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Rents, dissipation and lost treasures: Rethinking Tullock's paradox

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Abstract. In this paper we revisit Tullock's paradox (Tullock, 1980) and consider a rent-seeking game in which parties face increasing returns to effort. We allow parties to randomize their strategies and give them an exit option. Given the mixed participation strategies of the parties, valuable rents may occasionally remain unexploited. We consider such a lost-treasure effect as an additional cost of rent seeking and examine how the expected value of such a lost rent varies with changes in the parameters of the problem.

Introduction

In this paper we revisit Gordon Tullock's rent-seeking paradox (Tullock, 1980) when players have increasing returns to effort, and are provided with an exit option. In his seminal work "Efficient Rent-Seeking," Tullock developed the insight that the marginal return to rent-seeking expenditures influences the total expenditure on rent-seeking activity. This insight leads to three corollaries. First, when investments in rent seeking exhibit increasing returns, aggregate expenditures could exceed the contested prize. Second, over-dissipation could lead to negative expected returns for the players, with a violation of both parties' participation constraints. Third, when parties' participation constraints are violated, no one would enter the rent-seeking contest, and the prize would remain unclaimed.[1]

The existing literature has analyzed Tullock's paradox identifying mixed strategy solutions that would avoid the over-dissipation paradox and satisfy the parties' participation constraints. Baye, Kovenock and de Vries (1994) considered the case in which the parties always participate, using mixed strategies with varying effort levels. In addition, they give an explicit solution only for discrete strategies.[2] Our analysis is different from previous contributions in the literature as it allows parties to randomize their strategies with respect to participation in the rent-seeking contest. When provided with an exit option, players can simultaneously and independently choose (1) whether to play and (2) how much to invest in rent-seeking activities. This setting allows us to discuss the two problems of participation and the optimal effort separately in a manageable way.

This structure follows from the nature of the problem proposed by Tullock. In fact, the parties' payoffs also contain both a discrete element (the parties win a share in the prize or they win nothing) that depends on the decision whether or not to play, and a continuous element (their share in the prize) that depends on their efforts when playing. Tullock's paradox originates from a conflict between the decision whether or not to play and the optimal strategy when playing. Our model mirrors such a dual nature of the problem into a game that allows parties to take the two decisions separately.

By considering mixed strategies with an exit option, we account for the possibility that in some cases valuable rents may remain unexploited. This is an additional effect of rent seeking. Available value may remain unexploited when no contestant enters the rent-seeking contest. We refer to this as the lost-treasure effect. We study how the expected value of the lost treasure varies under different rent-seeking conditions.

Mixed strategies also allow for an opposite scenario: both parties might decide to play. We show that, although each party spends less than the rent, their total expenditures could exceed the rent, a result that confirms Tullock's claim that increasing returns to investment may induce over-dissipation. This result, however, can only be observed ex post in a fraction of the possible outcomes, while on average the game does not lead to over-dissipation.

Tullock's Paradox and the Efficient Rent-Seeking Puzzle

Tullock's seminal insight of how self-interested parties incur costs in the pursuit of rents (Tullock, 1967) has provided a valuable key for the understanding of economic behavior of actors outside the traditional profit-maximizing framework. Rent-seeking models consider players who engage in a contest in which each player expends costly efforts to increase the probability (probabilistic models) or the share (deterministic models) of a given prize. Tullock's basic model was followed by other formulations by Becker (1968), Krueger (1974), Posner (1975), Demsetz (1976), Bhagwati (1982), Tollison (1982) and many others. In these studies rent-seeking expenditures were considered a social cost rather than a transfer. Much of the theoretical literature focuses on how much effort each player expends, and how the degree of rent dissipation varies with the value of the prize, the number of contestants and the allocation rules. Two quite different positions were reached during the early years of this debate.

Early applications and extensions of Tullock's insight led to differing views on the equilibrium levels of rent dissipation. Most scholars (Becker, 1968; Demsetz, 1976; Krueger, 1974; Posner, 1975; and others) suggested that rent-seeking competition would generate equilibria similar to those generated by competitive markets. Most notably, Posner (1975) considered a probabilistic rent-seeking game with risk-neutral players where the probability of winning is proportional to investment, and the available rents are fully dissipated in equilibrium. Posner's full dissipation hypothesis became popular in the empirical literature and also had a strong appeal in the theoretical literature. In the subsequent years the literature analogized rents to profits, maintaining that both were likely to be competed away in the long-run equilibrium. In a long-run equilibrium, rent-seeking investments would thus yield the normal market rate of return (Tollison, 2003).

Tullock's results (Tullock, 1980) shook the conventional wisdom in the literature, identifying conditions under which competitive rent seeking could lead to under- or over-dissipation. Tullock (1980) showed that the full dissipation result would hold only under very narrow conditions. In most situations, some residual rent could be captured by the players and the rent would not be fully dissipated. Tullock further showed that under different conditions the aggregate rent-seeking expenditures could exceed the value of the prize. This could be the case where players face increasing returns to rent-seeking expenditures.

Although this scenario would generate negative expected returns for the participants, the over-dissipation result could still obtain when contestants initially entered the contest with a rent-seeking expenditure less than the value of the rent, and then incrementally increased their efforts in an attempt to capture the prize. In such a scenario, past expenditures would be sunk, making it rational to undertake gradual increases in effort, eventually reaching total rent-seeking expenditures exceeding the prize value. With rational expectations, parties would realize that the rent-seeking contest would generate negative expected returns, and would consequently choose to exit the contest, if given an opportunity to do so. Here Tullock points out the paradoxical result that if no one enters the contest, any one contestant that enters the race would win the prize, regardless of the effort level he chooses. Therefore, there is an incentive to enter, destabilizing the hypothesized no-participation equilibrium. Tullock thus concluded that the existence of negative expected returns when all parties participate cannot be used to infer that the equilibrium level of participation will always be zero.

The subsequent literature thus concentrated on mixed-strategy solutions that could avoid the over-dissipation paradox and satisfy the parties' participation constraint.[3] In Hillman and Samet (1987a)[4] players randomize over the investments in rent seeking, while the prize is entirely assigned to the highest bidder. In Baye et al. (1994)[5] players also randomize over the investment but the price is shared according to the relative size of the players' bids. These contributions considered the case in which the participants always participate, using mixed strategies with varying effort levels. In Pérez-Castrillo and Verdier (1992), randomization is attained over the number of players that enter the game.

Our analysis is different from these studies as it allows parties to randomize their strategies with respect to the exit option. In this sense, we propose a game theoretical solution to Tullock's paradox in which players simultaneously and independently (1) randomize their strategies concerning the choice whether or not to play and (2) optimize their investment in rent-seeking activities when they play. Thus, the two problems of participation and the optimal effort may be discussed separately in a manageable way.

The Rise and Fall of Rent Dissipation and the Lost-Treasure Effect

In the following, we formulate a model of rent seeking in which parties have an exit option. Under *The rise of rent dissipation: Dominant strategies for* $r \leq 2$ section we build upon Tullock's standard result (Tullock, 1980) according to which the social cost of rent seeking increases with the return to investment in rent-seeking activities, r, up to $r = 2$. Under *The fall of rent dissipation with increasing returns and exit option: Mixed strategies for* $r > 2$ section, we show that if contestants have an exit option and are allowed to play mixed-participation strategies, the expected dissipation of rents reaches its maximum at $r = 2$ (a point in which full dissipation occurs), and begins to decline for values of $r > 2$. This result is interesting to the extent that it reconciles much of the contradictory results developed in the literature. Optimal rent-seeking expenditures for the participating parties are similar to those identified by Tullock (1980) but no over-dissipation occurs because the parties not always enter the rent-seeking contest.

Since in our model parties do not always participate, there exists a positive probability that the rent remains unexploited. We refer to the unexploited rent as the lost-treasure effect. As it will be further discussed, such lost-treasure effects may or may not amount to a real social loss. If rent seeking leads to the discovery of treasures, that is, to the appropriation of valuable resources that would remain unexploited in the absence of parties' participation, the unclaimed rent would constitute a true social loss.

Under *Rent dissipation and lost treasures: Bridging the gap* section, we look at the combined effect of declining rent-dissipation costs and raising lost-treasure costs. We show that the sum of these two costs is constant and always equal to the full value of the rent. In this respect, if lost-treasure effects are accounted for as a social loss, we obtain results that can be reconciled with Posner's full dissipation hypothesis (Posner, 1975). In our case, however, full dissipation obtains not only from the parties' expenditures, but also from the fact that a valuable rent remains unexploited.

The rise of rent dissipation: Dominant strategies for $r \leq 2$

We develop a deterministic rent-seeking game, where players gain a share of a fixed prize equal to the respective ratios of own effort to total effort. Two risk neutral players make ex ante non-recoverable investments equal to fractions A and B of the rent,[6] respectively. The price is divided according to $A^r/(A^r + B^r)$, where r is a factor determining the productivity of rent-seeking expenditures. If $r = 1$, marginal returns to rent-seeking expenditures are constant; if $r < 1$, marginal returns are decreasing; if $r > 1$, marginal returns are increasing. The parties' net shares in the rent are

$$S_A = \frac{A^r}{A^r + B^r} - A \quad \text{and} \quad S_B = \frac{B^r}{A^r + B^r} - B \tag{1}$$

The parties seek to maximize their net share by choosing $A*$ and $B*$ that satisfy the following first order conditions:

$$\frac{\partial S_A}{\partial A} = \frac{rA^{r-1}B^r}{(A^r + B^r)^2} - 1 = 0 \quad \text{and} \quad \frac{\partial S_B}{\partial B} = \frac{rA^r B^{r-1}}{(A^r + B^r)^2} - 1 = 0 \tag{2}$$

The levels of investments that satisfy Equation (2) are $A^* = B^* = r/4$.[7] Clearly A^* and B^* increase in r. The share in the rent is always half for each party. However, the net share decreases when A^* and B^* increase as a reaction to an increase in r. At $r = 2$ the net share is zero, as each party spends exactly half of the rent in rent-seeking activities. For higher values of r the participation constraint is not satisfied, as the net share is negative.

The dissipated portion of the rent is given by the sum of the parties' investments:

$$D = A^* + B^* = r/2 \tag{3}$$

It is evident that the more the return to investment r increases, the larger the portion of the rent that is dissipated in rent-seeking activities. At $r = 2$, the rent is fully dissipated.

The fall of rent dissipation with increasing returns and exit option: Mixed strategies for $r > 2$

When r increases over 2, the parties' participation constraint is not satisfied as they expect a negative net return from participation. In this article, we provide a game theoretical analysis for the case in which $r > 2$ by allowing for parties to randomize their participation strategies. They do so by playing with probabilities π_A and π_B, respectively.

When party A plays, his or her payoff depends on whether or not B plays. In fact, if B plays, the prize will be divided as before, but if B does not play, A will earn the entire prize. The same applies to B. Thus, the parties' shares in the prize (when they play) are not only functions of the parties' levels of investments in rent seeking, but also of each other's probability of participation.

$$\begin{aligned} S_A &= \pi_B \left(\frac{A^r}{A^r + B^r} - A \right) + (1 - \pi_B)(1 - A) \\ S_B &= \pi_A \left(\frac{B^r}{A^r + B^r} - B \right) + (1 - \pi_A)(1 - B) \end{aligned} \tag{4}$$

The first order conditions are

$$\begin{aligned} \frac{\partial S_A}{\partial A} &= \pi_B \frac{rA^{r-1}B^r}{(A^r + B^r)^2} - 1 = 0 \quad \text{at } A^*(\pi_B) \\ \frac{\partial S_B}{\partial B} &= \pi_A \frac{rA^r B^{r-1}}{(A^r + B^r)^2} - 1 = 0 \quad \text{at } B^*(\pi_A) \end{aligned} \tag{5}$$

The first order conditions yield that each party's optimal investment depends on the other party's probability of playing: $A^*(\pi_B) = \pi_B r/4$ and $B^*(\pi_A) = \pi_A r/4$.[8]

A stable equilibrium is reached with respect to the parties' probabilities to participate when each party participates in the game with a probability that makes the other party indifferent between participating and not participating. In this sense, the equilibrium requires, for example, that π_B should be such that party A earns the same net benefit from participation as he does from exit.

If π_B were higher than this critical value, party A would never participate in the game, as the net benefit from doing so would be lower than the net benefit from exit. This would resuscitate the paradox, because B would anticipate this option and lower his level of effort below B^*, as he expects never to have to compete with A for the rent. In turn, A's costs of participation would be lower, and he would be re-induced to participate.

If π_B were lower, party A would always participate, but this would induce party B to increase his or her effort over B^*, as he or she always expects to compete with A for the rent. This would raise the participation cost for A and push back towards exit. In this case, the paradox arises again.

It is important to note the following. The net benefit from exit is equal to zero (the party earns nothing and makes no effort). Since in equilibrium a party is indifferent between participation and exit, the equilibrium net benefit from participation must also be equal to zero. Therefore, the equilibrium levels of π_A and π_B may be found by setting S_A and S_B in Equation (4) equal to zero. Substituting $A^*(\pi_B)$ and $B^*(\pi_A)$ in Equation (4), we obtain $\pi_A^* = \pi_B^* = 4/(2+r)$. Consequently $A^* = B^* = r/(2+r)$.

The fact that the net benefit from participation is zero should not be surprising. When r reaches the value of 2, the parties' net benefits fall to 0. For values of $r < 2$, the net benefit is positive and thus parties always participate in the game. For $r = 2$, parties participate with zero profits. For $r > 2$, parties' net expected benefits remain at zero, while their participation in the game becomes less frequent. A negative expected benefit would give rise to Tullock's paradox, but so would a positive expected benefit. In fact, if the net benefits were positive, parties would always participate, which would in turn give them incentives to increase their efforts and drive the net benefit towards a negative value, thereby reproducing Tullock's paradox.

When $r > 2$, one party's participation in effect prevents the other party's undisturbed conquest of the prize. By gauging their respective participation levels, they drive their net expected benefits to zero. The understanding of the parties' mixed-participation strategies provides a common ground in the debate between the proponents of mixed-strategy solutions (Baye et al., 1994; Hillman & Samet, 1987a; Pérez-Castrillo & Verdier, 1992) and the conceptual challenges posed by Tullock (1985, 1987, 1995).

The reader may easily verify that while A^* and B^* still increase in r, the rate of the increase is lower than in the case of $r \leq 2$ (it is $\pi/4$ instead of 1/4, where $0 < \pi < 1$). On the contrary, π_A and π_B decrease in r, that is, parties tend to play less often the more effective their investments become, even though, when they play, they spend more, and typically more than their shares in the rent. It is also important to notice that π_A and π_B are equal to 1 at $r = 2$ and they remain positive for any $r > 2$, decreasing asymptotically towards zero as r reaches infinity.

Figure 1 shows how the parties' expenditures and probabilities of participation vary with r and compares our results for the game with exit option with the effort exerted if the exit option is not available. Since parties' investments

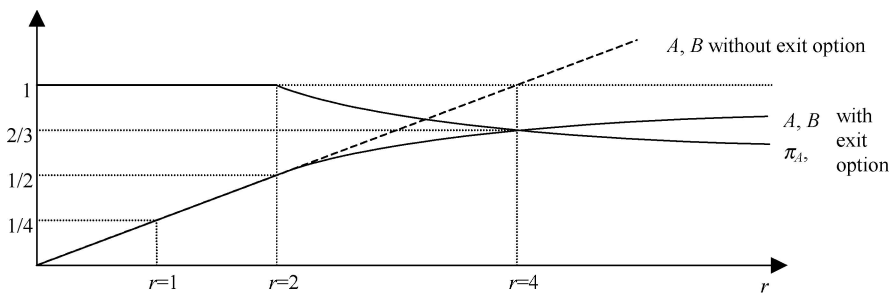

Figure 1. Parties' investments and probabilities of participation in the rent-seeking game.

increase over $1/2$ when $r > 2$, when both parties play, the rent is in fact over-dissipated.[9] However, as we will discuss in the following section, in expectation rents are never over-dissipated, as there exist positive probabilities that only one party plays (and each party's investment only asymptotically approaches 1) or that neither party plays.

Rent dissipation and lost treasures: Bridging the gap

The use of mixed strategies has effects on two important dimensions of the rent-dissipation problem: (a) the amount of total rent dissipation and (b) the likelihood that some valuable rent may remain unexploited.

The dissipation of the rent is given by the sum of the parties' investments weighed by the probability that they play:

$$\begin{aligned} D &= \pi_A^* \pi_B^* (A^* + B^*) + \pi_A^* (1 - \pi_B^*) A^* + (1 - \pi_A) \pi_B^* B^* \\ &= \pi_A^* A^* + \pi_B^* B^* \end{aligned} \quad (6)$$

In equilibrium, the dissipation is equal to $D(r) = 8r/(2 + r)^2$. It is easy to show that the dissipation decreases as r increases. In fact $\partial D/\partial r = 8(2 - r)/(2 + r)^3 < 0$ for $r > 2$. By analyzing the second derivative,[10] we can draw the dissipation curve as a function of r, initially decreasing at an increasing rate and then asymptotically approaching 0. For values of $2 < r < 4$, dissipation decreases at an increasing rate. At $r = 4$ exactly[11] $8/9$ of the rent are dissipated. After such point, for values of $r > 4$, dissipation continues to decrease with r, but at a decreasing rate.

When parties randomize their participation in the game, there is a positive probability that no party plays and the rent remains unexploited. This lost-treasure loss equals to

$$T = (1 - \pi_A^*)(1 - \pi_B^*). \quad (7)$$

The lost-treasure effect is the consequence of the parties' privately optimal use of mixed strategies. Lost treasures are a byproduct of the parties' uncoordinated optimization efforts. The value of this byproduct is not as such taken into account by the parties.

In real life economic situations, the lost treasure may constitute a real social loss, while in others it may just constitute a forgone reallocation of resources, with no social consequences. When lost treasures constitute a social loss, the total social loss from rent seeking, L, would be given by the sum of the rent-dissipation loss, D, and the expected value of the lost treasure, T:

$$\begin{aligned} L = D + T &= \pi_A^* \pi_B^* (A^* + B^*) + \pi_A^* (1 - \pi_B^*) A^* \\ &+ (1 - \pi_A^*) \pi_B^* B^* + (1 - \pi_A^*)(1 - \pi_B^*) = 1 \end{aligned} \quad (8)$$

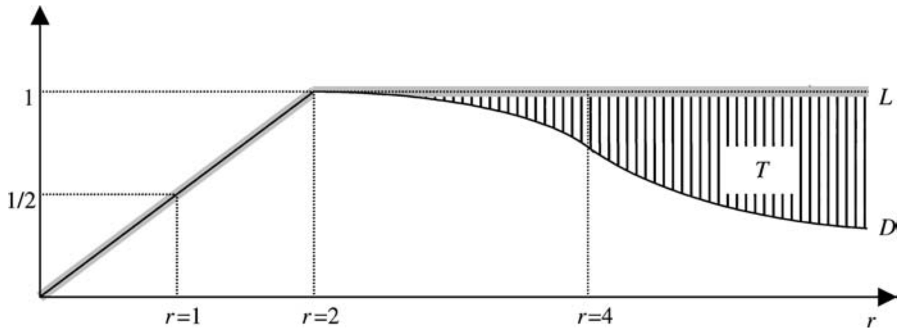

Figure 2. Rent dissipation and lost treasure in the rent-seeking game.

It is important to remember that, when $r \leq 2$, parties' probabilities of participation are both equal to 1; hence there is no lost treasure and $L = D$.

Figure 2 shows how the total cost of rent seeking varies with r. For $r \leq 2$, the dissipation follows the well-known pattern discussed under *The rise of rent dissipation: Dominant strategies for* $r \leq 2$ section. For $r > 2$, if the parties are given an exit option, mixed participation strategies would be used. This leads to a reduction in expected rent dissipation but also to an increase in the probability that valuable rent could be left unexploited.

Figure 2 shows the interesting relationship between the two rent-seeking costs, D and T. Direct rent dissipation due to rent expenditures decreases in r for values of $r > 2$. The expected lost treasure value instead increases in r for values of $r > 2$. Interestingly, the sum of D and T remains constant at 1 for any $r \geq 2$. This means that whatever reduction in direct rent-dissipation costs would readily increase the lost treasure costs by an equal amount, with a certain full dissipation for $r = 2$ and an expected full dissipation of the rent for $r > 2$.[12]

Conclusion

In this paper, we revisited Tullock's rent-seeking puzzle (Tullock, 1980), showing an interesting relationship between returns to rent-seeking investments and total rent dissipation when parties have an exit option and are allowed to undertake mixed participation strategies. Rent dissipation increases with the return to investment in rent-seeking activities, r, up to the value $r = 2$, when full dissipation occurs, with the social cost of rent-seeking activities equal to the value of the rent. Total expenditures in rent seeking begin to decline after such point, as parties will start using the exit option. With mixed-participation strategies, parties would play less often as r increases, although they would continue to increase their expenditures when choosing to participate. In this case, dissipation of rents results from two different sources:

(i) rent-seeking expenditures (i.e., direct rent dissipation) when parties participate and (ii) unexploited rents (i.e., lost-treasure effects), when parties do not participate. By computing how the sum of the parties' expenditures and the lost-treasure losses vary at the change of r, we can see that the sum of the two costs always amounts to the full value of the rent.

Whether unexploited rents should be computed among the social cost of rent seeking obviously depends on the nature of the situation. Economic rents are often a wealth transfer and an unexploited rent simply means that no transfer will take place, with no corresponding social loss. In this case, our results would more substantially differ from the previous contributions in the literature. When parties start randomizing their participation in the game, for $r \geq 2$, total rent-dissipation decreases with r, rather than increasing. As returns to investment in rent-seeking activities increase, total dissipation asymptotically approaches zero. This effect occurs because the parties internalize the lost rents as private costs, but unexploited rents need not be counted as a social cost. Hence, when r increases over 2 and parties participate less often, the probability that the game does not take place increases, thus reducing the expected social cost of rent seeking.

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Notes

1. See also Rowley (1991) on the central importance of this problem for the theory of rent seeking.
2. Hillman and Samet (1987a) analyzed a slightly different version of the rent-seeking paradox, in which the rent is entirely adjudicated to the highest bidder as in an all-pay auction.
3. Other solutions to Tullock's paradox have been sought by transforming the game into a dynamic one and by introducing asymmetries between the players.
4. See also comment in Tullock (1987) and reply by the authors (Hillman & Samet, 1987b).
5. See also comment in Tullock (1995).
6. In order to keep notation simple, we model the parties' investment in rent seeking as fractions of the rent. The literature has usually used capital letters like X and Y to denote the *absolute values* of the parties' expenditures in rent seeking and $X/(X+Y)V$ and $Y/(X+Y)V$ to denote the parties' shares in the rent. Party X's payoff thus is generally represented as $X/(X+Y)V - X$ (the portion of the rent he or she earns minus the rent-seeking expenditure). In our model we use the labels A and B to denote the *fractions* of the rent that are spent on rent seeking, rather than the absolute values of the expenditures. In our model, therefore $A = X/V$. This merely represents a different way to measure effort, and it does not impinge upon the generality or the validity of the model. In our model, party A's payoff is $A/(A+B)V - AV = [A/(A+B) - A]V$. The absolute value of the rent, V, can thus be simplified (or simply normalized to 1), allowing us to concentrate on the parties' expenditures and the magnitude of the dissipation as fractions of the rent.

7. The second order conditions for this problem are $\partial^2 S_A/\partial A^2 = [-(A^r + B^r) + r(B^r - A^r)][rA^{r-2}B^r/(A^r + B^r)^3]$ and $\partial^2 S_B/\partial B^2 = [-(A^r + B^r) + r(A^r - B^r)][rA^r B^{r-2}/(A^r + B^r)^3]$. The reader may easily verify that the necessary values $\partial^2 S_A/\partial A^2 < 0$ and $\partial^2 S_B/\partial B^2 < 0$ are always guaranteed by $A = B$ for any value of r. This formulation is analogous to Baye et al. (1994).
8. From Equation (5) we obtain $\pi_A A = \pi_B B$. That parties take $A = B$ follows from the symmetrical nature of the game. Our results are derived by substituting $A = B$ into Equation (5). The results presented later in the text confirm, as it is obvious, that $\pi_A = \pi_B$. The second order conditions are analogous (but for the terms π_A and π_B) to those in footnote 7.
9. This result is qualitatively analogous to Baye, Kovenock, and de Vries (1999).
10. $\partial^2 D/\partial r^2 = [-2^4/(2 + r)^6][2^4 + r(2^3 - r^2)]$, which is negative for $2 < r < 4$, equal to zero for $r = 4$, and positive for $r > 4$.
11. This point may be connected with Tullock's original analysis (Tullock, 1980). In Tullock's model, at $r = 4$ each party spends the whole rent in rent-seeking investments. In our model, this result only obtains at the limit, when r approaches infinity. At $r = 4$, each party is only spending 2/3 of the rent.
12. In Pérez-Castrillo and Verdier (1992) and Hillman and Samet (1987a) the dissipation is always equal to 1. In Baye et al. (1994) the dissipation is lower than 1. These results are driven by the different models they employ.

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