# Collective rent seeking when sharing rules are private information

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**Abstract**

We study a general model of the simultaneous-move game with sequential moves applicable to the study of two-party contests with sharing rules that are private information. Using the solution technique of the general model, we study collective rent seeking with private-information sharing rules. We also study collective rent seeking with public-information sharing rules. We compare the equilibrium sharing rules and the equilibrium outlays under private and public information regarding sharing rules.

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## 1. Introduction

Consider a situation in which two parties or groups of players compete for a rent. The players in each party first decide how to share the rent if they win. Then, all the players in both parties simultaneously and independently expend irreversible outlays. The winning party is selected according to a rule that is based on the total outlays of the parties. Such collective rent seeking has been studied by many economists: see Nitzan (1991a,b), Baik and Shogren (1995), Hausken (1995), Lee (1995), Davis and Reilly (1999), Baik and Lee (2001), and Baik et al. (2006), to name a few.[1]

We may expect the players in each party to expend their effort or outlays without observing the sharing rule to which the players in the other party agreed. For example, in elections, members of one political party do not know, when they campaign, how members of another party will share the political posts among themselves in case of winning. To the best of our knowledge, collective rent seeking with private information regarding sharing rules has not previously been studied.[2]

This paper has two objectives. The first is to analyze collective rent seeking with private-information sharing rules – precisely, to examine the equilibrium sharing rules of the parties and the equilibrium outlays of the individual players and parties in such rent-seeking contests. The second objective is to study a general model that is applicable to two-party contests with private-information sharing rules and other similar situations. We set up the general model in Section 2. Each party has two sequential moves, the first of which is hidden from the players in the other party, the second moves of the parties are chosen simultaneously, and payoffs to the players in each party do not depend directly on the first move of the other party. When solving the game in Section 3, we treat it as a simultaneous-move game between the two parties because each party chooses its two moves without observing moves of the other party.

In Section 4, we set up a model of collective rent seeking with private-information sharing rules. Then, using the solution technique explained in Section 3, we obtain the

equilibrium sharing rules of the parties and the equilibrium outlays of the individual players and parties. We find that the individual players in both parties expend the same outlay regardless of their different abilities. This happens because, given their asymmetric abilities, the parties choose the countervailing intra-party sharing rules. We also find that the equilibrium outlays of the parties are independent of the size of the parties – in other words, the extent of rent dissipation is independent of the size of the population.

In Section 5, we first analyze collective rent seeking with sharing rules that are public information – in which the players in each party expend their outlays after observing the sharing rule of the other party. We then compare the equilibrium sharing rules and the equilibrium outlays under private and public information regarding sharing rules. In the case of public information, each party chooses a more "selfish" sharing rule compared to private information. Comparing the equilibrium total outlays, we find that the equilibrium total outlay is greater in the case of public information about sharing rules than in the case of private information – that is, rent dissipation is smaller in the case of private information. Section 6 concludes.

## 2. The simultaneous-move game with sequential moves: general model

Consider a game between two parties, 1 and 2, in which each party has two *sequential* moves. The first move of each party, which is chosen by a player or group of players in that party, is observed by all of its players before the second move is chosen; however, it is *hidden* from the players in the other party. The second moves of the parties are chosen *simultaneously*. For expositional convenience, the player or group of players in party $i$, for $i = 1, 2$, who chooses the first move is called leader $i$, and that choosing the second move is called follower $i$.[3]

We formally consider the following game. First, leaders 1 and 2 choose actions $a_1$ and $a_2$ from $A_1$ and $A_2$, respectively, where $A_i$ denotes the set of all actions available to leader $i$. Next, follower $i$ observes the action $a_i$ chosen by leader $i$, but cannot observe the action $a_j$ chosen by leader $j$. (Throughout the paper, when we use $i$ and $j$ at the same time, we mean that $i \neq j$.) Finally, followers 1 and 2 simultaneously choose actions $b_1$ and $b_2$ from $B_1$ and $B_2$, respectively,

where $B_i$ is follower $i$'s set of actions. Let $u_i$ represent the (expected) payoff for leader $i$ and $v_i$ that for follower $i$. The payoff function for leader $i$ and that for follower $i$ are given by $u_i = u_i(a_i, b_i, b_j)$ and $v_i = v_i(a_i, b_i, b_j)$, respectively. Note that $a_j$ is absent in these functions. This implies that the payoffs to the players in each party do not depend *directly* on the first move of the other party.[4] We assume that all of the above is common knowledge among the leaders and followers.

The right way to look at this game is that each party chooses its two moves without observing moves of the other party. That is, the game is overall a simultaneous-move game between the two parties. Because the game has sequential moves, however, we call it the simultaneous-move game with sequential moves. Clearly, the game differs from the standard two-stage games which also have both simultaneous moves and sequential ones.[5] In the game under consideration, the first move of each party is hidden from the players in the other party, whereas in a standard two-stage game, it is observed by the players in the other party before the second moves are chosen.

## 3. Equilibrium actions

To solve the game, we need to find a quadruple vector of actions, $(a_1^*, b_1^*, a_2^*, b_2^*)$, which satisfies the following two requirements. First, each follower's action is optimal given the action of the leader in her own party and given the action of the follower in the other party. That is, follower $i$'s action $b_i^*$ is a best response to leader $i$'s action $a_i^*$ and follower $j$'s action $b_j^*$. Second, each leader's action is optimal given the action of the follower in the other party and given the subsequent behavior of the follower in her own party. Not surprisingly, such a quadruple vector permits the interpretation that the pair of actions for each party, $(a_i^*, b_i^*)$, is a best response to that for the other party, $(a_j^*, b_j^*)$.

To obtain such equilibrium actions of the game, we begin by obtaining party $i$'s best response to party $j$'s pair of actions $(a_j, b_j)$. The best response of party $i$ consists of two actions: leader $i$'s best response and follower $i$'s best response.[6] Thus, we need to consider two separate

but related maximization problems. Working backward, we will first consider follower *i*'s problem, and then consider leader *i*'s one.

Consider follower *i*'s maximization problem. After observing the action $a_i$ previously chosen by leader *i*, follower *i* seeks to maximize his payoff over his action $b_i$, taking follower *j*'s action $b_j$ as given:

$$\max_{b_i \in B_i} \quad v_i(a_i, b_i, b_j). \tag{1}$$

We assume that for each $a_i$ in $A_i$ and $b_j$ in $B_j$, maximization problem (1) has a unique interior solution, which is denoted by

$$b_i^{BR}(a_i, b_j). \tag{2}$$

This is follower *i*'s best response to leader *i*'s action $a_i$ and follower *j*'s action $b_j$.

Next, consider leader *i*'s maximization problem. Leader *i* seeks to maximize her payoff over her action $a_i$, taking follower *j*'s action $b_j$ as given:

$$\max_{a_i \in A_i} \quad u_i(a_i, b_i, b_j). \tag{3}$$

Because leader *i* can solve follower *i*'s maximization problem (1) as well as follower *i* can, leader *i* has perfect foresight about follower *i*'s best response to each action $a_i$ that she might take – that is, she knows in advance $b_i^{BR}(a_i, b_j)$ for each action $a_i$. Thus, leader *i*'s maximization problem (3) amounts to

$$\max_{a_i \in A_i} \quad u_i(a_i, b_i^{BR}(a_i, b_j), b_j). \tag{4}$$

We assume that for each $b_j$ in $B_j$, maximization problem (4) has a unique interior solution, which is denoted by

$$a_i^{BR}(b_j). \tag{5}$$

This is leader *i*'s best response to follower *j*'s action $b_j$.

We now obtain the reaction functions for the parties. Party *i* has two reaction functions, one for follower *i* and the other for leader *i*. Follower *i*'s reaction function shows his best response to every possible pair of actions that leader *i* and follower *j* might choose. Thus it comes from follower *i*'s best response (2): $b_i = b_i^{BR}(a_i, b_j)$. Similarly, leader *i*'s reaction function comes from leader *i*'s best response (5): $a_i = a_i^{BR}(b_j)$. Therefore, the reaction functions for party 1 are

$$a_1 = a_1^{BR}(b_2) \tag{6}$$

and

$$b_1 = b_1^{BR}(a_1, b_2). \tag{7}$$

The reaction functions for party 2 are

$$a_2 = a_2^{BR}(b_1) \tag{8}$$

and

$$b_2 = b_2^{BR}(a_2, b_1). \tag{9}$$

Finally, we obtain the equilibrium actions, $(a_1^*, b_1^*, a_2^*, b_2^*)$, of the game. Because by definition the equilibrium actions satisfy the two requirements specified above, they satisfy all the four reaction functions, (6) through (9), simultaneously. Hence, we obtain the equilibrium actions by solving the system of four simultaneous equations. First substitute (6) into (7), and (8) into (9), which yields

$$b_1 = R_1(b_2) \tag{10}$$

and

$$b_2 \;=\; R_2(b_1), \tag{11}$$

where $R_1(b_2) \equiv b_1^{BR}(a_1^{BR}(b_2),\ b_2)$ and $R_2(b_1) \equiv b_2^{BR}(a_2^{BR}(b_1),\ b_1)$.[7] We obtain $b_1^*$ and $b_2^*$ by solving the pair of simultaneous equations, (10) and (11). Next, substituting $b_2^*$ into (6), and $b_1^*$ into (8), we obtain $a_1^*$ and $a_2^*$, respectively.

## 4. Collective rent seeking when sharing rules are private information

Consider a contest in which two parties, $\alpha$ and $\beta$, compete for a rent. The rent is worth $G$, and will be awarded to one of the parties. Each party consists of $n$ risk-neutral players, where $n \geq 2$. Let $x_k$ represent the irreversible rent-seeking outlay of player $k$ in party $\alpha$, and $y_k$ the outlay of player $k$ in party $\beta$. Let $p(s_\alpha, s_\beta)$ represent the probability that party $\alpha$ wins the rent when the parties' total outlays are $s_\alpha$ and $s_\beta$. The probability that party $\beta$ wins the rent is then $1 - p(s_\alpha, s_\beta)$. The contest success function for party $\alpha$ is given by the following logit form:

$$p(s_\alpha, s_\beta) \;=\; \begin{cases} \gamma s_\alpha/(\gamma s_\alpha + s_\beta) & \text{for } s_\alpha + s_\beta > 0 \\ 1/2 & \text{for } s_\alpha = s_\beta = 0, \end{cases}$$

where $s_\alpha = \sum_{i=1}^{n} x_i$ and $s_\beta = \sum_{i=1}^{n} y_i$. The parameter $\gamma$ represents party $\alpha$'s abilities in the contest relative to party $\beta$'s. Without loss of generality, we assume $\gamma \geq 1$.

The players in each party share the rent among themselves if they win. When party $\alpha$ wins, the fractional share of player $k$ in party $\alpha$ is determined by

$$\sigma_k^\alpha \;=\; \delta_\alpha x_k/s_\alpha \;+\; (1 - \delta_\alpha)/n. \tag{12}$$

Similarly, when party $\beta$ wins, the fractional share of player $k$ in party $\beta$ is given by

$$\sigma_k^{\beta} \;=\; \delta_{\beta} y_k / s_{\beta} \;+\; (1-\delta_{\beta})/n. \tag{13}$$

We call $x_k/s_{\alpha}$ in (12) and $y_k/s_{\beta}$ in (13) the *outlay-dependent* sharing rule and $1/n$ the *outlay-independent* sharing rule. (Hereafter, $\delta$ is used when the context is applied to both $\delta_{\alpha}$ and $\delta_{\beta}$.) The sharing rule of each party is determined by the parameter $\delta$, which is chosen by the players in the party at the beginning of the contest. $\delta = 0$ implies that the players in the winning party share the rent equally regardless of their individual outlays expended, whereas $\delta = 1$ implies that player *k*'s share of the rent depends only on his outlay relative to his party's total outlay. We assume $\delta \geq 0$. A larger value of $\delta$ implies that more emphasis is placed on the outlay-dependent sharing rule.

We formally consider the following game. First, the players in each party decide how to share the rent among themselves if they win. That is, they make a binding agreement on the value of their sharing rule parameter $\delta$. Note that, because the players in each party are identical, their decision on $\delta$ is unanimous. Next, all the players in both parties expend their outlays simultaneously and independently. When expending their outlays, the players in each party know the sharing rule of their own party, but do not know the rival party's.[8] Finally, the winning party is chosen, and the players in the winning party share the rent according to the sharing rule on which they agreed earlier. We assume that there is no transaction cost associated with negotiating an agreement and sharing the rent. We also assume that all of the above is common knowledge among the players.

Let $\pi_k^{\alpha}$ represent the expected payoff for player *k* in party $\alpha$. Then the payoff function for player *k* in party $\alpha$ is

$$\pi_k^{\alpha} \;=\; \sigma_k^{\alpha} G p(s_{\alpha}, s_{\beta}) \;-\; x_k. \tag{14}$$

Similarly, the payoff function for player *k* in party $\beta$ is

$$\pi_k^{\beta} \;=\; \sigma_k^{\beta} G(1 - p(s_{\alpha}, s_{\beta})) \;-\; y_k. \tag{15}$$

To solve the game, we adopt exactly *the same steps as in the preceding section*.[9] Consider party $\alpha$. Working backward, we first consider the players' decisions on their outlays. After observing his party's sharing rule or equivalently $\delta_{\alpha}$, player *k* in party $\alpha$ seeks to maximize his payoff (14) over his outlay $x_k$, taking the outlays of all the other players as given.[10] We focus on the symmetric equilibrium actions. Thus let $x_k = x$ and $y_k = y$ for all *k*. Then the first-order condition for maximizing (14) reduces to

$$G\gamma y \;+\; G\gamma(n-1)\delta_{\alpha}(\gamma x + y) \;=\; n^2(\gamma x + y)^2. \tag{16}$$

From (16), we obtain the following reaction function:

$$x(\delta_{\alpha}, y) \;=\; \{G\gamma(n-1)\delta_{\alpha} \;-\; 2n^2 y \;+\; \sqrt{G^2\gamma^2(n-1)^2\delta_{\alpha}^2 + 4G\gamma n^2 y}\}/2n^2\gamma. \tag{17}$$

Next, consider the players' decision on their sharing rule. Since the players expend the same effort level, they have the same expected payoff: $\pi_k^{\alpha} = \pi^{\alpha}$ for all *k*. The players seek to maximize

$$\pi^{\alpha}(\delta_{\alpha}, y) \;=\; [G\gamma/n\{\gamma x(\delta_{\alpha}, y) + y\} \;-\; 1]\, x(\delta_{\alpha}, y) \tag{18}$$

with respect to $\delta_{\alpha}$, taking party $\beta$'s total outlay $s_{\beta}$, or rather *y*, as given. Note that we obtain (18) by substituting (17) into (14). From the first-order condition for maximizing (18), we obtain another reaction function of party $\alpha$:

$$\delta_{\alpha}(y) \;=\; \sqrt{ny/G\gamma}. \tag{19}$$

Now consider party $\beta$. After observing his party's sharing rule or equivalently $\delta_\beta$, player $k$ in party $\beta$ seeks to maximize his payoff (15) over his outlay $y_k$, taking the outlays of all the other players as given. We focus on the symmetric equilibrium actions. Thus the first-order condition for maximizing (15) reduces to

$$G\gamma x \;+\; G(n-1)\delta_\beta(\gamma x + y) \;=\; n^2(\gamma x + y)^2. \tag{20}$$

From (20), we obtain the following reaction function:

$$y(\delta_\beta, x) \;=\; \{G(n-1)\delta_\beta \;-\; 2\gamma n^2 x \;+\; \sqrt{G^2(n-1)^2\delta_\beta^2 + 4G\gamma n^2 x}\}/2n^2 \tag{21}$$

Next, consider the players' decision on their sharing rule. Since the players expend the same effort level, they have the same expected payoff: $\pi_k^\beta = \pi^\beta$ for all $k$. The players seek to maximize

$$\pi^\beta(\delta_\beta, x) \;=\; [G/n\{\gamma x + y(\delta_\beta, x)\} \;-\; 1]\, y(\delta_\beta, x) \tag{22}$$

with respect to $\delta_\beta$, taking party $\alpha$'s total outlay $s_\alpha$, or rather $x$, as given. Note that we obtain (22) by substituting (21) into (15). From the first-order condition for maximizing (22), we obtain another reaction function of party $\beta$:

$$\delta_\beta(x) \;=\; \sqrt{n\gamma x/G}. \tag{23}$$

Finally, we obtain the symmetric equilibrium actions, denoted by the $2(n+1)$-tuple vector of actions $(\delta_\alpha^*, x^*, \ldots, x^*, \delta_\beta^*, y^*, \ldots, y^*)$, by solving the system of four simultaneous equations, (17), (19), (21), and (23). Substituting (19) into (17), and (23) into (21), we have

$$x(y) \;=\; (\sqrt{G\gamma ny} \;-\; ny)/n\gamma \tag{24}$$

and

$$y(x) \;=\; (\sqrt{G\gamma nx} \;-\; \gamma nx)/n, \tag{25}$$

which correspond to (10) and (11) in the preceding section. By solving the pair of simultaneous equations, (24) and (25), we obtain $x^* = y^* = G\gamma/n(\gamma+1)^2$. Next, substituting $y^*$ into (19), and $x^*$ into (23), we obtain $\delta_\alpha^* = 1/(\gamma+1)$ and $\delta_\beta^* = \gamma/(\gamma+1)$, respectively.

Proposition 1 highlights the results obtained above.

**Proposition 1.** (*a*) *In the symmetric equilibrium of the rent-seeking contest with private-information sharing rules, party* $\alpha$ *chooses* $\delta_\alpha^* = 1/(\gamma+1)$, *and each player in party* $\alpha$ *expends* $x^* = G\gamma/n(\gamma+1)^2$. *Party* $\beta$ *chooses* $\delta_\beta^* = \gamma/(\gamma+1)$, *and each player in party* $\beta$ *expends* $y^* = G\gamma/n(\gamma+1)^2$. (*b*) *Both parties expend the same rent-seeking outlay:* $s_\alpha^* = s_\beta^* = G\gamma/(\gamma+1)^2$.

Proposition 1 implies the following. First, the sharing rule parameters, $\delta_\alpha^*$ and $\delta_\beta^*$, of the parties depend only on the ability asymmetry parameter $\gamma$; they are independent of the size $G$ of the rent and the size $n$ of the parties. Second, in the case where $\gamma = 1$, both parties choose the same sharing rule, and they give equal weight to the outlay-dependent sharing rule and the outlay-independent one: $\delta_\alpha^* = \delta_\beta^* = 1/2$. In the case where $\gamma > 1$, the strong party (party $\alpha$) gives more weight to the outlay-independent sharing rule than to the outlay-dependent one, whereas the weak party (party $\beta$) gives more weight to the outlay-dependent sharing rule than to the outlay-independent one: $\delta_\alpha^* < 1/2 < \delta_\beta^*$. Third, the individual players in both parties expend the same outlay. Finally, the equilibrium outlays of the parties are the same, and are independent of the size $n$ of the parties.

Brief explanations for these findings follow. In the symmetric equilibrium, the sharing rule parameters are independent of the valuation for the rent and the size of the parties. This is

because both parties value the rent equally, they have the same number of players, and the sharing rule of each party is hidden from the players in the other party. If the parties are perfectly symmetric in the sense that even their abilities are the same, then their equilibrium sharing rules are the same and lie at the midpoint between the two extreme sharing rules. However, if the parties have different abilities, they choose different intra-party sharing rules: The strong party (party $\alpha$) gives more weight to the outlay-independent sharing rule, whereas the weak party (party $\beta$) gives more weight to the outlay-dependent sharing rule. Why? In this asymmetric case, the strong party possesses a competitive advantage over its rival, and thus allows its players to ease up by choosing $\delta_{\alpha}^{*}$ less than one-half. By contrast, the weak party promotes greater intra-party competition by choosing $\delta_{\beta}^{*}$ larger than one-half in order to overcome its inter-party competitive disadvantage. Finally, it is interesting that the individual players in both parties expend the same outlay regardless of their different abilities. This happens because given their asymmetric abilities, the parties choose the countervailing intra-party sharing rules.

We end this section by reporting some comparative statics results. As $\gamma$ increases, $\delta_{\alpha}^{*}$ becomes smaller approaching 0 in the limit, while $\delta_{\beta}^{*}$ becomes larger approaching 1 in the limit. As $\gamma$ increases, the equilibrium individual outlay and the equilibrium outlays of the parties decrease. As *n* increases, the equilibrium individual outlay decreases. As *G* increases, the equilibrium individual outlay and the equilibrium outlays of the parties increase.

## 5. Comparison to collective rent seeking with public-information sharing rules

In this section, we first analyze collective rent seeking with public-information sharing rules.[11] Then we compare the equilibrium sharing rules and the equilibrium outlays under private and public information regarding sharing rules.

Consider a rent-seeking contest which is the same as the one in Section 4 with the exception that, when expending their outlays, the players in each party know the sharing rule of the rival party. More specifically, consider the following two-stage game. In the first stage, the

players in each party decide how to share the rent among themselves if they win. Then both parties simultaneously announce their sharing rule parameter values chosen independently – that is, party $\alpha$ announces publicly the value of $\delta_\alpha$, and party $\beta$ announces publicly the value of $\delta_\beta$. In the second stage, after knowing the parameter values, all the players in both parties expend their outlays simultaneously and independently. At the end of the second stage, the winning party is chosen, and the players in the winning party share the rent according to the sharing rule chosen in the first stage.

This is a standard two-stage game, so that we employ subgame-perfect equilibrium as the solution concept. We obtain Proposition 2.

**Proposition 2.** *In the symmetric subgame-perfect equilibrium of the rent-seeking contest with public-information sharing rules, party $\alpha$ chooses* $\delta_\alpha^{**} = \{2n\gamma^2 - (n+2)\gamma + n\}/\gamma(\gamma+1)(n-1)$, *and party $\beta$ chooses* $\delta_\beta^{**} = \{n\gamma^2 - (n+2)\gamma + 2n\}/(\gamma+1)(n-1)$. *Each player in party $\alpha$ expends* $x^{**} = G(n\gamma^2 - \gamma + n)(\gamma + n\gamma - n)/n^2\gamma(\gamma+1)^2$, *and each player in party $\beta$ expends* $y^{**} = G(n\gamma^2 - \gamma + n)(1 - n\gamma + n)/n^2(\gamma+1)^2$.[12]

Now using Propositions 1 and 2, we obtain that $\delta_\alpha^{**} > \delta_\alpha^{*}$ and $\delta_\beta^{**} > \delta_\beta^{*}$. This says that, in the case of public information regarding sharing rules, each party gives more weight to the outlay-dependent sharing rule compared to the case of private information. This can be explained as follows. In the case of public information, each party can make a strategic commitment for the second-stage inter-party competition by announcing, in the first stage, its intra-party sharing rule. Naturally, to achieve their competitive advantage in the second-stage inter-party competition, the players in each party have an incentive to motivate themselves or to make themselves "aggressive," and actually do so by giving a "large" weight to the outlay-dependent sharing rule when choosing their sharing rule. Such strategic behavior of the parties leads to the finding that $\delta_\alpha^{**} > \delta_\alpha^{*}$ and $\delta_\beta^{**} > \delta_\beta^{*}$.

Next, we obtain that the equilibrium *total* outlay is greater in the case of public information regarding sharing rules than in the case of private information: In terms of the symbols, $s_\alpha^{**} + s_\beta^{**} > s_\alpha^{*} + s_\beta^{*}$. Consider, in particular, the case where $\gamma = 1$. Using Proposition 1, we obtain $x^{*} = y^{*} = G/4n$; using Proposition 2, we obtain $x^{**} = y^{**} = G(2n-1)/4n^2$. Thus, in this case, even the equilibrium *individual* outlay is greater in the case of public information than in the case of private information. Not surprisingly, this arises because, in the case of public information, the players in each party make themselves more aggressive by choosing a more "selfish" sharing rule compared to the case of private information.

## 6. Conclusions

We have studied a general model of the simultaneous-move game with sequential moves, which is applicable to the study of two-party contests with private-information sharing rules – examples of these include collective rent seeking between two parties, R&D competition between two consortia, and election campaigns between two political parties. The key features of this game are threefold. First, the moves of each party occur in sequence, but the first move of each party is hidden from the players in the other party. Second, the second moves of the parties are chosen simultaneously. Third, the payoffs to the players in each party do not depend directly on the first move of the other party. We have solved the game, treating it as a simultaneous-move game between the two parties because each party chooses its two sequential moves without observing moves of the other party. We believe that the general model with two parties can be easily extended to the one with *n* parties.

We have analyzed collective rent-seeking with private-information sharing rules, which is an illustration of the general model. We have found the following. First, the equilibrium sharing rules of the parties are independent of the valuation for the rent and the size of the parties. Second, if the parties are perfectly symmetric, then their equilibrium sharing rules are the same and lie at the midpoint between the two extreme sharing rules. Third, in the case where the parties have different abilities, the strong party gives more weight to the outlay-independent

sharing rule, whereas the weak party gives more weight to the outlay-dependent sharing rule. Fourth, the equilibrium outlays of the individual players in both parties are the same, so that the equilibrium outlays of the parties are the same. Finally, the equilibrium outlays of the parties are independent of the size of the parties.

To make comparisons, we have also analyzed collective rent-seeking with public-information sharing rules. Comparing the equilibrium sharing rules, we have found that, in the case of public information regarding sharing rules, each party gives more weight to the outlay-dependent sharing rule compared to the case of private information. Comparing the equilibrium total outlays, we have found that the equilibrium total outlay is greater in the case of public information regarding sharing rules than in the case of private information.

An interesting extension of this paper is a model that incorporates the parties' decisions on releasing their sharing-rule information. We leave this for future research.

**Footnotes**

1. Unlike the other papers cited, Baik and Lee (2001) study collective rent seeking in which the rent is awarded to one of the players, not one of the parties. The literature on rent seeking is enormous and growing. Important papers in this literature include Tullock (1980), Hillman and Riley (1989), Ellingsen (1991), and Nitzan (1994).

2. Hurley and Shogren (1998a,b), Wärneryd (2003), and Malueg and Yates (2004) study individual rent seeking with private or asymmetric information. But, in these papers, private or asymmetric information exists regarding the players' valuations for the rent.

3. We allow leader *i* and follower *i* to be the same player or group of players.

4. However, their payoffs depend *indirectly* on the first move of the other party because the latter affects the second move of the other party, which is an argument of their payoff functions.

5. For the standard two-stage games, see Gibbons (1992, pp. 71-82) or Osborne (2004, pp. 205-212).

6. Note that because their payoffs do not depend directly on leader *j*'s action $a_j$, the best response of leader *i* and that of follower *i* to party *j*'s pair of actions ($a_j$, $b_j$) amount to their best responses to follower *j*'s action $b_j$ only.

7. Thus $R_i(b_j)$ is follower *i*'s best response to follower *j*'s action $b_j$ when follower *i* takes into account leader *i*'s best response, $a_i^{BR}(b_j)$, to follower *j*'s action $b_j$.

8. Nitzan (1991a,b), Baik and Shogren (1995), Hausken (1995), Lee (1995), and Davis and Reilly (1999) study collective rent seeking, using the sharing rule specification as in (12) and (13). But all the papers assume that the players in each party know the rival parties' sharing rules as well as their own party's before they expend their outlays or effort.

9. Unlike the general model described and analyzed in Sections 2 and 3, each party has *n* "followers" in this collective rent-seeking game. However, since we try to obtain the symmetric equilibrium actions of the game, we have no problem following the steps in Section 3.

10. It is straightforward to see that $\pi_k^{\alpha}$ in (14) is strictly concave in $x_k$, and thus the second-order condition for maximizing (14) is satisfied.

11. Nitzan (1991a,b) studies collective rent seeking in which the parties' sharing rules are *exogenously* given, and are observed before the players expend their outlays. Nitzan (1991b) shows that, when different sharing rules are given to the parties, an equilibrium with *positive* outlays by all the players often fails to exist. Davis and Reilly (1999) establish that an equilibrium, interior or not, always exists for the games which Nitzan (1991b) considers. Baik and Shogren (1995) and Lee (1995) study collective rent seeking in which the parties' sharing rules are *endogenously* determined, and are announced before the players expend their outlays.

12. Because $y^{**}$ is nonpositive when $\gamma \geq (n+1)/n$ holds, Proposition 2 is valid if and only if $1 \leq \gamma < (n+1)/n$.

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