The Value of Rents and the Likelihood of Conflicts

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April 2008

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JEL: D74-H56
January 2008

Abstract

This paper extends the prey–predator model of Grossman and Kim (1995) to analyze the relation between the value of the contested rent and the emergence of a conflict. We show that an increase in the value of the rent makes the conflict equilibrium more likely. We also analyze the case where the valuation of the rent is different for the two players. We find, for example, that a conflict equilibrium may occur even though the predator has an important disadvantage in warfare. That's when its valuation of the rent is sufficiently high compare to that of the prey.

1 Introduction

The economics of conflict is build on the idea that individuals, tribes or states, allocate their endowments between productive and appropriative activities. One of the main issue is to derive the factors that determine the emergence of conflicts. We adopt the framework of Grossman and Kim (1995, henceforth GK). Two agents divide their endowments in time and effort between the appropriation of an exogenous rent and the production. The effort allocated by the prey is used to defend his initial claims to resources. He moves first and takes into account the reaction of the predator.

We use this analytical framework to address the following questions: What is the relation between the value of the rent and the type of equilibrium, whether a conflict or a no conflict equilibrium? Under what conditions the conflict equilibrium prevails? Does the existence of an asymmetry with respect to the valuation of the rent influence the probabilities of winning?

By our analysis, we want first to explain the fact that natural resources are important factors of conflict between groups. One may then understand the causes of civil wars between a government and rebels. The government can be considered as a first mover player who provides military defense with the objective to protect primary commodity. Collier and Hoeffler (2004) studied the relationship between natural resources and the risk of rebellion. They show that the level of dependence on primary commodity exports affects the risk of conflict.

The present paper builds on GK who distinguish between offensive and defensive activities. They show that security of claims to property does not depend on the size of the contested resource. There is no conflict when the prey has some advantage in that the relative effectiveness of his weapons is greater than a threshold level which is, however, independent of the value of the contested resource. In this paper, by considering a more general specification for the production technology, we show that the relative effectiveness of prey's weapons and the value of the rent matter when analyzing the type of equilibrium that obtains.

Many authors has adopted the prey-predator framework of GK to analyze the relation between the size of the contested resource and the security of claims to property. Their results rests on strong assumptions. Olsson (2007) extends the prey-predator model of GK for her empirical analysis of the relationship between diamond abundance and economic growth. In her theoretical analysis, she shows that whether a conflict equilibrium emerges or not depends on the size of the natural resources under the control of the ruler and contested by rebel. The size effect on equilibrium is captured with a strong assumption : rebel and his opponent in arms, named citizen, have different production functions. The production of the rebel comes from a subsistence activity that is, as in GK, linear in labor. But the production function of the formal sector is of Cobb-Douglas type and, then, depends on labor and capital. This assumption permits the derivation of a closed form solution for the reaction of rebel and makes the profit function of ruler concave. Baker (2003) assumes that the relative effectiveness of the defending group depends negatively on the size of the defended parcel. He shows that larger territories are less likely to be geographically stable. Konrad (2002) adopts a rather different contest success function that allows the prey to win without any effort. He comes to a similar prediction: an increase in the prize under contest increases the likelihood of a conflict. Caselli and Coleman (2006) analyze the role of ethnic cleavage in the likelihood of conflict between a dominant group and a weak group whose members have the possibility to switch to the dominant group. They show that, all other things equal, the probability of conflict is inverted-U shaped in the size of the prize.

The remainder of the paper is organized as follows: In the section

2, we specify the model and notation. Section 3 derives the Stackelberg equilibrium and its properties. Section 4 presents a comparative statics analysis. Section 5 analyzes the case with different valuations of the rent. Section 6 concludes the paper and suggestions for future research are presented.

2 The model

There are two collective entities or "tribes" X, the prey, and Y, the potential predator, with N_X and N_Y their labor endowments. They divide their initial endowments between productive and appropriative activities. Let $f_X(.)$ be the production function of the prey. We assume that f_X is strictly increasing and concave. The production function of the predator $f_Y(.)$ is assumed to be strictly increasing and concave with $f_Y'''' \leq 0$. One have $x + L_X = N_X$ and $y + L_Y = N_Y$, where x and y are the allocations to appropriative activities and L_X and L_Y are the allocations in productive activities. An exogenous rent E is subject to appropriation. We consider a two stage game in which agent X moves first and determines his defensive efforts.

The winning probability p of agent X takes the following form:

$$p = \frac{1}{1 + \theta y/x}$$

where θ is a positive parameter that indicates the effectiveness of the predator's weapons against the prey's weapons.

The final expected wealth for X and Y are respectively

$$U_X = pE + f_X(L_X) \tag{1}$$

and

$$U_Y = (1 - p)E + f_Y(L_Y) \tag{2}$$

3 Equilibrium

To analyze the allocation of time and effort to appropriative activities, we begin by considering the second-stage choice of the agent Y. At this second stage, this agent Y takes x as given and chooses y to maximize U_Y, subject to the constraints $y \geq 0$ and $y \leq N_Y$. We are interested in deriving the conditions under which a conflict does not occur in the equilibrium. That is when the predator allocates no resources to offensive activities. When we deal with internal and domestic conflicts, the latter situation means that the predator "surrender" and gives the prey free reign on the country's resource.

Since π_Y is strictly concave in the strategy y, the maximizer is unique. The solution is characterized by the Kuhn-Tucker conditions of the maximization problem in (2):

$$\frac{\partial U_Y}{\partial y} = -\frac{\partial p}{\partial y}E - f_Y'(L_Y) = 0, \quad 0 < y < N_Y$$

or

$$\frac{\partial U_Y}{\partial y} = -\frac{\partial p}{\partial y}E - f_Y'(L_Y) \leq 0, \quad y = 0$$

or

$$\frac{\partial U_Y}{\partial y} = -\frac{\partial p}{\partial y}E - f_Y'(L_Y) \geq 0, \quad y = N_Y$$

We have

$$\frac{\partial U_Y}{\partial y}(y=0) = \frac{\theta}{x}E - f_Y'(N_Y) > 0 \Leftrightarrow x < \theta E / f_Y'(N_Y)$$

Let $x^* = \theta E / f_Y'(N_Y)$. Two cases hold.

Proposition 1 *When x^* is greater than N_X, then in equilibrium a conflict always takes place.*

This case holds either if the rent E is high enough or if the relative effectiveness θ of the predator is high enough. The production technology also plays an important role in that the conflict equilibrium prevails when the predator has a low productivity. The result of Proposition 1 shows that a rich tribe, or country, has no chance to ensure peaceful coexistence with neighborhoods who are good at warfare and with low productivity.

In the second case, x^* is not greater than N_X. We assume that the constraint $y \leq N_Y$ is not binding[1]. In this case, we obtain:

Proposition 2 *Given the allocation x of the prey, the optimal reaction y of the potential predator is null for $x \geq x^*$ and strictly positive for $0 < x < x^*$ with x and y verifying*

$$\theta E x = (x + \theta y)^2 f_Y'(L_Y) \tag{3}$$

For the remainder of the paper we assume that x^* not greater that N_X. If the prey chooses x smaller than x^*, then the best reaction of the predator is to choose y given by equation (3) and hence a conflict occurs. But if x is not smaller than x^*, then $y = 0$ and the predator allocates all her time endowment in production.

[1] A sufficient condition is that the endowment of the predator in time and effort is sufficiently high, that is $4N_Y > E/f_Y'(0)$.

We consider now the choice of the first stage of the prey. At this first stage, the agent X chooses his defensive efforts x to maximize expected wealth subject to the constraint that $0 \leq x \leq N_X$. When choosing x, the agent X takes into account the reaction of the potential predator describing above.

If $x \geq x^*$, then $y = 0$ and $p = 1$. Equation (1) implies that the expected wealth of the prey is a decreasing function of x. Consequently, the optimal choice of the prey is obtained at x not greater than x^*.

Let's begin by showing that the constraint $x \geq 0$ is not binding. We have:

Lemma 1 *When $x \to 0$, then $y \to 0$ and $y/x \to +\infty$.*

Furthermore, we have:

Lemma 2 *In the limit as x approaches zero, the derivative of U_X with respect to x becomes infinite.*

It follows from lemma 2 that the optimal choice of X is positive. We show next that the type of equilibrium, with or without conflict, depends on the sign of the (left-hand) derivative of U_X at $x = x^*$.

Consider first the case in which the (left-hand) derivative dU_X/dx is negative for $x = x^*$. The X's expected wealth π_X has an interior maximum at a value of x that satisfies

$$\left(\frac{\partial p}{\partial x} + \frac{\partial p}{\partial y}\frac{dy}{dx}\right) E = f'_X(L_X) \qquad \text{with } 0 < x < x^* \tag{4}$$

The first term inside the parentheses captures the direct effect of greater defensive efforts x by the prey on his winning probability. The second term represents the strategic effect of greater defensive efforts through its impact on the predator's reaction. In this case, the prey chooses his defensive efforts x such that the marginal benefit of x equals the marginal opportunity cost of the foregone production. Given that x is smaller than x^*, the conflict equilibrium takes place.

Consider second the case in which the (left-hand) derivative dU_X/dx is not negative at $x = x^*$. We need the following Lemma:

Lemma 3 *For the prey X, the marginal benefit of x in increasing his winning probability is superior to his marginal benefit at $x = x^*$, for all $0 < x < x^*$.*

Let $R = \dfrac{\partial p}{\partial x} + \dfrac{\partial p}{\partial y}\dfrac{dy}{dx}$. By Lemma 3 it comes that $R(x) > R(x^*) \geq f'_X(N_X - x^*) \geq f'_X(N_X - x)$, for all $0 < x < x^*$. Hence dU_X/dx is positive for all $0 < x < x^*$ and the expected wealth of the prey is then strictly increasing. Consequently, the prey chooses his defensive efforts x equal to x^*, and hence there exists no conflict in equilibrium. We summarize the preceding analysis with the following

Lemma 4 *The type of equilibrium, with or without conflict, depends on the sign of the (left-hand) derivative of U_X at $x = x^*$. The no conflict equilibrium holds if and only if this derivative is not negative.*

4 Comparative statics

We show easily[2] that the (left-hand) derivative of U_X for $x = x^*$ is given by

$$\frac{dU_X}{dx}(x = x^*) = \frac{f_Y'(N_Y)}{\theta\left[2 - Ef_Y''(N_Y)/\left[f'(N_Y)\right]^2\right]} - f_X'(N_X - \theta E/f_Y'(N_Y)) \tag{5}$$

Let's consider the special case in which $f_X' = f_Y' \equiv 1$. In this case, explicit solution for equation (3) and well-behaved reduced-form expected wealth function are obtained. Eq. (5) becomes:

$$\frac{dU_X}{dx}(x = x^*) = \frac{1}{2\theta} - 1$$

We then obtain the result derived by GK:

Proposition 3 *When marginal production functions are constant and equal to 1, the type of equilibrium is independent of the value of the rent. In equilibrium, a conflict does not takes place if and only if $\theta \leq 1/2$.*

In contrast, when production functions are nonlinear, the value of the rent may matter. Figures 1 illustrates the following results.

Proposition 4 *For a given value of θ, there are two cases:*
i) If $\theta \geq \frac{f_Y'(N_Y)}{2f_X'(N_X)}$, then the conflict equilibrium holds for all values of the rent.
ii) If $\theta < \frac{f_Y'(N_Y)}{2f_X'(N_X)}$, there exists a threshold level E^* that determines which of the two equilibria holds. A conflict does not take place if and only if the value of the rent E is not greater than E^*. θ and E^* are monotonically and negatively related.

[2] See the proof of Lemma 3 in the Appendix.

Proposition 5 *For a given value of E, there exists a threshold level θ^* that determines which of the two equilibria prevails . A conflict does not take place if and only if θ is not greater than θ^*. Furthermore, θ^* and E are monotonically and negatively related.*

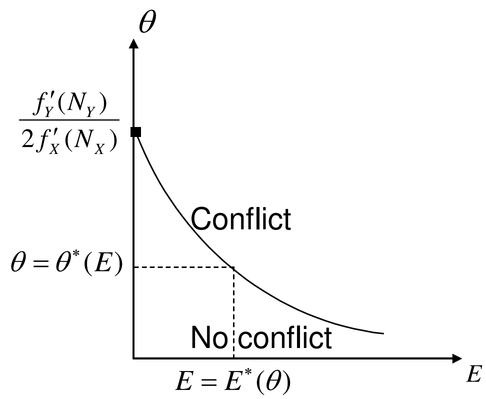

Figure 1: Conflict or no conflict

Propositions 5 shows that the value of the rent is a major determinant of the risk of conflict. Tribes initially well-endowed with resources have a much higher risk of aggression than tribes poorly endowed. More resources require a better fighting efficiency for the prey troops to avoid conflict. The intuition is the following: when the value of the rent is high, the predator has a strong incentive to divert some resources away from production and toward appropriative activities. It follows that the prey needs a high investment in defensive efforts to induce the prey to allocate no effort to predation. But in this situation, a small effort is devoted to production. Since the production function exhibits decreasing marginal productivity, the marginal returns from productive activities will be greater than the marginal returns from defensive efforts. Consequently, the prey prefers to moderate his investment in defensive arms and then aggression occurs.

Considering more general specifications for production technology yields another striking result which contrasts with the result obtained in the Proposition 2. The incumbent may have incentives to deter entry even though it does not exist an advantage for the effectiveness of its armies. For example, the no conflict equilibrium may hold for θ larger than one. That's when $\frac{f'_Y(N_Y)}{2f'_X(N_X)}$ is larger than θ and the size of the rent smaller than E^* (see figure 1).

Collier and Hoeffler (2004) have investigated the causes of civil conflicts. The result of Propositions 4 and 5 may provide rational for their empirical findings. They found that a country with no natural resource exports has a very low probability of a war-start, about one percent. But for countries with a dependence on the primary commodity export, with a share of 32 percent, the risk of civil war is much higher (about 22 percent). If rebels are motivated by natural resources extortion, then these findings are conform with our theoretical results. Collier and Hoeffler found that countries with a very high dependence on natural resource incomes have a relatively lower risk of conflict. Based on our results, a plausible explanation is that, for these countries, the relative effectiveness of government defenses are sufficiently high and then $x^* \leq N_X$ and $\theta \leq \theta^*$. Also, they found that geographic variables affect the risk of conflict. When geographic conditions strengthen rebels, increased population dispersion and mountainous terrain, the risk of conflict increases. Our model suggests that helpful geographic conditions for rebels is synonym of an increase in the relative effectiveness of their arms. Our theoretical analysis predicts that the likelihood of a rebellion increases.

5 Asymmetric valuations of the rent

Consider now the case where the valuation of the rent is different for the two players[3] but agents have perfect information about their opponent's valuations. Let E_X and E_Y represent the valuation of the rent respectively by the prey and the predator. In this case, x^* becomes equal to $\theta E_Y / f'_Y(N_Y)$. Hence, as the valuation of the predator increases, the prey must increase his defensive efforts to induce the predator not to have appropriative activities. Analogous calculations as in the symmetric valuations case yield:

$$\frac{dU_X}{dx}(x = x^*) = \frac{f'_Y(N_Y)}{\theta \left[2 - E_Y f''_Y(N_Y) / \left[f'_Y(N_Y)\right]^2\right]} \left(\frac{E_X}{E_Y}\right) - f'_X(N_X - \theta E_Y / f'_Y(N_Y)) \tag{6}$$

Comparing Eq. (5) and Eq. (6), we see that asymmetric valuations introduce an additional term–the ratio of prey's valuation to the predator' valuation–compare with the case with symmetric valuations. In addition, the other two terms on the right-hand side depends on the valuation of the predator but not of the prey. From Eq. (6) we can deduce that the relative effectiveness of the predator's armies, θ, the predator's valuation, E_Y, and the ratio of the two valuations, E_X/E_Y, determine the type of equilibrium. The introduction of an asymmetry with respect to the valuations of the rent may then modify the type of equilibrium that obtains. When agents are more different in their valuation of the

[3] Stein (2002) and Meland and Straume (2005) analyze contests with asymmetric valuations.

rent, other things equal, with the predator who has the highest valuation, the likelihood of the conflict equilibrium increases. To focus on the impact of the effectiveness of armies and difference in valuations, let us consider, following GK, the special case where marginal productions are constant and equal to 1. Using Eq. (6), one can easily show that the winning probability of the prey is

$$p = \min\left[1, \frac{1}{2\theta}\frac{E_X}{E_Y}\right] \tag{7}$$

GK analyze the symmetric case and comes to the result that the type of equilibrium does not depend on the value of the rent. However, by Eq. (7), when the prey and the predator are asymmetric with respect to their valuations, the type of equilibrium depends both on the effectiveness of their armies and on the ratio of their valuations of the rent. The conflict equilibrium may emerge even though the predator has a clear disadvantage for the effectiveness of her armies. That's when her valuation of the rent is sufficiently high per respect to that of the prey. Furthermore, the probability that the predator wins increases if her valuation of the rent increases, other things equal.

This result is consistent with casual empiricism. Columbus' discovery of the New World led other explorers from Spain to the new world and these explorers, motivated by the desire for gold, conquered the existing ancient civilizations. The Spanish advantage of having horses and guns has been detrimental for their success. But the fact that Incas do not value gold has also influenced the issue of the confrontation. This evidence shows that warfare technology and the valuations of the resource matter for the security of property.

6 Conclusion and extension

In this paper, we show that the value of the contested rent matters when analyzing a prey-predator model. An increase in the value of the rent makes the conflict equilibrium more likely. We also analyze the case where the valuation of the rent is different for the two players. We find, for example, that a conflict equilibrium may occur even though the predator has an important disadvantage in warfare. That's when her valuation of the rent is sufficiently high compare to that of the prey.

This paper has not addressed the related issue of the impact of the value of the rent on welfare. Since the value of the rent has influences the likelihood of conflict, one may expect that its existence may have a negative impact on welfare. Several empirical studies have indicated a negative relationship between natural resource abundance and economic growth (Sachs and Warner, 1997, 2001). However, we show easily that in the context of this model, the gain from the rent outweigh the opportunity cost of arming and then welfare with a rent Pareto superior welfare without the rent[4].

In this paper we assume that no trade takes place between adversaries whether a conflict occurs or not. The relationship between trade and conflict has been examined by Skaperdas and Syropoulos (1996, 2001) in the context of a contest on a part or all the productive resource. The prospect of trade affects the equilibrium allocation and then Skaperdas and Syropoulos compare welfare under trade and welfare under autarky. An extension to the present analysis is to study the relationship between trade, conflict and the value of the contested resource by integrating the negative impact of conflict on trade. Glick and Taylor (2005) find large negative impact of wars on trade[5]. One may then obtain the result that welfare without rent Pareto superior welfare with a rent. Exploring these issues in detail, however, is left for future work.

A Proof of Lemma 1

Eq. (3) yields $\theta E x \geq \theta^2 y^2 f_Y'(L_Y) \geq \theta^2 y^2 f_Y'(N_Y)$. Hence $0 < y^2 \leq Ex/(\theta f_Y'(N_Y))$. It follows that $y \to 0$ for $x \to 0$. Also, it comes from Eq. (3) that $\theta y/x = \sqrt{\theta E/(x f_Y'(L_Y))} - 1$. Since $x f_Y'(L_Y) \to 0$ for $x \to 0$, hence $y/x \to +\infty$ for $x \to 0$.

B Proof of Lemma 2

Let $R = \dfrac{\partial p}{\partial x} + \dfrac{\partial p}{\partial y}\dfrac{dy}{dx}$. Using Eq. (3) and by applying the envelope theorem, we obtain the derivative dy/dx and then we have

$$\begin{aligned}
R &= \frac{\theta y}{(x+\theta y)^2} - \frac{f_Y'(L_Y)}{E}\left\{\frac{\theta E - 2(x+\theta y) f_Y'(L_Y)}{2\theta(x+\theta y) f_Y'(L_Y) - (x+\theta y)^2 f_Y''(L_Y)}\right\} \\
&= \frac{y}{x}\frac{f_Y'(L_Y)}{E} - \frac{f_Y'(L_Y)}{E}\left\{\frac{\theta E(x+\theta y) - 2\theta E x}{2\theta(\theta E x) - \theta E x(x+\theta y) f_Y''(L_Y)/f_Y'(L_Y)}\right\} \\
&= \frac{y}{x}\frac{f_Y'(L_Y)}{E} - \frac{f_Y'(L_Y)}{E}\left\{\frac{\theta E(\theta y/x - 1)}{2\theta^2 E - \theta E(x+\theta y) f_Y''(L_Y)/f_Y'(L_Y)}\right\}
\end{aligned}$$

Hence $R = A + B$ with $A = \dfrac{y}{x}\dfrac{f_Y'(L_Y)}{E}\left[1 - \dfrac{\theta}{2\theta - (x+\theta y) f_Y''(L_Y)/f_Y'(L_Y)}\right]$ and $B = \dfrac{f_Y'(L_Y)}{E}\left[\dfrac{1}{2\theta - (x+\theta y) f_Y''(L_Y)/f_Y'(L_Y)}\right]$. By Lemma 1, it comes that $B \to \frac{f_Y'(N_Y)}{2\theta E}$ and $A \to +\infty$ for $x \to 0$.

[4] For the proof see the Appendix.

[5] See also Pollins (1989a, 1989b), van Bergeijk (1994), and Mansfield and Bronson (1997)

C Proof of Lemma 3

For $x = x^*$, $A = 0$ and $B = \frac{f_Y'(N_Y)}{E}\left[\frac{1}{2\theta - x^* f_Y''(N_Y)/f_Y'(N_Y)}\right]$. For $0 < x < x^*$, $A > 0$. We then need to show that

$$\frac{f_Y'(L_Y)}{E}\left[\frac{1}{2\theta - (x+\theta y) f_Y''(L_Y)/f_Y'(L_Y)}\right] \geq \frac{f_Y'(N_Y)}{E}\left[\frac{1}{2\theta - x^* f_Y''(N_Y)/f_Y'(N_Y)}\right]$$

Since $f_Y'(L_Y) \geq f_Y'(N_Y)$ and $f_Y''(L_Y) \geq f_Y''(N_Y)$, it suffices that $(x + \theta y) \leq x^*$ for each (x, y) verifying Eq. (3). Eq. (3) yields $\theta E x = (x + \theta y)^2 f_Y'(L_Y)$ and $\theta E x^* = (x^*)^2 f_Y'(N_Y)$. Consequently, for $0 < x < x^*$, we get $(x + \theta y)^2 f_Y'(L_Y) \leq \theta E x^* = (x^*)^2 f_Y'(N_Y) \leq (x^*)^2 f_Y'(L_Y)$.

D Welfare analysis

When the valuable resource E does not exist, all the endowment in time is allocated to productive activities; hence, one has $U_X = f_X(N_X)$ and $U_Y = f_Y(N_Y)$. Let analyze the impact of the rent on welfare. For this, we study the change in welfare when the value of the rent becomes positive. By the Lemma 1, it comes that the winning probability p of the prey approaches zero as x tends to zero, and hence, his expected welfare tends to $f_X(N_X)$. Lemma 2 gives that U_X is increasing for x sufficiently small. It follows that the prey benefits from the existence of the contested rent, whether a conflict takes place or not. For the predator, her expected welfare is not modified when a conflict does not occur in equilibrium. We show next that her expected welfare increases when a conflict takes place in equilibrium. By the mean-value theorem and the fact that the function f_Y' is nonincreasing, we have $f_Y(N_Y) - f_Y(L_Y) < y f_Y'(L_Y)$. Eq. (3) yields $f_Y'(L_Y) = \theta E x/(x + \theta y)^2$. Since $y > 0$, it follows that $(x + \theta y)^2 > x(x + \theta y)$, and therefore $f_Y(N_Y) - f_Y(L_Y) < (1 - p)E$.

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