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Abstract. A growing empirical literature links natural resource abundance and "pointiness" to impeded economic growth and civil strife. We develop rent seeking and conflict models that capture the most salient features of contests for resource rents, and show how both resource abundance and geographical clustering can be associated with intense contests and sub-optimal economic performance. However, we also show that these relationships are not necessarily monotonous – pointiness can trigger more intense contests but can also facilitate the coordination on peaceful outcomes. Finally we show that contesting resources through violent conflict may yield superior outcomes (from an economy-wide perspective) than contests through rent seeking.

1. Introduction

Conventional wisdom suggests that having access to greater quantities of inputs should lead to higher levels of output. This expectation has been challenged for natural resource endowments. Recent empirical work suggests that resource rich countries tend to grow slower than their resource poor counterparts (Sachs & Warner, 1997, 2001), and are more prone to suffer from civil strife (Collier & Bannon, 2003) and rent seeking (Leite & Weidmann, 1999; Auty, 2001a; Torvik, 2002). For these reasons natural resource abundance has been coined a curse for development rather than a blessing.

There exist competing explanations for the mechanism linking resources to conflict and impeded growth. One prominent hypothesis that is gaining momentum highlights the adverse implications of resource richness on institutional quality (Isham et al., 2003). In particular, empirical work suggests an inverse relation between so-called "point resources" and institutions or governance proxies (Leite and Weidmann, 1999; Isham et al., 2003, Bulte et al., 2005). Not surprisingly, therefore, it appears that economies that are abundantly endowed with *diffuse* resources (resources spread thinly across space), typically grow faster than countries with resources that are geographically clustered (or "*pointy*"). Similarly, Ross (2004b) shows that pointy resources trigger and prolong conflicts whereas diffuse resources do not. Pointiness therefore appears to matter, and arguably deserves a more prominent place in economic theory than it currently occupies.

In light of the empirics two important questions emerge. First, what is the causal mechanism linking natural resource abundance to economic performance, rent seeking and conflict, and why do point resources have a more pronounced and negative impact on the fate of economies than diffuse resources? Second, how do resources and their geographical distribution impact on income distribution and thus, indirectly, on institutional quality? To address these issues we develop simple rent seeking and conflict models, and explore how resource abundance and pointiness affect the incentives of agents to divert resources away from production and toward contesting activities. Such activities are not productive, but merely intend to redistribute the surplus. We do not model institutional quality directly, but note that this is likely associated with income distribution (e.g. due to envy, social tension and the ensuing division of power – see also Engerman & Sokoloff, 2000; Bourguignon & Verdier, 2000).

There are two relevant but rather separate streams of literature that feed into the problem we analyze. One literature examines the inverse relation between resources, rent seeking and growth. This literature started out as mainly empirical in nature, but recent years have also seen theoretical explorations into the nature of the resource curse.[1] The second literature focuses on the relation between resources and conflict.[2] we pull together elements of these different literatures, and analyze the effects of resource abundance and pointiness on contest intensity, income distribution and aggregate output. We therefore identify both direct and indirect channels through which resources and the implied incentives for conflict affect economic outcomes.

Our main findings are as follows. First, and not surprisingly, we demonstrate that resource abundance induces a re-allocation of effort from production toward rent seeking or conflict. However, the effects of increased pointiness are less straightforward, and we show that more pointy resources may be more or less heavily contested. Second, we show that resource abundance and pointiness could promote an unequal distribution of income between groups in society, regardless of whether resources are contested through rent seeking or conflict. And third, unlike earlier work (as discussed by, say, Neary, 1999), we find that contesting resources through conflict may yield more favorable outcomes for the economy as a whole than contesting resources through rent seeking. This result follows from our specification of conflict in the context of fighting over resource rents (which differs from the standard specification of conflict models).

The paper is structured as follows. Section 2 introduces the basic features of the model, including our interpretation of "resource pointiness", and presents the "contest game" in a general form (encompassing the rent seeking and conflict model as two special cases). Section 3 considers the rent seeking model. A crucial assumption is that contesting resources does not affect production possibilities elsewhere in the economy. We demonstrate that the degree of resource pointiness determines which kind of equilibrium will arise. In Section 4 we allow for the possibility that a contest for resources *does* adversely affect production. Production possibilities may be curtailed, for example, because of factors like reduced trust and safety, or a deterioration of the physical infrastructure or social capital. Since these factors are associated with violence we interpret the model in Section 4 as a conflict model. Section 5 concludes, and we contrast our model outcomes to stylized facts about resource abundance, pointiness and economic performance.

2. The Basic Setup

There are different approaches to modeling "contests". Economic literature distinguishes between rent seeking models and conflict models. A common element is that agents have to decide about the optimal allocation of their endowment between two activities: redistribution (contesting a certain prize) and production. Rent seeking models, typically, are of a partial equilibrium nature – both the size of the prize that is contested and the opportunity costs of effort devoted to redistribution (or the foregone returns to production) are fixed and independent of rent seeking decisions. Conflict models, in contrast, capture general equilibrium effects. They differ from rent seeking models because both the contested prize and the opportunity cost of effort are endogenously determined. The prize is typically a measure of aggregate production in the economy – people contest the surplus that they create themselves. This implies that the net benefits from production (the share of own production that agents are able to retain for themselves, or the private opportunity cost of redistribution) are affected by aggregate decisions with respect to the allocation of the endowment.[3]

The differences between the modeling approaches of rent seeking and conflict have several implications (see Neary, 1997 for an overview). One important consequence is that rent seeking generally results in more favorable outcomes for the economy than conflict. Ceteris paribus, the aggregate value of endowments wasted in conflicts exceeds that wasted during seeking rents. However, it is important to realize that this outcome is an artifact of the way economists model conflicts. In the context of conflicts over access to resource rents in the "real world", moreover, it is not at all obvious that the standard conflict model provides a suitable specification. After all, the purpose of the contest is to gain access to resources and not to gain access to each other's output. This has as an important consequence that agents can opt out of the conflict game – leaving the resources to the rival fraction.[4]

In this paper, therefore, we have chosen to approach "conflict" rather differently. First, we recognize that agents may dispute a given resource base. This implies a feature shared with the standard rent seeking models where a given prize is contested. But, second, we also recognize that violent conflict may affect production possibilities elsewhere in the economy through potentially adverse effects on social and physical infrastructure, limited opportunities for trading and communication, etcetera. In other words, we assume that the opportunity cost of conflict is endogenous – labor allocated to production is more productive in times of "peace" than in times of "war". This feature, obviously, is unlike the standard rent seeking model, but it is consistent with intuition and supported by observations about the deteriorating impact of violent conflict on production possibilities in real life (Collier & Bannon, 2003).

We start by developing a general contest model.[5] Consider an economy that consists of two (risk neutral) groups or tribes, each consisting of a number of members or agents, E_i, $i = 1, 2$. One agent is the tribe leader, akin to a social planner, who decides on the allocation of tribe labor between production or redistribution. Redistribution implies engaging in the contest for controlling the natural resource. Define the number of people allocated to production as W_i, and the number engaged in the contest as F_i, where $W_i + F_i = E_i$. The payoff from working is given by a production function, exhibiting constant returns to scale.[6] To keep the model as simple as possible, labor is the only production factor and we assume it is a homogenous input (i.e. we do not account for skill differences and entrepreneurial talent, but see Sachs & Warner, 2001; Torvik, 2002; for rent seeking models with heterogenous agents). Denoting the production function by $f(W_i)$, we write:

$$\Pi_{iW} = f(W_i) = A_j \cdot W_i \quad i = 1, 2 \quad j = C, P \quad 0 < A < \infty, \tag{1}$$

where Π_{iW} is tribe i's payoff from working and A is a parameter, the magnitude of which may depend on whether the contest is characterized by violent conflict. The subscripts C and P indicate whether the tribe is engaged in the contest or not (C is short for contest and P is short for peace). For the rent seeking model in Section 3 we assume $A_C = A_P$, so the opportunity costs of the contest are fixed – the rent seeking activity does not disrupt production elsewhere in the economy. For the conflict model (Section 4), instead, we assume that $A_C < A_P$ to reflect the disruptive effects of war. We also assume that the production function is the same for both tribes, and that production industries are disconnected (no overlap in the production sectors of the two tribes).

The expected payoff from contesting is given by:

$$\Pi_{iF} = p_i(F_i, F_j) \cdot R, \tag{2}$$

where Π_{iF} is tribe i's expected payoff from contesting and R is the total value of the natural resource in the common pool. The specification in Equation (2) is a common approach in the contest literature. The term $p_i(F_i, F_j)$ is a so-called contest success function (CSF in what follows). The CSF determines the share of the resource that tribe i will obtain, given it allocates F_i people to the contest and the other tribe allocates F_j members to the contest. Different suggestions for functional forms of the CSF have been advanced. In this paper we adopt the following specification:

$$\frac{p_1}{p_2} = \left(\frac{F_1}{F_2}\right)^m, \tag{3}$$

which can be rewritten as

$$p_1 = \frac{F_1^m}{F_1^m + F_2^m}, \tag{4}$$

and $p_2 = (1 - p_1)$.

One of the innovations of this paper is our interpretation of the parameter m.[7] We argue that $m > 0$ may be treated as a proxy for pointiness of the contested resource – the larger this parameter, the "pointier" the resource. To get some intuition, consider Figure 1, which plots expected benefits from contest of tribe 1 for a range of different contest levels (i.e. varying F_1 for given F_2) and different values of the parameter m.[8]

Figure 1 has two limiting cases. As m approaches zero, the function becomes a flat line and, regardless of contest effort, the success probability of tribe 1 is always 1/2. As m grows larger, the function changes such that a given difference in contest effort has greater influence on the success probability of the tribes. In the extreme, as m approaches infinity, the CSF approaches a step function: a marginally higher value of F_1 compared to F_2 implies that the entire resource is allocated to tribe 1 – and vice versa for $F_1 < F_2$. The

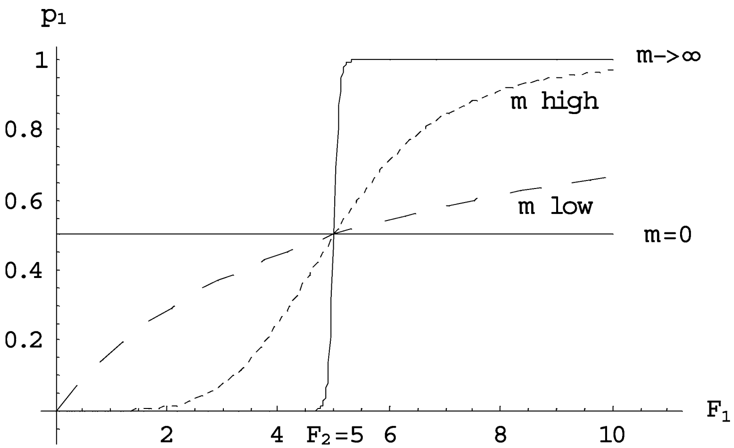

Figure 1. Contest success function for $F_2 = 5$.

case of $m = 1$ represents a natural benchmark in the sense that the share of the resource that is controlled is proportional to contest effort. We explore what happens when m increases so that the distribution becomes increasingly skewed toward the more powerful tribe.

We postulate that pointiness affects economic outcomes because different degrees of geographical clustering reflect different costs of controlling the resource. When resources are clustered they are easier to grab and control, or easier to defend against rivals – defensive activities need not be spread out across space. More pointy resources therefore are more likely to be controlled by certain groups in society, excluding others (Engerman & Sokoloff, 2000; Isham et al., 2003; Ross, 1999, 2004b). Similarly, pointiness likely matters when agents are rent seeking. Extremely clustered resources are more likely to end up under the control of a small group of agents than resources that are spread across space, if only for administrative reasons. This is consistent with the picture that emerges from Figure 1. As pointiness increases, the resource contest more closely resembles a winner-takes-all contest. In contrast, for low m values the resource is diffuse. A small difference in contest effort, then, has little impact on the allocation of the resource.

We approach the resource contest as a two-stage game. In the first stage the tribe leader decides to enter the contest or not. Based on these choices, he acts accordingly in stage 2 and optimally chooses contest effort and production effort. If the tribe leader chooses not to enter the contest, instead, he devotes all effort to peaceful production. The game is solved by backwards induction, i.e. we first solve the tribe leader's problem in stage 2 and with this knowledge go back to solve for optimal behavior in stage 1.

2.1. *The second stage*

If a tribe leader decides not to enter the contest, aggregate tribe income is $E_i \cdot A_P$, where A_P denotes the constant returns in peaceful production.[9] If, in contrast, a leader opts for contest, aggregate tribe income is the sum of income from production and contesting. Contest income is determined by taking into account the opposing tribe's actions. If one tribe enters and the other tribe does not, it is optimal for the first tribe to allocate a tiny fraction ϵ of his effort to the contest and secure the full resource.[10] Aggregate income in this case is simply $R + (E_i - F_i)A_P$, with $F_i = \epsilon$ (and $\epsilon \to 0$).

If, in contrast, both tribes enter the contest, the payoffs are determined by a Cournot game. To find the Cournot equilibrium we first establish optimal responses of tribe leaders to each others' actions. We consider each tribe's optimal decision in turn. Tribe leaders maximize expected payoffs:

$$\Pi_i = \Pi_{iW} + \Pi_{iF} = f(W_i) + p_i(F_i, F_j) \cdot R \tag{5}$$

by optimally choosing W_i and F_i, respecting the endowment constraint. Solving this problem yields a first-order condition stating that the marginal returns to both activities must be equal in an optimum:

$$\frac{\partial f(W_i)}{\partial W_i} = \frac{\partial p_i(F_i, F_j)}{\partial F_i} \cdot R. \tag{6}$$

Given CRS technology, the first-order condition for tribe leader i, given the action of tribe leader j, is then:

$$A_C = \frac{\partial p_i(F_i, F_j)}{\partial F_i} \cdot R. \tag{7}$$

Solving for the Cournot equilibrium gives the equilibrium contest efforts:

$$F_1^* = F_2^* = \frac{mR}{4A_C} \tag{8}$$

From (8) follows that optimal contest intensity is independent of the tribe's endowment (assuming the tribes are sufficiently large for an interior solution to occur, i.e. $E_i \geq \frac{mR}{4A_C}$ for all i). In other words: contest intensity is independent of the relative size of tribes. Both tribes choose the same level of contest effort, and the resource will be split equally between them. Aggregate tribe income in case of a contested resource is therefore given by $\frac{1}{2}R + (E_i - F_i^*)A_C$. Note also that contest intensity is increasing in the pointiness of the resource contested. If the parameter m is large, the marginal return from using more resources in the contest (for any given effort by the other tribe) is higher, thus attracting more resources into the contest from both groups and in turn increasing social waste.

2.2. *The first stage*

After deriving expected payoffs for all potential situations, we now return to the decision of a tribe leader in the first stage. The decision problem can be depicted in a 2×2 matrix.

In Table 1 we assume that resources that are not contested will not be used by either tribe. However, the main results that follow are robust with respect to the main alternative specification that resources are equally shared when uncontested – a result akin to a cooperative outcome.[11] This game gives several possible equilibria[12]. Note that $R + E_i A_P > E_i A_p$, hence (acquiesce, acquiesce) cannot be a Nash equilibrium. The nature of the equilibrium depends on whether the following holds:

$$E_i \cdot A_P > \frac{1}{2}R + (E_i - F_i) \cdot A_C \quad \text{for all i.} \tag{9}$$

Table 1. The game matrix

	Tribe 2			
	Acquiesce		Contest	
Tribe 1				
Acquiesce	$E_1 \cdot A_P$		$E_1 \cdot A_P$	
		$E_2 \cdot A_P$		$R + E_2 \cdot A_P$
Contest	$R + E_1 \cdot A_p$		$\frac{1}{2}R + (E_1 - F_1)A_C$	
		$E_2 \cdot A_P$		$\frac{1}{2}R + (E_2 - F_2)A_C$

If this condition holds, a coordination game arises. Tribes prefer "acquiesce" or "contest" depending on what the other tribe does. Three equilibria arise in this game: two in pure and one in mixed strategies. The coordinated outcomes (contest, acquiesce) and (acquiesce, contest) are the two equilibria in pure strategies. In the mixed strategy equilibrium tribes sometimes play $F = 0$ and sometimes they play $F = F^*$. Each one of the possible final outcomes – (acquiesce, contest), (contest, acquiesce), (acquiesce, acquiesce) and (contest, contest) – emerges with a certain probability. The probability distribution associated with the mixed strategy is determined by the payoffs in Table 1, and thus depends on parameters. The (contest, contest) outcome will be termed a "contest trap" in what follows. Properties of the equilibria will be analyzed in the next section.

Another outcome is characterized by the following condition:

$$E_i \cdot A_P < \frac{1}{2}R + (E_i - F_i) \cdot A_C \quad \text{for all } i. \tag{10}$$

If (10) holds a game arises in which "contest" is the dominant strategy for both tribes. The unique equilibrium outcome then is (contest, contest). Note that condition (10) is always satisfied if the value of the resource is large enough, i.e. $R > \frac{4E_i(A_P - A_C)}{2-m}$ for all i. However, to focus on the crucial role of resource pointiness (parameter m) we exclude this trivial case in what follows. Also the case where (10) holds for one of the tribes but not for the other one might arise. This possibility is relevant in Section 4.

3. The Rent Seeking Model

In this section we analyse the case where contest does not affect production possibilities, $A_P = A_C = A$, which we term the rent seeking model. Depending on the magnitude of the parameter m (greater than 2 or not) either a coordination game or a game with contest as a dominant strategy emerges. If the resource is sufficiently pointy (if $m > 2$, i.e. if condition (9) is fulfilled) a coordination game arises. If, instead, $m < 2$ (i.e. (10) is fulfilled), then a game with rent seeking as a dominant strategy arises. We refer to $m = 2$ as the *critical m* for the rent seeking model, or $\bar{m}_R$, in what follows.[13]

We now consider the properties of the equilibria arising in the different cases. In what follows we assume that tribe 1 is the bigger tribe, i.e. $E_1 > E_2$. When analyzing the properties of the equilibria we are interested in two issues. First, we are interested in the contest intensity in economies, i.e. $F_1 + F_2$. This is a proxy of resources "wasted" in the contest process – resources diverted away from production. Second, we are interested in the income distribution that eventuates. We aim to establish which tribe benefits most from the resource.[14]

3.1. *The case of $m < 2$: Contest as a dominant strategy*

If the economy is endowed with a rather diffuse resource ($m < 2$), tribes maximize their per capita incomes by choosing some rent seeking. The reason is that contest intensity will be rather low in equilibrium (as m is rather low, see (8)), so losses from rent seeking in terms of production foregone are modest. Contest intensity in the economy is simply:

$$F_1 + F_2 = 2 \cdot \frac{mR}{4A}, \tag{11}$$

which is increasing in m. Income maximizing tribes will sacrifice some production to obtain a share of the resource. And, consistent with intuition and empirical observations, the amount of endowment wasted in rent seeking (i.e. the departure from the aggregate optimum) is larger for more pointy resources. The per capita income distribution is as follows:

$$D = \frac{\pi_1}{\pi_2} = \frac{A - \frac{F_1}{E_1} + \frac{R}{2E_1}}{A - \frac{F_2}{E_2} + \frac{R}{2E_2}} < 1. \tag{12}$$

This result suggests that the smaller tribe is better off. The reason is that for $m < 2$ the tribal benefits from rent seeking outweigh the costs, but the revenues are the same for both tribes ($\frac{R}{2}$), regardless of their size. Since the extra benefits are shared with fewer tribe members in tribe 2, they are better off than members in the large tribe. However, as the resource becomes more pointy (increasing m), the distribution becomes more equal. The reason is simply that the costs of obtaining the resource share go up, but these costs are borne by a larger number of tribe members in tribe 1.

3.2. *The case of m > 2: A coordination game*

The case of $m > 2$ is slightly more complex because different outcomes may emerge. If $m > 2$ neither of the two pure strategies is dominant. There are three possible Nash equilibria, two of which are in pure and one in mixed strategies.

3.2.1. *One tribe grabs all*

The two equilibria in pure strategies can be termed “coordinated outcomes”. Equilibrium strategies in this case are (contest, acquiesce) and (acquiesce, contest). In both of the outcomes induced by those strategies only one tribe grabs the whole resource. Here we consider for expositional purposes the former equilibrium outcome. In this case rent seeking intensity will be very low.

$$F_1 + F_2 = \epsilon + 0 \quad \text{with} \quad \epsilon \to 0. \tag{13}$$

Aggregate output in this case is

$$Y = R + ((E_1 - \epsilon) + E_2) \cdot A \quad \text{with} \quad \epsilon \to 0, \tag{14}$$

which is the maximum possible, as there are virtually no resources wasted in rent seeking. The per capita income distribution is given by:

$$\frac{\pi_1}{\pi_2} = \frac{\frac{R}{E_1} + A}{A} > 1. \tag{15}$$

Obviously the tribe that engages in rent seeking is better off as it receives all the resource rents. Note that this outcome yields a very unequal income distribution, as it is only one of the two tribes that grabs all the resource.

There is also an equilibrium in mixed strategies. Each tribe leader decides for each of the two strategies with a certain probability. The pair of equilibrium strategies is given by (σ_1^*, σ_2^*), with $\sigma_i^* = (\sigma_{iC}^*, \sigma_{iA}^*)$ and where $\sigma_{iC}^*(\sigma_{iA}^*)$ denotes the probability with which tribe i plays strategy contest (acquiesce). Specifically, equilibrium strategies are $\sigma_1^* = \sigma_2^* = (\frac{4}{m+2}, \frac{m-2}{m+2})$. This strategy pair induces a probability distribution over final outcomes. Each one of the four final outcomes may emerge. This is to say, that in addition to the already discussed “coordinated outcomes” also the outcomes (acquiesce, acquiesce) and (contest, contest) may materialize. Each one of the four outcomes emerges with a certain probability, which in this case depends solely on the size of the parameter *m*.

3.2.2. *The uncontested resource*

One possible outcome is that both tribes choose "acquiesce". Of course this is an inefficient outcome as resource (rents) go unused. In a real setting, therefore, such an outcome would not be stable as tribes have a strong incentive to restart the game. The probability of this outcome happening, if a mixed strategy is played, increases with the parameter m. If the resource is pointier, tribe leaders playing a mixed strategy choose more often for the peaceful outcome, because outcomes where both parties enter the contest are costly for both participants (i.e. are characterized by intense competition). As mentioned above, these qualitative results are the same when we assume that the uncontested resource is split down the middle and used by both tribes.

3.2.3. *The "contest trap"*

An interesting possible case emerges when resources are sufficiently pointy ($m > 2$). Given an equilibrium in mixed strategies emerges, there is a positive probability that tribes find themselves in a "contest trap". Since the optimal rent seeking level is linearly increasing in pointiness, contest intensity will be high. For $m > 2$ the value of the resources wasted due to rent seeking exceeds the (tribe's share of the) value of the resource, and both tribes are worse off than they would have been had they opted for "acquiesce" instead. Rent seeking intensity is:

$$F_1 + F_2 = 2 \cdot \frac{mR}{4A}. \tag{16}$$

Consistent with the case of $m < 2$ above we see that the contest becomes more intense (i.e. aggregate output is diminished more) as the resource becomes pointier. The arising per capita income distribution is

$$D = \frac{\pi_1}{\pi_2} = \frac{A - \frac{F_1}{E_1} + \frac{R}{2E_1}}{A - \frac{F_2}{E_2} + \frac{R}{2E_2}} > 1. \tag{17}$$

If tribes find themselves in a contest trap, the bigger tribe is not as bad off as the smaller tribe. The reason is that it can spread the costs of inefficient rent seeking over a larger number of tribe members. Inequality becomes more pronounced as m increases.

3.3. *Summary*

The simple rent seeking model developed confirms a number of expectations and is consistent with several stylized facts. For moderately pointy resources

($m < \bar{m}_R$) we find that increasing pointiness tends to lower aggregate production. And further, increasing m such that $m > \bar{m}_R$ holds, may make economies with easy access to resources even worse off than they would have been without access to resources (that is: if a wasteful contest trap eventuates). Furthermore, increasing m will enhance inequality between tribes and thereby potentially contribute to social unrest. However, increasing pointiness is not always bad. Upon comparing outcomes where $m < \bar{m}_R$ with those where $m > \bar{m}_R$ we note that increased pointiness may also imply a reduction in rent seeking effort. For $m < \bar{m}_R$ rent seeking is a dominant strategy but this is no longer true for $m > \bar{m}_R$.

Note the resemblance of our findings to standard rent seeking models. Most of the literature on rent seeking is concerned with "rent dissipation". This term captures the ratio of resources devoted to (unproductive) rent seeking to the total rent available. It is a well known standard result in this literature that rent dissipation D equals $\frac{m(N-1)}{N}$, where N is the number of parties (tribes) engaging in rent seeking (Nitzan, 1994; Tullock, 1980). D in our model is equal to $\frac{2m}{4}$, where $\frac{2}{4}$ coincides with the term $\frac{N-1}{N}$, because $N = 2$ in our model.

There are two main differences between our approach and standard rent seeking models.[15] One is that in the rent seeking literature it is widely established that rent dissipation will not exceed one, so there will be no over dissipation of rents (for a discussion see Baye et al., 1993). However, our model allows for a "contest trap", where the value of resources wasted in rent seeking exceeds the value of the price. This is due to the existence of a productive sector.[16]

The second main difference in this paper, compared with the standard rent seeking approach, is dealt with in the next section. We remove the usual assumption of a constant and exogenous cost of contesting (rent seeking). In the conflict model below we explore what happens if conflict is costly in terms of reduced production opportunities in the rest of the economy. We will show that under certain conditions this might actually produce more favorable overall economic outcomes.

4. The Conflict Model

In this section we will depart from the assumption that production possibilities are unaffected by contest and turn to the scenario we refer to as "conflict". Specifically, we consider the case where conflict has a deteriorating effect on production: $A_C < A_p$. Interestingly, this deteriorating effect need not imply that the economy as a whole is worse off.

First we consider how $A_C < A_P$ affects the "critical m", or the necessary degree of pointiness where the tribe is indifferent between going to war and acquiesce if it expects that the rival tribe goes to war. This "critical m", (or

$\bar{m}_C$) is found by solving:

$$E_i \cdot A_P = \frac{1}{2}R + (E_i - F_i) \cdot A_C \leftrightarrow m = 2 - \frac{4E_i \cdot (A_P - A_C)}{R} = \bar{m}_C. \tag{18}$$

From this equation follow two results. First, since $A_C < A_P$ it follows directly that $\bar{m}_c < \bar{m}_R = 2$. In other words, the range of values for which the resource is always contested (i.e. $m < \bar{m}_C$) becomes smaller, compared to a rent seeking model. Second, $\bar{m}_C$ is not independent of tribe size, E_i. Specifically, for $E_1 > E_2$ we know that $\bar{m}_C^1 < \bar{m}_C^2$ (i.e. $\frac{\partial \bar{m}}{\partial E_i} < 0$). The larger tribe will "switch" from conflict as a dominant strategy to playing a mixed strategy at a *lower* degree of pointiness. This is natural, as the larger tribe has a larger production sector, and therefore stands more to lose from conflict than the small tribe. This result is reminiscent of the "paradox of power" (Hirshleifer 1991a).

The latter result has an interesting implication. Since tribe size matters in our conflict model we find that there is a smaller range of m values for which "contest" is a dominant strategy for both tribes – the degrees of pointiness where a contest equilibrium is inevitable. This is illustrated in Figure 2 where for $m < \bar{m}_1$ conflict is the dominant strategy for both tribe leaders. For $m \in (\bar{m}_1, \bar{m}_2)$ the resource is uncontested and goes to the smaller tribe. Fighting does not pay for the large tribe but it still does for the small tribe, hence the latter can credibly commit to a conflict strategy. Note that this range gets wider if E_1 and E_2 are further apart: the more unequal tribe size, the more likely is this outcome. If $m > \bar{m}_2$ a coordination game emerges, with the possible equilibrium outcomes already discussed in Section 3.

Upon comparing the outcomes of the rent seeking and the conflict model it is evident that they cannot be unambiguously ranked in terms of welfare losses for the economy. Whether conflict or rent seeking models of contest are to be preferred depends on the degree of resource pointiness. On the one hand, as mentioned above, a wasteful contest equilibrium will not materialize in the conflict model for a range of m values.[17] On the other hand, and opposing

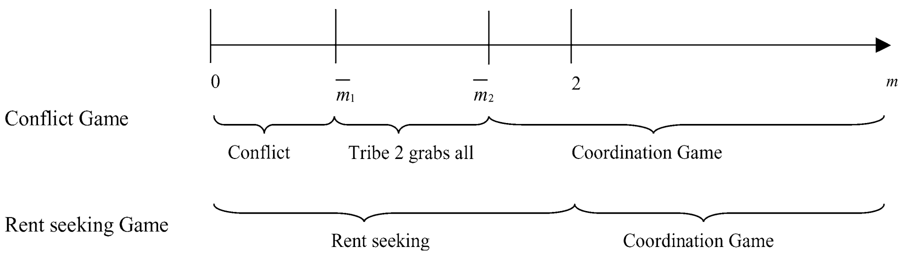

Figure 2. Comparing outcomes for the conflict and the rent seeking model.

the first effect, contest intensity will be greater in case a conflict equilibrium does emerge. For $m < \bar{m}_1$ both tribes will opt for conflict (and they may both do this for $m > \bar{m}_2$), lowering productivity. This reduction in the opportunity costs of conflict implies that optimal contest effort will be higher in a war equilibrium.

5. Discussion

Empirical work suggests that resource abundance and pointiness are significant determinants of economic performance and (civil) war. Using a simple framework we have tried to explore an underlying mechanism that could give rise to both of these phenomena. Our general contest model may be specified as either a rent seeking or a conflict (war) model, and for both specifications we examine how resources impact on the incentives of agents to divert their endowment (effort) away from production and toward redistribution. The results are richer and more subtle than perhaps expected *a-priori.*

Nevertheless, our main theoretical predictions match well with stylized facts. For a range of parameter values we find that increasing pointiness provides an incentive to allocate effort toward contesting. Indeed, we find that the economy as a whole can be made worse off following the discovery of a new resource stock if that resource is sufficiently "pointy" – the potential "conflict trap" equilibrium. However, we also note that the link between resources and conflict intensity is not unambiguous; there are circumstances where more pointy resources may be less heavily contested. This is consistent with findings by Ross, 2004a, who notes that "resources do not necessarily make conflicts longer or more severe – at times they appeared to shorten conflicts and promote cooperation among opposing sides."

We also find that the impact of pointiness on distribution is not straightforward. According to our specification the effect of increased resource pointiness is that the contest more closely resembles a winner-takes-all event. Very pointy resources, therefore, appear to contribute to inequality as they end up being controlled by one tribe.[18] But there is also a range of intermediate parameter values where the resource is contested and where increased pointiness implies a more equal distribution. Per capita income in the disadvantaged (larger) tribe creeps closer to incomes in the privileged (smaller) tribe.

One further result of the model is that contesting resources through the mode of violent conflict (as opposed to rent seeking) may yield superior outcomes for the economy as a whole. Conflict equilibria are less likely to emerge – the fact that the opportunity cost is endogenous facilitates coordination on no-contest outcomes. When conflict arises this is destructive as the productivity in the rest of the economy decreases, thus making this strategy more costly to initiate. Therefore, the economy may end up with one (the smallest) of the tribes grabbing the resource rents without the other entering into the conflict. As a consequence an unproductive "arms race" is not initiated, and little resources are wasted in the conflict. On the other hand if conflict does occur it is more fierce than in the rent seeking case. The presence of conflict lowers the opportunity cost of contest effort and thus intensifies the conflict. The net effect in terms of labor wasted is ambiguous and depends on the degree of resource pointiness.

Finally, the model could be extended in at least two different directions. First, it would be interesting to place the framework in a dynamic setting to enable a firmer link between the theory and the empirical literature on the resource curse (which focuses on average growth rates and not production levels). Second, the model could be enriched by introducing decreasing or increasing returns to scale in the production sector (see, for example, Matsuyama, 1992 for a model with IRS and Hotte et al., 2000 for a model with DRS in manufacturing). Similar as in the conflict model explored above we would find that the returns to labor in production are affected by the allocation of labor. But unlike the conflict specification above the returns would be affected in a smooth and continuous manner, and moving labor from production to contesting could raise (rather than depress) the marginal return to labor in production. Exploring these issues in detail, however, is left for future work.

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6. Appendix

To find the SPNE of the described game, we calculate the best-answer correspondences of the two tribes. We find:

$$b_1(\sigma_2) = \begin{cases} \text{Contest} & \text{if } \sigma_{2A} > \sigma_{2A}^* \\ (\text{Contest, Acquiesce}) & \text{if } \sigma_{2A} = \sigma_{2A}^* \\ \text{Acquiesce} & \text{if } \sigma_{2A} < \sigma_{2A}^* \end{cases}$$

where

$$\sigma_{2A}^* = \frac{-\frac{1}{2}R + E_1(A_P - A_C) + \frac{mR}{4}}{\frac{1}{2}R + E_1(A_P - A_C) + \frac{mR}{4}}$$

σ_{2A}^* denotes the probability with which tribe 2 plays strategy (Acquiesce). Note that $\sigma_{2A}^* < 1$, i.e. (Acquiesce) is never dominant for tribe 1. Similarly, the best-answer correspondence of tribe 2 is given by:

$$b_2(\sigma_1) = \begin{cases} \text{Contest} & \text{if } \sigma_{1A} > \sigma_{1A}^* \\ (\text{Contest, Acquiesce}) & \text{if } \sigma_{1A} = \sigma_{1A}^* \\ \text{Acquiesce} & \text{if } \sigma_{1A} < \sigma_{1A}^* \end{cases}$$

where

$$\sigma_{1A}^* = \frac{-\frac{1}{2}R + E_2(A_P - A_C) + \frac{mR}{4}}{\frac{1}{2}R + E_2(A_P - A_C) + \frac{mR}{4}}$$

Again we see, that the pure strategy (Acquiesce) is never dominant for tribe 2. Note the intuition behind the best-answer correspondences: Tribe i only chooses (Contest) if the probability with which the other tribe chooses (Contest) is sufficiently small (i.e. if σ_{jA} is sufficiently high. Furthermore we find that

$$\sigma_{iA}^* > 0 \leftrightarrow E_j \cdot A_P > \frac{1}{2}R + (E_j - F_j) \cdot A_C$$

Therefore the classification in section 2.2. If

$$E_j \cdot A_P < \frac{1}{2}R + (E_j - F_j) \cdot A_C$$

for $j = 1, 2$ (i.e. if condition (10) is fulfilled), then

$$\sigma_{iA}^* < 0 \quad \text{for all } \ i$$

i.e. the pure strategy (Contest) is dominant for each tribe.

Since we assume $E_1 > E_2$ it could be the case that

$$E_2 \cdot A_P < \frac{1}{2}R + (E_2 - F_2) \cdot A_C$$

but

$$E_1 \cdot A_P > \frac{1}{2}R + (E_1 - F_1) \cdot A_C$$

which implies

$$\sigma_{2A}^* > 0 \quad \text{and} \quad \sigma_{1A}^* < 0.$$

In this case the pure strategy (Contest) is dominant for tribe 2, but not for-tribe 1.

If, on the other hand,

$$E_j \cdot A_P > \frac{1}{2}R + (E_j - F_j) \cdot A_C$$

for $j = 1, 2$ (i.e. if condition (9) is fulfilled), then

$$\sigma_{iA}^* > 0 \quad \text{for all } i$$

By referring to the best-answer correspondences above, we find that there are now three equilibria, two in pure and one in mixed strategies. The two equilibria in pure strategies are: (Contest, Acquiesce) and (Acquiesce, Contest). The one in mixed strategies is given by $((1 - \sigma_{1A}^*, \sigma_{1A}^*), (1 - \sigma_{2A}^*, \sigma_{2A}^*))$. Note that in this general case σ_{iA}^* depends on all the parameters in the model, in particular on E_i. The mixed strategy equilibrium induces a probability distribution over possible outcomes of the game. The probability for each of the outcomes are shown in the following table:

Outcome	Probability
(Contest, Contest)	$(1 - \sigma_{1A}^*) \cdot (1 - \sigma_{2A}^*) = \frac{R}{\frac{1}{2}R + E_2(A_P - A_C) + \frac{mR}{4}} \cdot \frac{R}{\frac{1}{2}R + E_1(A_P - A_C) + \frac{mR}{4}}$
(Contest, Acquiesce)	$(1 - \sigma_{1A}^*) \cdot \sigma_{2A}^* = \frac{R}{\frac{1}{2}R + E_2(A_P - A_C) + \frac{mR}{4}} \cdot \frac{-\frac{1}{2}R + E_1(A_P - A_C) + \frac{mR}{4}}{\frac{1}{2}R + E_1(A_P - A_C) + \frac{mR}{4}}$
(Acquiesce, Contest)	$\sigma_{1A}^* \cdot (1 - \sigma_{2A}^*) = \frac{-\frac{1}{2}R + E_2(A_P - A_C) + \frac{mR}{4}}{\frac{1}{2}R + E_2(A_P - A_C) + \frac{mR}{4}} \cdot \frac{R}{\frac{1}{2}R + E_1(A_P - A_C) + \frac{mR}{4}}$
(Acquiesce, Acquiesce)	$\sigma_{1A}^* \cdot \sigma_{2A}^* = \frac{-\frac{1}{2}R + E_2(A_P - A_C) + \frac{mR}{4}}{\frac{1}{2}R + E_2(A_P - A_C) + \frac{mR}{4}} \cdot \frac{-\frac{1}{2}R + E_1(A_P - A_C) + \frac{mR}{4}}{\frac{1}{2}R + E_1(A_P - A_C) + \frac{mR}{4}}$

Notes

1. Important contributions, highlighting various dimensions of the causal link, include Sachs and Warner (1997), Auty (2001a,b), Gylfason and Zoega (2001), Acemoglu et al. (2001), Sachs and Warner (2001), Torvik (2002), Isham et al. (2003) and Mehlum et al. (2003).
2. The conflict literature was established by theoretical contributions by Hirshleifer (1991a,b), Skaperdas (1992), Grossman (1994), Grossman and Kim (1995), Hirshleifer (1995), and others. Collier and Hoeffler (1998), Baker (2003), Fors and Olsson (2004) and Ross (2004b) explicitly consider the link between conflict and natural resources.
3. If other agents allocate a larger share of their endowment to contesting the prize, or if new agents enter the game, the share appropriated by the individual agent goes down and, hence, the opportunity cost of contesting the prize goes down as well.
4. Note that opting out of a normal conflict model is not feasible – there is no way for individual agents to prevent their own output from being taken by others.
5. The model is general in the sense that it nests a rent seeking and a conflict model. Grossman (2003) has a more general approach that complements ours, where he allows agents to choose the sort of game that they play (in his case: invest in fortifications – perhaps akin to rent seeking in our model –, conflict or do nothing). In our model the nature of the game that is played is exogenously determined – agents cannot choose between rent seeking or conflict.
6. An alternative specification could have decreasing returns to scale in manufacturing (e.g. Hotte et al., 2000). This could reverse some of the effects in our model – the assumption of DRS introduces an offsetting force because labor flows from production to conflict

could raise – rather than lower – the marginal and average productivity of labor in production. The assumption of CRS, instead, allows us to to generate some unambiguous results.

7. Hirshleifer [1995] calls m the "decisiveness parameter" which, in his interpretation, is a measure for conflict technology rather than the characteristics of the prize that is contested. For example, in World War I mainly men and simple (machine) guns were used in combat. Attacks usually did not achieve more than small changes to the front line – decisiveness was very low. On the other hand, in World War II, conflict technology was much more advanced, intensifying the effect of force superiority (think of Hiroshima). This corresponds to a situation with high m.
8. Note that – although it might appear that way – the graphs in Figure 1 are not symmetric around 5. To see this mathematically, note that $\frac{\partial^2 p_1}{\partial F_1^2} < 0 \leftrightarrow \frac{F_1}{F_2} > \left(\frac{m-1}{m+1}\right)^{\frac{1}{m}}$. In the figure we chose $m = 1$ for the "m low" curve, which (as can readily be seen from the second derivative, because $\left(\frac{m-1}{m+1}\right)^{\frac{1}{m}} = 0$) corresponds to a function that is always concave. For the "m high" curve we chose $m = 5$, which corresponds to a function first being convex and then concave. As the resource's pointiness increases (i.e. as m goes up), the gradient of the contest success function at the point $F_1 = F_2$ increases. For sufficiently high m, an inflection point emerges, and the CSF becomes convex-concave.
9. In Section 4 where we model violent conflict we adopt the reasonable assumption that the return to production is only A_F when *both* tribes choose to enter the conflict. There can be no violent conflict unless two tribes allocate some effort to conflict. Note that the payoff structure may be different when there are more than 2 tribes — it would be possible to adversely affect the returns to productive labor of a peaceful tribe when two or more other tribes wage a war. This is ignored in what follows, but the analysis can be extended in a straightforward fashion to capture this possibility.
10. For $F_j = 0$ it follows from (2) that $p_i = 1$, unless $m = 0$ in which case $F = 0$ is always optimal.
11. The only change of assuming a split down the middle instead of an unused resource base is as follows: if the parameters are such that a mixed strategy equilibrium emerges, then the probabilities with which the different strategies are played will be different. This does not affect the main results.
12. For a formal treatment consult the Appendix.
13. The case of $m = 2$ is not interesting as such but merely constitutes a threshold level. Were pointiness exactly such that $m = 2$, either one of the three equilibria in pure strategies (contest, contest), (contest, acquiesce) and (acquiesce, contest) might arise.
14. We compare the evolving income distribution to an initial situation of full equality. This starting point is justified by considering a situation in which both tribes employ all their members in constant returns to scale production, whereby the income per capita would be the same in both tribes.
15. We thank an anonymous referee for pointing this out to us.
16. As Baye et al. (1993) point out, the mutual fighting equilibrium is not a global maximum in standard rent seeking models. In our model the condition introduced in Section 2.1. ($E_i \geq \frac{mR}{4A_C}$ for all i) is sufficient to ensure that the second order condition is satisfied (i.e. a global maximum is reached).
17. Note that in the "conflict model", contest actually arises in fewer cases than in the rent seeking model. Still we believe the wording here is valid, because the effects captured by this model are mainly relevant for the case of violent conflict. In times of violence, productivity is reduced due to the destructive effect of conflict on institutions and infrastructure. Therefore, in cases where conflict does *not* emerge, the "shadow of conflict" still determines the nature of the equilibrium that ensues.

18. That is: unless tribes end up in a conflict trap and share the rents equally. As mentioned above, however, this would imply that both are worse off than they would have been had they specialized in production instead.

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