Rent Seeking and Bargaining

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Abstract

This paper models a rent-seeking game in which the contest success function is derived by specifying a time-consistent objective of the principal. Each firm invests in discovering an innovation that the principal values. The principal bargains with a firm (if any) which innovated. If both firms innovated then each firm gains less than if only one firm did. Equilibrium investment will be excessive. Though firms can collude to restrict investment, they maximize joint profits by investing at a positive, non-infinitesimal level, and restrict investment to a finite level even if the cost of rent-seeking effort is zero.

1 Introduction

The theory of rent seeking is immensely insightful and fruitful, shedding light on how government behaves. Nevertheless, the microfoundations of the theory are imperfect. Some models, including those based on the classic work of Tullock (1967), treat rent seeking as a black box: the probability that a firm wins the reward increases with its share of total rent-seeking spending. But if, as is often assumed, the firms are identical, why and how government officials are swayed by such spending is unclear. That is, the Tullock model skirts explicitly stating what motivates government, and thus avoids explicitly explaining how spending by firms affects government policy.

Also novel in my formulation is consideration of bargaining between the firm and the government official, with the firm rationally expecting bargaining, and the official maximizing his utility after knowing the results of the investment activities. If both firms fail in innovating, neither gets any profit. If one or both firms innovated, government negotiates with an innovating firm over how to share the surplus.

Other approaches do examine motivation, but suffer from a time inconsistency problem. In the all-pay auction,[1]firms make payments to government, which then chooses the highest payer to win the prize. But in a one period model, it is unclear why the highest payer should be favored. Nor is it clear what are the payments.

The menu auction model of governmental decisions[2]supposes each firm offers the government a contribution schedule, which maps every policy vector government may choose into a payment from the firm to the government (or politician). This model assumes that firms make the payments after government sets policy. Such behavior by the firms, however, is time inconsistent—after the policy is set the firm maximizes its profits by contributing nothing. Moreover, data show that a firm would suffer little from reneging on a promised contribution: McCarty and Rothenberg (1996) find that incumbents do *not* punish lobbying groups who had failed to support them (or who had supported their opponents) in a prior election.

The problem of time-inconsistency is especially severe in politics, where bribery is often illegal, and its revelation can be politically damaging. Whereas

[1]See Baye, Kovenock and de Vries (1993).

[2]The model was introduced by Grossman and Helpman (1994), building on work by Bernheim and Whinston (1986).

in auctions for private goods the seller and potential buyers can sign a binding contract forcing a bidder to pay the amount promised, the courts will not enforce such contracts when entered between a lobbyist and a policymaker. The mere public revelation of such a contract can greatly harm the policymaker. A multi-period model, which allowed for reputational effects, could overcome the time-inconsistency problem. Multi-period models, however, introduce new complications. In particular, an application of the Folk Theorem says that firms could collude to pay nothing to government.

Here I take a different approach.[3] I suppose that government cares only about maximizing social welfare, and that a firm's rent-seeking activities can make award of the contract to that firm generate higher social benefits than award of the contract to another firm.

1.1 Why not auctions

One may ask why the government must negotiate with the firms. Why not hold an auction, or make a take-it-or-leave it offer? Bajari, and Tadelis (2001) and Bajari, McMillan and Tadelis (2002) offer several reasons, and empirical support for them. First, auctions perform poorly when projects are complex and contractual design is incomplete. Second, the benefits to auctions can be small when few firms bid. Third, auctions stifle communication between the buyer and the contractor, preventing the buyer from taking advantage of the contractor's expertise when choosing how to design the project. Fourth, auctions fail to protect the privacy of the buyer and involve increased administrative expenses and wait.

With procurement by government additional considerations can appear. Government's threats may not be credible. Suppose government makes an offer to firm 1 which firm 1 rejects. Government could then attempt to contract with firm 2. But such a switch from firm 1 to firm 2 can impose a cost, even a small one, on government; the cost could be a short delay in fulfilling the contract. Following Diamond (1971), suppose that the cost of moving from one firm to another is s. Then government would prefer to come to an agreement with firm 1 over firm 2 if firm 1 charged at most s more than firm 2 did. Any take it or leave it offer made by government for a price less

[3] My approach also differs from the axiomatic justification for the contest success function is axiomatic. See, in particular, Skaperdas (1996).

than G can therefore not be an equilibrium. The problem does not appear with Nash bargaining (which I consider) because the reservation utility level can incorporate any costs of negotiating with the alternative firm.

2 Literature

I shall consider two periods with investment in period 1 a sunk cost. The sunk cost can generate a hold-up problem. Several other papers use a similar approach. Hart (1979) considers monopolistic competition in which firms simultaneously decide whether to pay a setup cost that will enable them to produce goods. Hart (1980) shows that if the goods are complementary, the equilibria can be inefficient. Makowski and Ostroy (1995) consider individuals who choose occupations, with the occupations determining the goods that can be consumed. Felli and Roberts (2000) model Bertrand competition among workers for jobs.

Acemoglu (1996) studies two-sided investments with matching and with costly bilateral search. Acemoglu (1997) analyzes a worker-firm model in which investment in human capital may be inefficiently low. The inefficiency in that model stems from costly search if a worker-firm match is dissolved. Acemoglu and Shimer (1999) use a matching model with one-sided investments to investigate the hold-up problem. Their focus, however, is on the role of search frictions and the non-investing partner's ability to direct search. MacLeod and Malcomson (1993) study the hold-up problem associated with investment decisions made before contracting.

3 Assumptions

Each of two firms can invest an amount x in pursuit of an innovation; the probability that a firm succeeds in innovating is an increasing function, $f(x)$, of the amount it invests, with $f'x() > 0$ and $f''(x) < 0$. An innovation need not be a technical one. A firm could innovate by generating political support for its position, discovering a way of overcoming limitations on campaign contributions, and so on. My approach can thus be viewed as complementary to the Grossman and Helpman (1994) model: they have special interest groups commit to pay the government official after observing the policy he chooses; I have government bargain with firms after it observes what benefits each firm could give it.

Government values the good or service produced with an innovation at G, and values the good or service without it at 0. After the firms made their investments, and the success or failure of each firm's efforts are known, government enters into bargaining with the firms. Government procurement for a new product provides an example of the type of situation I have in mind. Similar situations arise when a cable firm attempts to win a monopoly franchise by offering an innovative (or better, or cheaper) service to the community, or when different lobbyists search for compelling reasons to offer a congressmen about why it would be to his political benefit to support the policy they favor.

If only one firm innovated, then a standard solution for the Nash bargaining game is that the surplus (G) is divided equally between the government and the innovating firm.

The Nash bargaining solution for firm A when both firms innovated maximizes the product of the utility gain to each party from the agreement. Let ϕ_i be government's share of the surplus (G) when it reaches an agreement with firm i. If government first bargains with firm A and fails to reach agreement with it, government could bargain with firm B; its share of the surplus would be ϕ_B. But suppose also that changing the firm with which the firm bargains requires some delay, or imposes some probability that no agreement will be reached. The benefit of $\phi_B G$ is therefore multiplied by a parameter δ, which lies between zero and 1; a simple interpretation is that δ is the intertemporal discount factor.

4 Bargaining

The value of ϕ_A in a Nash bargaining solution, for a given value of ϕ_B, is the value of ϕ_A which maximizes the following expression

$$(G\phi_A - \delta G\phi_B)(1 - \phi_A)\, G. \tag{1}$$

The first-order condition is

$$1 - 2\phi_A + \delta\phi_B = 0. \tag{2}$$

Assuming that solutions are symmetric across the firms, substitute $\phi_A = \phi_B = \phi$, obtaining

$$\phi = \frac{1}{2-\delta}. \tag{3}$$

Let the cost of a unit of effort be 1. So firm A's expected profit when its effort is x_A is

$$-x_A + f(x_A)(1 - f(x_B))\frac{G}{2} + f(x_A)f(x_B)G\left(1 - \frac{1}{2-\delta}\right). \tag{4}$$

The first-order condition with respect to x_A is

$$Gf'(x_A) = \frac{2\delta - 4}{\delta f(x_B) + \delta - 2}. \tag{5}$$

In a symmetric equilibrium, $x_A = x_B = x$, thus yielding as the solution

$$Gf'(x) = \frac{2\delta - 4}{\delta f(x) + \delta - 2}. \tag{6}$$

For example, suppose $f(x) = x^\alpha$. Then the equilibrium has

$$G\alpha x^{\alpha-1} = \frac{2\delta - 4}{\delta x^\alpha + \delta - 2}. \tag{7}$$

In particular, if $\alpha = 1/2$, then the solution is

$$G\,(1/2)\,x^{(1/2)-1} = \frac{2\delta - 4}{\delta x^{1/2} + \delta - 2}, \tag{8}$$

or

$$x = G^2 \frac{(\delta - 2)^2}{(G\delta - 4\delta + 8)^2}. \tag{9}$$

(When $\delta = 1$, the value of x always lies between 0 and 1, thus ensuring that the probability of an innovation lies between 0 and 1. When $\delta = 0$, the corresponding condition is that $G < 4$.)

In standard models of rent-seeking, the socially optimal level of spending is zero. But in my model some investment is socially useful, because it can generate an innovation which has social value. Investment, however, might be excessive, because any spending by a firm which failed to innovate is a social loss. The first-order condition for the socially optimal solution is

$$\frac{\partial(-2x + G(1 - (1 - x^{\alpha})^2)}{\partial x} = 0. \tag{10}$$

When $\alpha = 1/2$ the solution is

$$x = \frac{G^2}{(G+2)^2} \tag{11}$$

(The value of x lies between 0 and 1 for all G, thus ensuring that for all G the probability of an innovation also lies between 0 and 1.) The ratio of effort in equilibrium to socially optimal effort is

$$\frac{\frac{G^2(\delta-2)^2}{(G\delta+8-4\delta)^2}}{\frac{G^2}{(G+2)^2}} = \frac{(\delta-2)^2}{(G\delta - 4\delta + 8)^2}(G+2)^2, \tag{12}$$

which is positive for all δ lying between 0 and 1. Thus, equilibrium effort is excessive.

4.1 Collusion by firms

This section considers collusion by firms. In the standard rent-seeking model, they would collude to have infinitesimal rent seeking. In my model that is different. I suppose that collusion can occur over rent-seeking effort, not after the results are known and government negotiates with a firm. Note that infinitesimal investment is suboptimal for the firms, because it is likely that neither firm will develop the product, and thus each will get zero profits.

Efficient collusion might have asymmetric asymmetric behavior—one firm investing zero, and the other a positive amount. But such collusion would require that one firm pay another, which may be difficult to achieve. I therefore consider symmetric collusion, where both firms agree on investment levels, and so lead to an outcome which to the firms is Pareto superior to the Nash equilibrium. There will be an optimal level of investment, which is positive. It is not too large, both because of the cost of investment, and because when both firms invest much both firms develop the project and as a result of bargaining with the government, each wins low profits.

Let the unit cost of investment be $c = 1$. The firms' objective is to maximize expected joint profits, or to maximize

$$-2cx + \frac{G}{2}2f(x)(1 - f(x)) + \left(1 - \frac{1}{2-\delta}\right) Gf(x)^2. \tag{13}$$

Making the substitution $f(x) = x^{1/2}$ gives

$$-2cx + \frac{G}{2}2x^{1/2}(1 - x^{1/2}) + \left(1\frac{1}{2-\delta}\right) G\left(x^{1/2}\right)^2. \tag{14}$$

The first-order condition with respect to x is

$$-\frac{1}{2}\frac{-8c\sqrt{x} + 4c\sqrt{x}\delta - 2G\sqrt{x} + 2G\delta\sqrt{x} + 2G - G\delta}{(-2+\delta)\sqrt{x}} = 0, \tag{15}$$

with the solution

$$x = \frac{1}{4}G^2\frac{(\delta-2)^2}{(-4c + 2c\delta - G + G\delta)^2}. \tag{16}$$

An interesting case has $c = 0$:

$$x = \frac{1}{4}G^2\frac{(\delta-2)^2}{(-G + G\delta)^2} = \frac{1}{4}\frac{(\delta-2)^2}{(\delta-1)^2}. \tag{17}$$

The firms will limit the amount of rent seeking even though the investment is costless. The reason is that increased investment has two effects. First it increases the probability that at least one firm innovates, which is a necessary condition for government to pay some firm. But, second, an increase in x increases the probability that both firms innovate, thereby reducing any firm's bargaining power. The balancing of these two effects leads to a positive, but finite, level of investment.

To proceed with consideration of positive c, without loss of generality let $c = 1$. With $f(x) = x^{1/2}$, compare the collusive solution to the Nash equilibrium. The ratio of the solution under collusion to the Nash solution is

$$\frac{\frac{1}{4}G^2\frac{(\delta-2)^2}{(-4+2\delta-G+G\delta)^2}}{G^2\frac{(\delta-2)^2}{(G\delta-4\delta+8)^2}} = \frac{1}{4(-4+2\delta-G+G\delta)^2}(G\delta - 4\delta + 8)^2. \tag{18}$$

When $\delta = 2/3$, this ratio equals 1. For small δ the ratio is less than 1, and for δ close to 1 the ratio excees 1. Thus, collusion may generate either more or less effort than does the Nash equilibrium.

5 Variable number of innovations

I so far supposed that a firm either succeeds or fails to innovate, without allowing more ways in which the firms can differ. Here I relax that assumption, allowing the number of innovations by a firm to take on any number, and supposing that government prefers the service or good provided by the firm with more innovations. On the other hand, I simplify the problem by supposing that government offers a fixed prize rather than negotiating with the firms.

Suppose then that a firm chooses the number of projects in which to invest; on each project the firm may either succeed or fail to innovate. If the number of projects is large and the probability of success on any one is sufficiently close to 1/2, then the number of innovations follows the normal distribution. More specifically, let firm i invest in n_i projects. The probability that a project yields an innovation is p. Thus the expected number of innovations is pn_i. This follows a normal distribution with mean $\mu_i = pn_i$ and variance $\sigma_i^2 = n_i p(1-p)$.

As before, consider two firms. The difference between two normal distributions has a mean of $\mu_1 - \mu_2 = p(n_1 - n_2)$, and a variance of $\sigma_1^2 + \sigma_2^2 = p(1-p)(n_1+n_2)$. So the probability that firm 1 wins the prize is the probability that is has more innovations, or

$$\int_0^\infty \frac{1}{\left(\sqrt{p(1-p)(n_1+n_2)}\right)\sqrt{(2\pi)}} e^{-(x-(p(n_1-n_2)))^2/(2p(1-p)(n_1+n_2))} dx. \qquad (19)$$

The derivative of the expression within the integral sign with respect to n_1 when $p = 1/2$ and evaluated at $n_1 = n_2 = n$ is

$$\int_0^\infty \frac{e^{-x^2/n}\left(2x^2+4nx-n\right)}{4\sqrt{\pi}n^{5/2}} dx = \frac{1}{2\sqrt{\pi}\sqrt{n}}. \qquad (20)$$

Note that this differs from the results in the standard Tullock contest. When effort is n in a symmetric equilibrium for a Tullock contest, increased effort increases the probability of winning the prize by $1/(4n)$. Or more generally, when the contest success function is $x_1^\alpha/(x_1^\alpha + x_2^\alpha)$, the increased probability of winning is $\alpha/(4n)$. This differs from the increased probability in my model, $\frac{1}{2\sqrt{\pi}\sqrt{n}}$.

In my model, if the value of the prize is W, and the unit cost of n is c then the equilibrium has

$$\frac{W}{2\sqrt{\pi}\sqrt{n}} = c \tag{21}$$

or

$$n = \frac{1}{4}\frac{W^2}{\pi c^2}. \tag{22}$$

Total spending on the projects (or, loosely speaking, total rent seeking) is $2nc = cW^2/(2\pi c^2)$. Profits are

$$W - cW^2/(2\pi c^2) = \frac{1}{2}W\frac{2c\pi - W}{c\pi}, \tag{23}$$

which is positive if $W < 2c\pi$. This has the counter intuitive result that the profits of firms are negative if W exceeds some threshold. Of course, if we extended consideration to mixed strategies, no firm would expect to earn negative profits in equilibrium. One possible equilibrium has zero effort by each firm: if the cost of effort is sufficiently high, or p is sufficiently low, then even when $f = 0$ for the other firm, it is unprofitable for a firm to increase x. That differs from a Tullock contest, overcoming the questionable feature of the Tullock function that an infinitesimal spending can yield the prize for sure and that rent-seeking effort is always positive.

6 Conclusion

This paper examined rent seeking as an incentive mechanism—it induces firms to make investments which the policymaker values. This approach has several attractive features: it makes explicit what is rent-seeking effort, it explains why a decision maker is more likely to reward the firm that spent more, and it explains why a firm's chances of winning the prize decline with the other's firms efforts. Of course, this model does not cover all instances of rent seeking. It does not directly explain, for example, why a politician will more likely grant tariff protection to an industry or to firms which had more heavily lobbied him. But even then the model can be relevant. We can think of a politician who will grant tariff protection to that industry which gives him more compelling reasons to protect it. The innovations I considered can then be thought of as arguments, with the firm that comes up with more or better arguments more likely to win protection.

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7 Notation

$f(x)$ Probability that a firm succeeds in innovating

G Government's gross benefits from the project

x_i Investment by firm i

δ Intertemporal discount factor

ϕ_i Share of surplus retained by government when it bargains with firm i