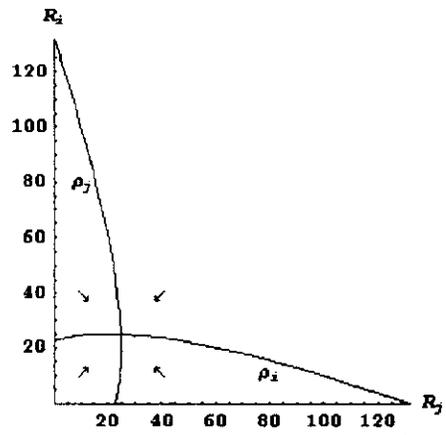


Figure 1B: Case of $4[(1 + \alpha)/\alpha]^2 N > V > 4N$
where $V = 100$; $N = 12$; $\alpha = 2/3$

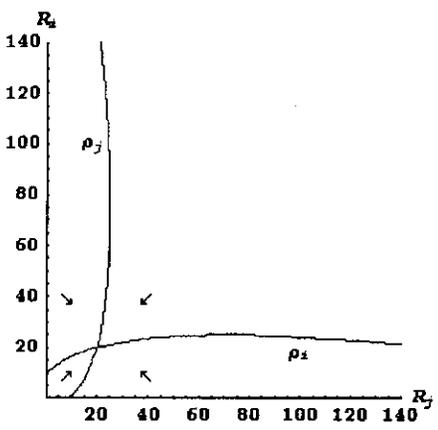


Figure 1C: Case of $V > 4[(1 + \alpha)/\alpha]^2 N > 4N$
where $V = 100$; $N = 1$; $\alpha = 1/3$

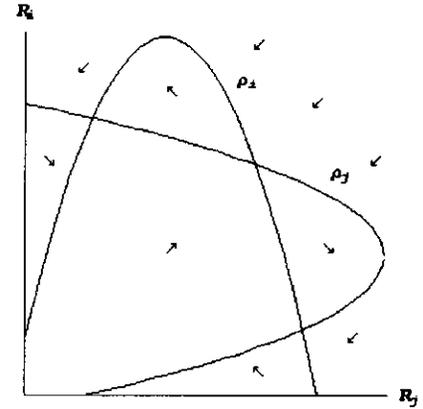


Figure 1D: Possible Case of $V > 4[(1 + \alpha)/\alpha]^2 N > 4N$?
Unproven Possibility of Multiple Equilibria

Figure 1. The shape of reaction functions, equilibrium, and stability.

lobbying expenditures will fall as competition increases, while if V is sufficiently large relative to N , then there is a range where N is sufficiently small that equilibrium lobbying expenditures will rise as competition increases before they begin to fall at higher levels of competition. In Figure 1A, $V/4 < N$, and in Figure 1B, $(1 - \alpha)V/4 < N$, so the equilibrium would move toward the origin if α increases. In these figures, lobbying expenditures are strategic substitutes in the neighborhood of equilibrium. In Figure 1C, $(1 - \alpha)V/4 > N$, where expenditures are strategic complements in the neighborhood of equilibrium, the equilibrium would move away from the origin.

Intuitively, one might expect that as competition increases, so would the equilibrium lobbying expenditures. This view finds support in some previous models that rely on the number of firms or entry conditions to model competition (Posner 1975; Rogerson 1982; Sun and Ng 1999). Our model, however, predicts that the effect of competition depends on the value of the rent relative to the

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political costs of supplying the rent. Greater competition *decreases* expenditures if $V \leq 4N$ and for lower levels of α where $V > 4N$. This result is in line with empirical research in political science, which indicates that firms lobby policymakers on issues with a low N , such as requesting a rent that is consistent with the officials' ideology and/or constituency interests or has low visibility, and on issues over which there is little competition (small α) (Lowi 1969; Browne 1995; Wolpe and Levine 1996). This also reflects the empirical result in economics that campaign contributions are more likely to "buy votes" on narrow issues with concentrated benefits and dispersed costs than on broader issues (Stratmann 1991, 1995). In other words, firms look for issue niches where their rent-seeking activities are unlikely to conflict with other firms' activities, and the granting of the good will not offend other interests (Evans 1991; Hojnacki and Kimball 1998). Finally, this parallels earlier theoretical results that the dissipation rate can decrease as the number of firms increases (e.g., Baye, Kovenock and de Vries 1993). Greater competition causes an *increase* in spending only when the rent is very valuable compared with the political costs involved.

Next, we consider the effect of competition on expected profits. The envelope theorem is not applicable (Nti 1997). In Appendix F we show that if V is sufficiently large relative to N , then $\partial \Pi_i^e / \partial \alpha$ is unambiguously negative. Beyond this it becomes difficult to sign $\partial \Pi_i^e / \partial \alpha$, but numerous graphs of equilibrium profit for many relative values of V and N invariably show the profit to be decreasing in α and strictly convex over $\alpha \in (0, 1]$.¹¹

6. Dissipation When $\sigma = 1$

In the standard model, underdissipation occurs if $\sigma = 1$. Baye, Kovenock, and de Vries (1994) showed that if $\sigma = 1$, the equilibrium dissipation rate is $V(n - 1)/n$, or simply $V/2$ in the two-player case. In contrast, our model predicts less than 50% dissipation almost everywhere on the best reply function. To see this, first note that the two firms' combined lobbying expenditures sum to

$$\rho_T = 2\rho_e = \frac{\sqrt{4(1 + \alpha)NV + \alpha^2 V^2} + \alpha V - 2(1 + \alpha)N}{(1 + \alpha)^2},$$

so the derivative of the firms' total lobbying expenditures with respect to N is

$$\frac{\partial \rho_T}{\partial N} = \frac{2(1 + \alpha)V(\sqrt{4(1 + \alpha)NV + \alpha^2 V^2})^{-1} - 2(1 + \alpha)}{(1 + \alpha)^2}. \tag{8}$$

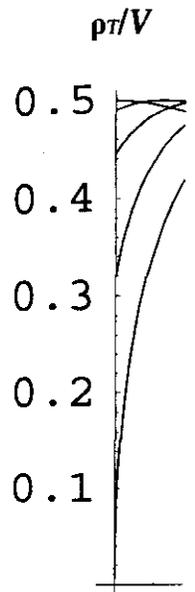
The second derivative is obviously negative because N appears only in the inverted radical in the numerator of Equation 8, so the derivative is strictly concave in N . Then $\partial \rho_T / \partial N = 0$ (so ρ reaches a maximum) when the numerator equals zero. At this point, $N = (1 - \alpha)V/4 \geq 0$.¹²

Given the preceding, we prove that total lobbying expenditures are less than $V/2$ almost everywhere.

THEOREM 2: For any N and α , the firms' total lobbying expenditures, $\rho_T = 2\rho_e$, are less than $V/2$ everywhere except at the point where $N = (1 - \alpha)V/4$.

¹¹ Nti (1997) completely derived comparative statics for a game similar to ours, but he was able to do so because he did not have nonmonotonicities in the derivatives of expenditures with respect to the parameters.

¹² To see this, set the numerator of Equation 8 equal to zero and simplify to get $V[4(1 + \alpha)NV + \alpha^2 V^2]^{-1/2} = 1$. From this, it follows that $V = [4(1 + \alpha)NV + \alpha^2 V^2]^{1/2} \Rightarrow V^2 = 4(1 + \alpha)NV + \alpha^2 V^2 \Rightarrow N = (1 - \alpha)V/4 \geq 0$.



Note: ρ_T/V is the
Figure 2. Dissipation

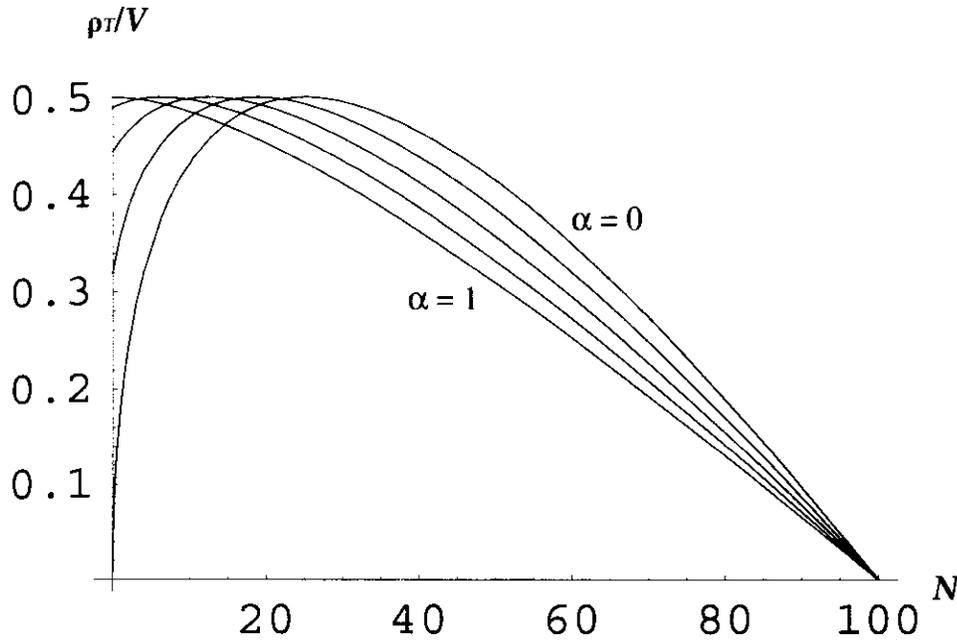
PROOF: See A

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¹³ In other words, becau
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Note: ρ_T/V is the dissipation rate, and $V = 100$. Each curve corresponds to a different α .

Figure 2. Dissipation rate as a function of policymakers' costs for various values of α .

PROOF: See Appendix G.

Thus, firms will spend less than in the standard model except at a point of measure zero.¹³ This is so for two reasons. First, for $N < (1 - \alpha)V/4$, political costs are low enough that firms do not have to spend very much relative to the size of the rent. For $N > (1 - \alpha)V/4$, rising political costs lower the probability of firms being able to gain the rent, thereby causing equilibrium rent dissipation to decrease, approaching zero as $N \rightarrow V$. Figure 2 demonstrates the effects of policymaker costs on dissipation under various degrees of competition. Here, $V = 100$ and the dissipation rate (or ρ_T/V) is plotted over $N \in (0, V)$ for selected values of α . Recall that the standard game is a special case of our model in which $\alpha = 1$ and $N \rightarrow 0$; at this point in Figure 2 the dissipation rate is 50% and decreases monotonically with increases in N . For other values of α , the dissipation rate is maximized at 50% at $N = (1 - \alpha)V/4$. For any value of α , the dissipation rate is less than 30% for about half the range of $N \in (0, 100)$.

These results are highly intuitive. Policymakers with low costs require relatively small rent-seeking outlays as long as the level of competition is low. As policymakers' costs increase, however, so must lobbying. But for sufficiently high policymaker costs, where $N \geq (1 - \alpha)V/4$, continued lobbying efforts become less profitable. Firms' expenditures decline to zero as $N \rightarrow V$. This reflects the property that lobbying a legislator with parliamentary rights over a policy area is worth more than lobbying other legislators. Similarly, agents are less likely to lobby policymakers with a predisposition against the policy.

We derived our preceding results under the assumption that benefits are equal for both firms.

¹³ In other words, because N and V are continuous real variables, the *a priori* probability of N being equal to $(1 - \alpha)V/4$, so firms spend as much as in the standard model, is zero.

Unequal benefits would result in unequal profits and expenditures (the firm with the higher valuation would spend more). However, this would not damage our qualitative results as long as we change Assumption 1 to

ASSUMPTION 2: $\min\{V_1, V_2\} > N$.

7. Cases of $\sigma > 1$ and $\sigma > 2$: Increasing Returns

As discussed in Section 2, the case of $\sigma > n/(n - 1)$ drew attention in the literature following Tullock (1980) because total spending exceeded potential rents. Baye, Kovenock, and de Vries (1999) suggested that spending zero dominates such an equilibrium, and showed that the standard game has a pure-strategy equilibrium if and only if $\sigma > n/(n - 1)$. However, overdispersion occurs in mixed strategies roughly half the time (Baye, Kovenock, and de Vries 1999). To consider increasing returns in the model incorporating politics, we generalize the profit maximization problem to

$$\max_{R_i} \Pi_i = \left[\frac{R_i^\sigma}{R_i^\sigma + \alpha R_j^\sigma + N} \right] V - R_i, \quad \text{where } \sigma > 1. \quad (9)$$

As in previous literature, we restrict attention to cases where σ is an integer. The first-order condition is

$$\frac{\partial \Pi_i}{\partial R_i} = \left[\frac{\sigma R_i^{\sigma-1}}{R_i^\sigma + \alpha R_j^\sigma + N} \right] V - \left[\frac{\sigma R_i^{2\sigma-1}}{(R_i^\sigma + \alpha R_j^\sigma + N)^2} \right] V - 1 = \left[\frac{\sigma(\alpha R_j^\sigma + N) R_i^{\sigma-1}}{(R_i^\sigma + \alpha R_j^\sigma + N)^2} \right] V - 1 = 0. \quad (10)$$

To determine the reaction function, we might rearrange the first-order condition to obtain R_i as a function of R_j . This results, however, in a complicated quartic function. Instead, we prove in Appendix H that the first-order condition implicitly defines R_i as a function of R_j , except possibly at a point of measure zero.¹⁴ This implicit function can conceptually be rearranged to an explicit form of Firm i 's reaction function. A symmetrical equilibrium would require that

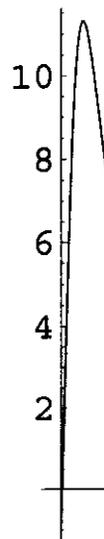
$$\left[\frac{\sigma(\alpha R_j^\sigma + N) R_i^{\sigma-1}}{(R_i^\sigma + \alpha R_j^\sigma + N)^2} \right] V - 1 = 0 \quad (11)$$

$$\text{and } R_1 = R_2 > 0 \quad \text{with } \Pi_1 = \Pi_2 \geq 0 \quad (12)$$

so the firms are maximizing profit (by Eqn. 11), where expenditures are positive and profits are nonnegative (by Conditions 12). Consider a case where $\sigma = 2, n = 2, V = 100, N = 25, \alpha = 1/3$, and $R_1 = R_2$. Figure 3 plots the graph of Equation 11 between $R_1 = R_2 = 0$ and $R_1 = R_2 = 100 = V$.¹⁵ There is only one positive R_i where the first-order condition is satisfied and $R_1 = R_2 > 0$. Closer inspection reveals that the equilibrium R_i falls between 38.42 and 38.43.¹⁶ At these values, the expected profits are 27.50 and 27.49. Thus, Equation 11 and Conditions 12 are satisfied, and we have found a symmetrical Nash equilibrium in pure strategies. In this equilibrium the rent is approximately 76.85% dissipated.

We perform the same operations for a case where $\sigma = 3, n = 2, V = 100, N = 25, \alpha = 1/4$, and $R_1 =$

$\partial \Pi_i / \partial R_i$



Note: $\partial \Pi_i / \partial R_i$ is the equilibrium

Figure 3. Determining

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8. Conclusion

The approach policymaker costs a greater verisimilitude how firms allocate

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¹⁴ The Implicit Function Theorem gives sufficient, but not necessary, conditions for a function to exist. Failure of the conditions at a single point does not mean that a function cannot exist at that point (Chiang 1984). Moreover, because the theorem fails only at a point of measure zero, the function certainly exists around neighborhoods at all other points.

¹⁵ Recall that firms would certainly spend no more than $R_1 = R_2 = V$.

¹⁶ At $R_i = 38.42, \partial \Pi_i / \partial R_i = 0.00008$, while at $R_i = 38.43, \partial \Pi_i / \partial R_i = -0.00019$, so we have found the neighborhood of a maximum.

¹⁷ Again, by "standard r of rent seeking.

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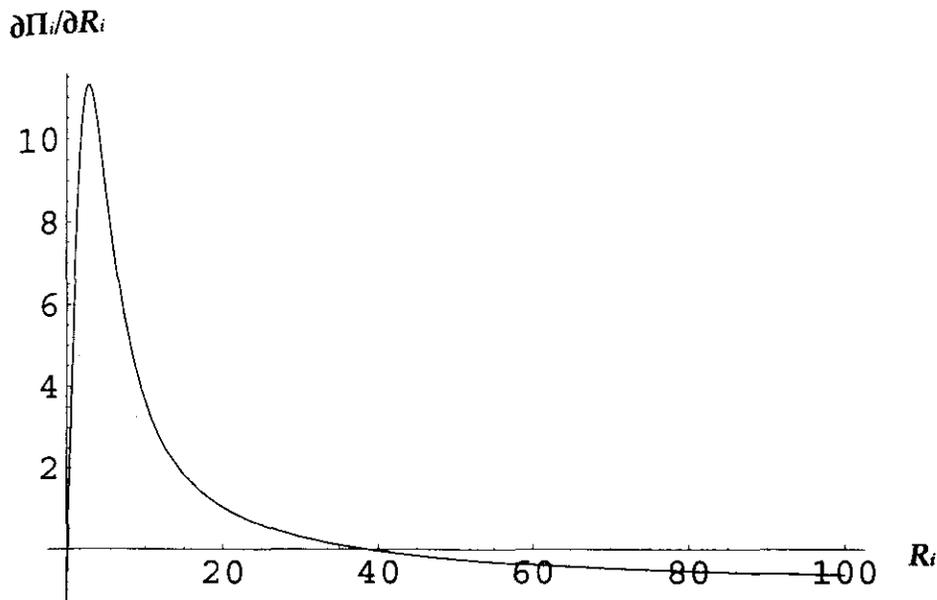
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Note: $\partial\Pi_i/\partial R_i$ is the first order condition, which is the implicit reaction function. The symmetric equilibrium is found by setting $R_1 = R_2$.

Figure 3. Determining a symmetric equilibrium when $\sigma = 2$, $n = 2$, $V = 100$, $N = 25$, and $\alpha = 1/3$.

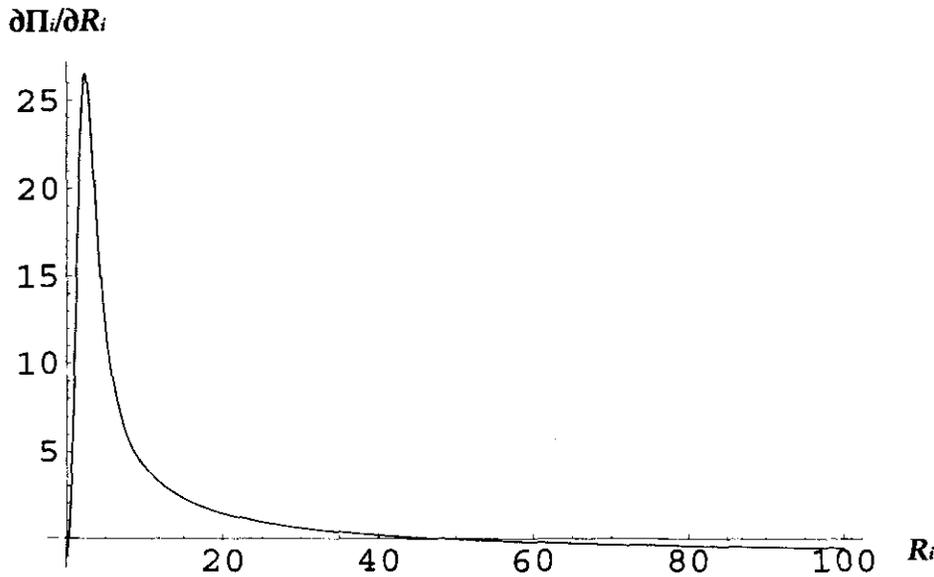
R_2 . Figure 4 graphs the first-order condition. Here, the equilibrium R_i falls between 48.02 and 48.03, with corresponding profits of 31.97 and 31.96, and the dissipation rate is approximately 96.05%. Thus, with policymaker costs and political competition incorporated into the standard game, a symmetrical Nash equilibrium in pure strategies exists with underdissipation of rents, even for $\sigma > n/(n - 1)$.

8. Conclusion

The approach outlined here emphasizes the politics involved in rent-seeking games. Adding policymaker costs and offering an alternative conceptualization of competition between firms provide greater verisimilitude to the political process and a more reasonable approximation to the question of how firms allocate resources to rent seeking.

Intuitively, incorporating politics serves to generalize the standard rent-seeking model. As we discussed regarding Equations 1 and 2, the standard model is a special case of our model.¹⁷ Incorporating policymaker costs (N) and political competition (α) fundamentally alters the game's underlying success probabilities, which changes the way firms behave in the model. This leads to very different conclusions regarding lobbying behavior and the social costs of rent seeking. For example, our Theorem 1 indicates that firms will avoid political competition in many cases, rather than spend

¹⁷ Again, by "standard model" we refer to the class of games that follow the approach based on Tullock's (1980) lottery model of rent seeking.



Note: $\partial\Pi_i/\partial R_i$ is the first order condition, which is the implicit reaction function. The symmetric equilibrium is found by setting $R_1 = R_2$.

Figure 4. Determining a symmetric equilibrium when $\sigma = 3$, $n = 2$, $V = 100$, $N = 25$, and $\alpha = 1/4$.

more under greater competition. In fact, our model finds that dissipation rates are generally lower than the standard model suggests (Theorem 2), even under increasing returns to rent-seeking expenditures as shown in section 7. Much of what has followed Tullock's seminal contribution consists of mathematically elegant extensions that generate politically complicated results. The model we advance is much simpler. In its results, we see that the political context helps to determine the strategies that firms will use, as well as the likely outcomes of rent-seeking expenditures.

In short, as the policy that embodies the rent is more costly for policymakers to pass, *ceteris paribus*, rent seekers are less likely to win the rent and will be less interested in lobbying for it. Rent seekers will similarly avoid lobbying where there are intense counteracting efforts from other interests—expected profits are higher where political competition is lower. In addition, political costs and competition will dissuade rent seekers from spending more to win a prize than the value of the prize itself.

Appendix A: The Best Reply Functions

Rearranging Equation 4 yields the profit-maximizing level of R_i as a function of R_j and exogenous variables:

$$R_i = \sqrt{(\alpha R_j + N)V} - \alpha R_j - N. \tag{A1}$$

From Equation A1, note that (1) $R_i > 0$ if R_j is sufficiently low that it pays Firm i to lobby; (2) $R_i = 0$ at a sufficiently high R_j ; and (3) $R_i < 0$ for even higher R_j , which is not feasible because $R_i \geq 0$. We restrict analysis to $R_i, R_j \geq 0$. We next establish that the R_i and R_j intercepts of Equation A1 are positive. Then, because Equation A1 is obviously continuous, we know that the best reply function passes through the first quadrant in $R_i - R_j$ space. It follows that for $N \in (0, \infty)$, there are points of Equation A1 at which R_i and R_j are both positive. From Equation A1, the R_i and R_j intercepts are

LEMMA A1. The R_i and

PROOF. By Assumption 0, so the R_j intercept is positive.

We next establish Firm i 's

LEMMA A2. Firm i 's

PROOF. Expected profit

Obviously, if $R_i = 0$, then Π is nonnegative if $V - \alpha R_j - N \geq R_i$, which is nonnegative if

We complete the proof by showing that Π reaches a maximum of $(V - N)^2/4$.

Defining the set of R_i values

THEOREM A1. The best

Appendix B: The Best Reply Functions

We show that ρ_i is strictly increasing in V and N . Two lemmas provide the proof.

LEMMA B1. Firm i 's

PROOF. The first derivative

and the second derivative is

which is clearly negative. Thus

LEMMA B2. If $V \leq 4N$, the maximum at $R_j = (V/4 - N)$

PROOF. The slope of

$$R_i|_{R_j=0} = \sqrt{NV} - N \tag{A2}$$

$$\text{and } R_j|_{R_i=0} = \frac{V-N}{\alpha} \tag{A3}$$

LEMMA A1. The R_i and R_j intercepts of Equation A1 are positive. Furthermore, the R_i intercept is less than the R_j intercept.

PROOF. By Assumption 1, $V > N$, hence $\sqrt{NV} - N > 0$, so the R_i intercept is positive. $V - N > 0$ and $\alpha > 0 \Rightarrow (V - N)/\alpha > 0$, so the R_j intercept is positive. Because $\alpha \in (0, 1]$, we have

$$\frac{V-N}{\alpha} > \frac{\sqrt{NV} - N}{\alpha} \geq \sqrt{NV} - N. \quad QED.$$

We next establish Firm i 's willingness to invest in lobbying according to Equation 5 in the paper.

LEMMA A2. Firm i 's profit is nonnegative on Equation A1 for $R_i \in [0, \sqrt{NV} - N]$.

PROOF. Expected profit is

$$\Pi_i = \left[\frac{R_i}{R_i + \alpha R_j + N} \right] V - R_i. \tag{A4}$$

Obviously, if $R_i = 0$, then $\Pi_i = 0$. Next, consider $R_i \in (0, \sqrt{NV} - N]$. Rearranging Equation A4, we see that profit is nonnegative if $V - \alpha R_j - N \geq R_i$, which by Equation A1 can be expressed as $V - \alpha R_j - N \geq R_i = \sqrt{(\alpha R_j + N)V} - \alpha R_j - N$. So profit is nonnegative if

$$V \geq \sqrt{(\alpha R_j + N)V}. \tag{A5}$$

We complete the proof by showing that Equation A5 holds on Equation A1. The right side of Equation A5 increases in R_j , which reaches a maximum of $(V - N)/\alpha$ in the interval of this lemma. Then, because $(V - N)/\alpha \geq R_j$,

$$\sqrt{[\alpha(V - N)/\alpha + N]V} = V \geq \sqrt{(\alpha R_j + N)V}. \quad QED.$$

Defining the set of R_i values that satisfy Equation A1 as ρ_i , we have proven

THEOREM A1. The best reply function of Firm 1 is

$$\rho_i = \begin{cases} \sqrt{(\alpha R_j + N)V} - \alpha R_j - N & \text{for } 0 \leq R_j \leq \frac{(V-N)}{\alpha} \\ 0 & \text{for } \frac{(V-N)}{\alpha} < R_j \end{cases}$$

Appendix B: The Shape of the Best Reply Functions

We show that ρ_i is strictly concave over $R_j \in [0, (V - N)/\alpha]$, but that its exact shape depends on the relative magnitudes of V and N . Two lemmas prove these conjectures and will be useful later.

LEMMA B1. Firm i 's best reply function is strictly concave over $R_j \in [0, (V - N)/\alpha]$.

PROOF. The first derivative of ρ_i with respect to R_j is

$$\frac{\partial \rho_i}{\partial R_j} = \frac{\alpha \sqrt{V}}{2\sqrt{\alpha R_j + N}} - \alpha \tag{B1}$$

and the second derivative is therefore

$$\frac{\partial^2 \rho_i}{\partial R_j^2} = \frac{-\alpha^2 \sqrt{V}}{4\sqrt{(\alpha R_j + N)^3}}$$

which is clearly negative. Therefore, ρ_i is strictly concave. QED.

LEMMA B2. If $V \leq 4N$, then ρ_i is monotonically decreasing over $R_j \in [0, (V - N)/\alpha]$. If $V > 4N$, then ρ_i has an interior maximum at $R_j = (V/4 - N)/\alpha$, which is in the interior of $[0, (V - N)/\alpha]$.

PROOF. The slope of ρ_i is given by $\partial \rho_i / \partial R_j$. Rearranging Equation B1, we see that

$$\frac{\partial \rho_i}{\partial R_j} > 0 \Leftrightarrow R_j < \frac{V/4 - N}{\alpha}, \quad \frac{\partial \rho_i}{\partial R_j} = 0 \Leftrightarrow R_j = \frac{V/4 - N}{\alpha}, \quad \text{and} \quad \frac{\partial \rho_i}{\partial R_j} < 0 \Leftrightarrow R_j > \frac{V/4 - N}{\alpha}.$$

We are concerned with ρ_i over $R_j \in [0, (V - N)/\alpha]$. Now $V/4 - N < V - N$, so $(V/4 - N)/\alpha < (V - N)/\alpha$. Thus, the critical point $R_j = (V/4 - N)/\alpha$ is less than $(V - N)/\alpha$. However, if V is small enough that $(V/4 - N)/\alpha \leq 0$, then R_j cannot be less than $(V/4 - N)/\alpha$ since R_j cannot be negative. It follows that $\partial \rho_i / \partial R_j \leq 0$ on $R_j \in [0, (V - N)/\alpha]$. Note that $(V/4 - N)/\alpha \leq 0$ implies that $V \leq 4N$. Thus, if $V \leq 4N$, then ρ_i is decreasing and strictly concave in R_j . However, if $V > 4N$, then there exists an interior maximum for ρ_i in $[0, (V - N)/\alpha]$. Because the second derivative is negative by Lemma B1, ρ_i reaches a maximum where $R_j = (V/4 - N)/\alpha$. Hence, if $V > 4N$, then ρ_i has an interior maximum at $R_j = (V/4 - N)/\alpha \in (0, (V - N)/\alpha)$. QED.

Appendix C: Equilibrium

We must establish the existence of equilibria because games with infinite strategy sets may not have an equilibrium (Morrow 1994). We first note the following: (1) the strategy space $R_i \in [0, V]$ for $i = 1, 2$ are compact and convex; (2) the expected profit function $\Pi_i = [R_j/(R_i + \alpha R_j + N)]V - R_i$ is defined, continuous, and bounded on the strategy sets; and (3) Π_i is strictly concave in R_i because $\partial^2 \Pi_i / \partial R_i^2 < 0$.

THEOREM C1. The game has at least one Nash equilibrium.

PROOF. The profit function is concave, hence it is also quasiconcave. This, together with points (1) and (2) above, satisfies the conditions for a well-known existence proof for Nash equilibrium (Fudenberg and Tirole 1995). QED.

Thus, there exists at least one Nash equilibrium. However, it is possible that multiple equilibria exist. We therefore consider uniqueness. To this end, we establish

THEOREM C2. If $V \leq 4N$, then there is a unique Nash equilibrium for the game. Furthermore, the equilibrium is symmetric, so in equilibrium $\rho_i = \rho_j$.

PROOF. By Theorem 3.4 of Friedman (1990), and given points 1 and 2 above, a unique equilibrium exists as long as the best reply functions are contractions. In our game, the best reply functions, Equation 5, do not contain R_i on the right side. Thus, because the best reply functions are symmetrical, they are contractions if the value of $|\partial \rho_j / \partial R_j|$ for Equation 5 is less than one. Suppose $V \leq 4N$, then, by Lemmas B1 and B2, ρ_1 is monotonically decreasing and strictly concave. Hence, $\partial \rho_j / \partial R_j \leq 0$ and reaches its minimum value at the largest possible value of R_j , where $R_j = (V - N)/\alpha$. Substituting this into Equation 5, we get

$$\frac{\partial \rho_i}{\partial R_j} \geq \frac{\alpha\sqrt{V}}{2\sqrt{\alpha(V - N)/\alpha + N}} - \alpha = \frac{\alpha\sqrt{V}}{2\sqrt{V}} - \alpha = \frac{-\alpha}{2}.$$

$|\alpha/2| \leq 1/2$ because $\alpha \in (0, 1]$, so $0 \leq |\partial \rho_j / \partial R_j| \leq 1/2 < 1$, and uniqueness is guaranteed for $V \leq 4N$. Symmetry of the functions implies that the unique equilibrium is where $\rho_1 = \rho_2$. QED.

Uniqueness is not so easy to show in the case where $V > 4N$ because the best reply function is not necessarily a contraction. As R_j approaches 0 from above, $\partial \rho_j / \partial R_j$ increases, approaching

$$\frac{\alpha\sqrt{V}}{2\sqrt{N}} - \alpha > \frac{\alpha\sqrt{4N}}{2\sqrt{N}} - \alpha = 0.$$

While we know that the derivative is greater than 0, we have no upper bound for it. Certainly, for some cases the derivative will be less than 1, but this will not hold with generality. Another well-known uniqueness theorem requires the Jacobian of the best reply functions to be negative quasidefinite (e.g., Friedman 1990). However, our best reply functions do not satisfy this condition. On the other hand, we can apply the contraction theorem to special cases where $V > 4N$. We have

THEOREM C3. If $4 \left(\frac{1+\alpha}{\alpha}\right)^2 N > V > 4N$, there is a unique Nash equilibrium for the game. The reaction functions are symmetrical, so in equilibrium $\rho_i = \rho_j$.

PROOF. This is not a vacuous case, because $(1 + \alpha)/\alpha > 1$. By Theorem 3.4 of Friedman (1990), we must show that the best reply function is a contraction. For the decreasing portion of the best reply function, Theorem C2 indicates that $|\partial \rho_j / \partial R_j| < 1$. On the increasing portion, $\partial \rho_j / \partial R_j \geq 0$; and the largest value of $\partial \rho_j / \partial R_j$ occurs at $R_j = 0$, where, by Equation B1,

$$\frac{\partial \rho_i}{\partial R_j} \leq \frac{\alpha\sqrt{V}}{2\sqrt{N}} - \alpha.$$

Suppose $V < 4 \left(\frac{1+\alpha}{\alpha}\right)^2 N$, the

Thus, on the upward sloping for this function under the c: $\rho_i = \rho_j$. QED.

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Appendix D: Equil

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Rearranging terms, we get (

From the quadratic equation

where it can be shown that

we get

The sign of the term under t it would yield a negative ρ_c

Appendix E: Proof

To analyze the effect respect to α . After consideri

$$\frac{\partial \rho_c}{\partial \alpha} = \left[\right.$$

In the following, we concen follows, that $\alpha \in (0, 1]$. Defi

LEMMA E1. If $\alpha = 1$,

PROOF. Suppose $\alpha =$

$$4N\sqrt{V^2 + 8}$$

Because the denominator of

LEMMA E2. As $\alpha \rightarrow 0^+$, a negative limit if and only

PROOF. To prove state intermediate result that $\Omega =$

Suppose $V < 4 \left(\frac{1-\alpha}{2}\right)^2 N$, then

$$\frac{\partial p_i}{\partial R_j} \leq \frac{\alpha\sqrt{V}}{2\sqrt{N}} - \alpha < \frac{\alpha\sqrt{4\left(\frac{1-\alpha}{2}\right)^2 N}}{2\sqrt{N}} - \alpha = \frac{2(1+\alpha)\sqrt{N}}{2\sqrt{N}} - \alpha = 1.$$

Thus, on the upward sloping portion of p_i , $0 \leq \partial p_i / \partial R_j < 1$, so the best reply function is a contraction. Therefore, $|\partial p_i / \partial R_j| < 1$ for this function under the condition of this theorem, so there is a unique equilibrium. Symmetry of best reply functions implies $p_i = p_j$. QED.

We do not prove uniqueness if $V > 4 \left(\frac{1-\alpha}{2}\right)^2 N$, but the only stable equilibrium is symmetrical (see text).

Appendix D: Equilibrium Lobbying Expenditures

We determine the optimal investment at the symmetrical equilibrium. Let $p_i = p_j = p_e$, so p_e satisfies

$$p_e = \sqrt{(\alpha p_e + N)V} - \alpha p_e - N \quad \text{for } p_e \in [0, (V - N)/\alpha].$$

Rearranging terms, we get $(1 + \alpha)p_e + N = \sqrt{(\alpha p_e + N)V}$ or

$$(1 + \alpha)^2 p_e^2 + 2(1 + \alpha)Np_e + N^2 = (\alpha p_e + N)V = \alpha p_e V + NV.$$

From the quadratic equation,

$$p_e = \frac{\alpha V - 2(1 + \alpha)N \pm \sqrt{[2(1 + \alpha)N - \alpha V]^2 - 4(1 + \alpha)^2(N^2 - VN)}}{2(1 + \alpha)^2},$$

where it can be shown that

$$[2(1 + \alpha)N - \alpha V]^2 - 4(1 + \alpha)^2(N^2 - VN) = \alpha^2 V^2 + 4(1 + \alpha)NV,$$

we get

$$p_e = \frac{\alpha V - 2(1 + \alpha)N \pm \sqrt{\alpha^2 V^2 + 4(1 + \alpha)NV}}{2(1 + \alpha)^2}.$$

The sign of the term under the radical is greater than $\alpha^2 V^2$, so we disregard the solution where the radical is subtracted because it would yield a negative p_e , and we are left with Equation 6 in the text.

Appendix E: Proof of Theorem 1

To analyze the effect of competition on equilibrium lobbying expenditures, we take the derivative of Equation 6 with respect to α . After considerable manipulation, we find that

$$\frac{\partial p_e}{\partial \alpha} = \frac{[2(1 + \alpha)N + (1 - \alpha)V] \left[\sqrt{\alpha^2 V^2 + 4(1 + \alpha)NV} \right] + \alpha(1 - \alpha)V^2 - 6(1 + \alpha)VN}{2(1 + \alpha)^3 \sqrt{\alpha^2 V^2 + 4(1 + \alpha)NV}}.$$

In the following, we concentrate on the numerator because the denominator is positive under our assumptions. Recall, in what follows, that $\alpha \in (0, 1)$. Define the numerator as Ω .

LEMMA E1. If $\alpha = 1$, then $\partial p_e / \partial \alpha < 0$.

PROOF. Suppose $\alpha = 1$, then $\Omega = 4N\sqrt{V^2 + 8VN} - 12VN$. Because $N < V$ by Assumption 1,

$$4N\sqrt{V^2 + 8VN} - 12VN < 4N\sqrt{V^2 + 8V^2} - 12VN = 4N\sqrt{9V^2} - 12VN = 12VN - 12VN = 0.$$

Because the denominator of $\partial p_e / \partial \alpha$ is positive, $\partial p_e / \partial \alpha < 0$. QED.

LEMMA E2. As $\alpha \rightarrow 0^+$, $\partial p_e / \partial \alpha$ approaches (1) a positive limit if and only if $V/4 > N$; (2) zero if and only if $V/4 = N$; and (3) a negative limit if and only if $V/4 < N$.

PROOF. To prove statement 1 of Lemma E2, we show that $\Omega > 0 \Leftrightarrow V/4 > N$. In doing this, we prove statement 2 by an intermediate result that $\Omega = 0 \Leftrightarrow V/4 = N$. Suppose $\alpha \rightarrow 0^+$, then Ω approaches $[V + 2N][\sqrt{4VN}] - 6VN$, and

$$[V + 2N][\sqrt{4VN}] - 6VN > 0 \Leftrightarrow [V + 2N][\sqrt{4VN}] > 6VN.$$

Divide both sides of the inequality by $V + 2N > 0$ to see that the latter holds if and only if

$$\begin{aligned} \sqrt{4VN} > \frac{6VN}{V+2N} &\Leftrightarrow 4VN > \frac{36V^2N^2}{(V+2N)^2} = \frac{36V^2N^2}{V^2+4VN+4N^2} \\ &\Leftrightarrow 4V^3N + 16V^2N^2 + 16VN^3 > 36V^2N^2. \end{aligned}$$

Divide through the last inequality by $4VN$ and rearrange terms to get

$$V^2 + 4VN + 4N^2 > 9VN \Leftrightarrow V^2 - 5VN + 4N^2 > 0.$$

The last quadratic equation is strictly convex, so the solutions to the inequality for N lie outside the solutions of the quadratic equality. The solutions are $V = N$ and $V/4 = N$. Because $V > N$ by Assumption 1, we have proved statement 2 of the lemma: $\partial\rho_e/\partial\alpha = 0$ if and only if $V/4 = N$. Continuing the proof of statement 1, either $V < N$ or $V/4 > N$. Again, the former is contrary to Assumption 1, so $\partial\rho_e/\partial\alpha > 0$ if and only if $V/4 > N$. Similar reasoning proves that, because $V > N$ by assumption, $\partial\rho_e/\partial\alpha < 0$ if and only if $V/4 < N$. QED.

Lemma E2 states that $\partial\rho_e/\partial\alpha$ approaches zero if $V/4 = N$, but it will not equal zero because $\alpha > 0$.

LEMMA E3. $\partial\rho_e/\partial\alpha = 0$ if and only if $\alpha = (V - 4N)/V \Leftrightarrow N = (1 - \alpha)V/4$.

PROOF. Because $N = (1 - \alpha)V/4 \Leftrightarrow 4N/V = 1 - \alpha < 1$, such an α exists if and only if $V > 4N$. We show that the only solution for $\Omega = 0$ under our assumptions occurs where $N = (1 - \alpha)V/4 \Leftrightarrow \alpha = (V - 4N)/V$. Thus,

$$\begin{aligned} &[(1 - \alpha)V + 2(1 + \alpha)N] \left[\sqrt{\alpha^2V^2 + 4(1 + \alpha)VN} \right] + \alpha(1 - \alpha)V^2 - 6(1 + \alpha)VN = 0 \\ &\Leftrightarrow [(1 - \alpha)V + 2(1 + \alpha)N] \left[\sqrt{\alpha^2V^2 + 4(1 + \alpha)VN} \right] = -\alpha(1 - \alpha)V^2 + 6(1 + \alpha)VN. \end{aligned}$$

Squaring both sides of the last equation and expanding the terms yields

$$\begin{aligned} &\alpha^2(1 - \alpha)^2V^4 + 4\alpha^2(1 + \alpha)(1 - \alpha)V^3N + 4\alpha^2(1 + \alpha)^2V^2N^2 + 4(1 + \alpha)(1 - \alpha)^2V^3N \\ &\quad + 16(1 + \alpha)^2(1 - \alpha)V^2N^2 + 16(1 + \alpha)^3VN^3 \\ &= \alpha^2(1 - \alpha)^2V^4 - 12\alpha(1 + \alpha)(1 - \alpha)V^3N + 36(1 + \alpha)^2V^2N^2. \end{aligned}$$

Subtracting $\alpha^2(1 - \alpha)^2V^4$ from both sides of the equality, dividing by $(1 + \alpha)VN$, and then subtracting the right side from both sides and simplifying, we get

$$(1 - \alpha)V^2 + (\alpha - 5)NV + 4N^2 = 0.$$

Solving the quadratic equation for N , we find that $N = (1 - \alpha)V/4$ or $N = V$. The latter contradicts Assumption 1, so $N = (1 - \alpha)V/4$. QED.

We now proceed to the proof of

THEOREM 1. (1) If $V/4 \leq N$, then $\partial\rho_e/\partial\alpha < 0$ at all levels of $\alpha \in (0,1)$. (2) If $V/4 > N$, then $\partial\rho_e/\partial\alpha$ is greater than, equal to, or less than 0 as α is less than, equal to, or greater than $(V - 4N)/V$ or, equivalently, as $(1 - \alpha)V/4$ is greater than, equal to, or less than N .

PROOF. (1) Suppose $V/4 \leq N$. By Lemma E1, $\partial\rho_e/\partial\alpha|_{\alpha=1} < 0$; and by Lemma E2, $V/4 \leq N \Rightarrow \lim_{\alpha \rightarrow 0^+} \partial\rho_e/\partial\alpha \leq 0$. By Lemma E3, $\partial\rho_e/\partial\alpha = 0 \Leftrightarrow \alpha = (V - 4N)/V \Leftrightarrow N = (1 - \alpha)V/4$. But by the assumption of part 1 of Theorem 1, $N \geq V/4 > (1 - \alpha)V/4$, so $\partial\rho_e/\partial\alpha \neq 0$ in the interior of $\alpha \in (0,1]$ if $V/4 \leq N$. Therefore, if $V/4 \leq N$, the derivative is never so high as 0. The derivative is obviously continuous, so if $V/4 \leq N$, then $\partial\rho_e/\partial\alpha < 0 \forall \alpha \in (0,1]$. (2) Suppose $V/4 > N$. By Lemma E1, $\partial\rho_e/\partial\alpha|_{\alpha=1} < 0$, and by Lemma E2, $V/4 > N \Rightarrow \lim_{\alpha \rightarrow 0^+} \partial\rho_e/\partial\alpha > 0$. If $V/4 > N$, there exists an $\alpha \in (0,1]$ such that $V/4 > (1 - \alpha)V/4 > N$ by the continuity of α . Hence, if $V/4 > N$, then $\partial\rho_e/\partial\alpha$ is greater than, equal to, or less than 0 as α is less than, equal to, or greater than $(V - 4N)/V$, or equivalently, as $(1 - \alpha)V/4$ is greater than, equal to, or less than N . QED.

Appendix F: The Effect of Increasing Competition on Profit

Denoting $\rho_e(V, N, \alpha)$ as $\rho_e(\alpha)$, the derivative of Equation 7 with respect to α is

$$\frac{\partial\Pi_e^i}{\partial\alpha} = \rho_e'(\alpha) \left[\left(\frac{N}{[\rho_e(\alpha) + \alpha\rho_e(\alpha) + N]^2} \right) V - 1 \right] + \frac{-[\rho_e(\alpha)]^2V}{[\rho_e(\alpha) + \alpha\rho_e(\alpha) + N]^2}.$$

The second term is obviously $\rho_e(\alpha)$, and because $\alpha\rho_e(\alpha)$

Then the first term is positive to N , then $\partial\Pi_e^i/\partial\alpha$ is ur

Appendix G: Pr

PROOF. Let $\alpha \in (0,1)$ at the single point where

$\rho_T =$

Because the first derivative is positive, therefore, total lobbying

Appendix H: TI

We prove that the derivative of the Implicit Function

LEMMA H1. The derivative

PROOF. We prove

Because N is positive, the

LEMMA H2. If $\Psi(\alpha)$

PROOF. If $\Psi(R_i, k)$

We can rewrite $\partial\Psi/\partial R_i$

This derivative is nonzero

The existence of a point where a function is zero because the Implicit Function Theorem. With these two it

THEOREM H1. The

The second term is obviously negative. Because the first-order condition (Eqn. 4) holds for any R_i and R_j , including $R_i = R_j = \rho_c(\alpha)$, and because $\alpha\rho_c(\alpha) > 0$, we can sign the term in braces as

$$\left[\frac{N}{(\rho_c(\alpha) + \alpha\rho_c(\alpha) + N)^2} \right] V - 1 < \left[\frac{\alpha\rho_c(\alpha) + N}{(\rho_c(\alpha) + \alpha\rho_c(\alpha) + N)^2} \right] V - 1 = 0.$$

Then the first term is positive, zero, or negative as $\rho_c'(\alpha)$ is negative, zero, or positive. Thus, if V is sufficiently large relative to N , then $\partial\Pi_i^*/\partial\alpha$ is unambiguously negative, but generally the sign will depend on the values of the parameter.

Appendix G: Proof of Theorem 2

PROOF. Let $\alpha \in (0, 1]$ and, by Assumption 1 and nonnegative political costs, $N \in (0, V)$. Recall that ρ_T is maximized at the single point where $N = (1 - \alpha)V/4$. Therefore,

$$\begin{aligned} \rho_T = 2\rho_c &= \frac{\sqrt{4(1 + \alpha)NV + \alpha^2V^2} + \alpha V - 2(1 + \alpha)N}{(1 + \alpha)^2} \\ &\leq \frac{\sqrt{(4/4)(1 + \alpha)(1 - \alpha)V^2 + \alpha^2V^2} + \alpha V - (2/4)(1 + \alpha)(1 - \alpha)V}{(1 + \alpha)^2} \\ &= \frac{\sqrt{V^2} + \alpha V - (1 + \alpha)(1 - \alpha)V/2}{(1 + \alpha)^2} = \frac{(1 + \alpha)V - (1 + \alpha)(1 - \alpha)V/2}{(1 + \alpha)^2} = \frac{V}{2}. \end{aligned}$$

Because the first derivative is strictly concave, the equality holds only at the point where $N = (1 - \alpha)V/4$; elsewhere $\rho_T < V/2$. Therefore, total lobbying expenditures are less than one half of the value of benefits almost everywhere. QED.

Appendix H: The Implicit Reaction Function

We prove that the first-order condition is an implicit function $R_i = R_i(R_j)$, except possibly at a point of measure zero using the Implicit Function Theorem. We first establish two lemmas where we define

$$\Psi(R_i, R_j) \triangleq \left[\frac{\sigma(\alpha R_j^\sigma + N)R_i^{\sigma-1}}{(R_i^\sigma + \alpha R_j^\sigma + N)^2} \right] V - 1.$$

LEMMA H1. The derivatives $\partial\Psi/\partial R_i$ and $\partial\Psi/\partial R_j$ are continuous everywhere.

PROOF. We prove the lemma for $\partial\Psi/\partial R_i$, then it will hold for $\partial\Psi/\partial R_j$. Note that

$$\frac{\partial\Psi}{\partial R_i} = \left[\frac{\sigma(\sigma - 1)(\alpha R_j^\sigma + N)R_i^{\sigma-2}}{(R_i^\sigma + \alpha R_j^\sigma + N)^2} \right] V - \left[\frac{2\sigma^2(\alpha R_j^\sigma + N)R_i^{2\sigma-2}}{(R_i^\sigma + \alpha R_j^\sigma + N)^3} \right] V.$$

Because N is positive, these terms obviously are continuous everywhere. QED.

LEMMA H2. If $\Psi(R_i, R_j) = 0$, $\partial\Psi/\partial R_i \neq 0$ except at a point of measure zero.

PROOF. If $\Psi(R_i, R_j) = 0$,

$$\left[\frac{\sigma(\alpha R_j^\sigma + N)R_i^{\sigma-1}}{(R_i^\sigma + \alpha R_j^\sigma + N)^2} \right] V = 1.$$

We can rewrite $\partial\Psi/\partial R_i$ of Lemma H1 as

$$\frac{\partial\Psi}{\partial R_i} = (\sigma - 1)R_i^{-1} - \frac{2\sigma R_i^{\sigma-1}}{(R_i^\sigma + \alpha R_j^\sigma + N)} = \frac{(\sigma - 1)(\alpha R_j^\sigma + N) - (1 + \sigma)R_i^\sigma}{R_i(R_i^\sigma + \alpha R_j^\sigma + N)}.$$

This derivative is nonzero except at $(\sigma - 1)(\alpha R_j^\sigma + N) = (1 + \sigma)R_i^\sigma$, a point of measure zero on R_i . QED.

The existence of this point where $\partial\Psi/\partial R_i = 0$ does not necessarily mean that the function does not exist at this point, because the Implicit Function Theorem establishes sufficient, not necessary, conditions. It is possible for this condition to fail at a point where a function exists (Chiang 1984).

With these two lemmas, we can prove

THEOREM H1. The first-order condition 10 implicitly defines a function $R_i = \Phi(R_j)$, except possibly at a point of measure zero.

PROOF. In our case, the Implicit Function Theorem states that (1) if $\partial\Psi/\partial R_i$ and $\partial^2\Psi/\partial R_i^2$ are continuous; and (2) if, at the point where $\Psi(R_i, R_j) = 0$, $\partial\Psi/\partial R_i$ is nonzero, then $\Psi(R_i, R_j)$ defines an implicit function in neighborhoods around points where these conditions hold. QED.

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What Dr Determin

Nathan S. Balke* and

In this paper, we which expectatio from one in whic distinguish betw ratio are very pe information abou stock prices and stock price move nor does it appe

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1. Introduction

Before 1981, r principal determinar (1981) found that, ur be consistent with n hypothesis, argues variables. Several pa Shapiro 1991) challe Shiller, on the groun of the subsequent li dividend variability, and Shiller 1987; W By relaxing the Campbell (1991) att

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The authors would comments on a previous c reflect the views of the Fe Received March 20 Cochrane (1991, 1992), explained by time-varyin 1998], and Bulkley and I On the existence of bub