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Abstract

This paper investigates the impact of land inequality on conflict intensity. A fundamental distinction with the existing literature lies in the nature of inequality under consideration. We investigate how land inequality *across landlords only* influences the intensity of the fight against a rebel group constituted by landless individuals. We show that conflict intensity is non-monotonic in land inequality. In particular, the most severe conflicts occur for intermediate land inequality levels. Moreover, a Pareto improving transfer of land from the smaller to the larger landlord may exist.

Keywords: Conflict; Land redistribution; Inequality
JEL classification: Q15; D74; H41

1 Introduction

Land related conflicts represent a cost for society. In addition to the losses caused by diverting productive resources to fighting, there are relevant costs resulting from the uncertain economic environment and physical destruction (Deininger, 2003; Binswanger and Deininger, 2007). Latin American recent history provides several cases of land related struggles. The on-going Colombian conflict initiated in the early 1950s constitutes perhaps a famous example. Although the *guerrilla* might no longer fight for land nowadays, it is hardly disputable that land redistribution was initially one of its central goals. According to some estimates the FARC (Revolutionary Armed Forces of Colombia) alone occupies some 20,000 people, the ELN (National Liberation Army) around 5,000 more individuals, while the conflict has caused several tenths of thousand victims over the last decades (Restrepo et al., 2003). In Brazil, a history of failed land reforms along with policies benefiting the wealthy elite accelerated land concentration and exacerbated rural poverty (Graham et al., 1987). Starting in the mid-1980s, the Landless Farmworkers' Movement (MST) organized to occupy idle farmland and to demand expropriation under the slogan "Agrarian Reform, by law or by disorder" (Hammond, 1999). Alston et al. (1999) report a yearly average of 500 land related conflicts throughout the country over the period 1986-1997. The usual response of landlords has been to evict the squatters with greater or lesser violence depending on negotiations between the occupiers and the authorities. Given this unsafe environment, landowners often hire thugs

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or paramilitary forces to intimidate and harass the occupiers, especially during early occupation. Guatemala's Guerrilla Army of the Poor (EGP), active between 1972 and the peace agreement in the 1990s, and Peru's Shining Path movement constitute other examples of armed rebel groups fighting for land.

A recurrent feature of the aforementioned conflicts is the existence of a wealthy landed aristocracy, typically descending from colonial settlers, owning most of the land (Engerman and Sokoloff, 2000; Binswanger and Deininger, 1997), and of a mass of landless individuals prone to develop antagonistic feelings towards landlords. Inequality as a driving force of conflicts has been widely investigated. One strand of the literature argues that strong grievance feelings may trigger internal conflicts (Gurr, 1970; Migdal, 1974; Scott, 1976). This thesis seems to be supported by the findings of Hidalgo et al. (2007) who use Brazilian data to point out that "in highly unequal municipalities, negative income shocks cause twice as many land invasions than in municipalities with average land inequality". Other scholars rather emphasize the rapacity motivation of the rebels (Muller and Selingson, 1987; Collier and Hoeffler, 2004)[1]. Esteban and Ray (1999), on the other hand, argue that what matters for the emergence of conflicts is the polarization of the society more than inequality, where polarization is a measure of "the sum of interpersonal antagonisms". In a later article, they show that polarization is also associated with more intense conflicts (Esteban and Ray, 2008).

In this study, we investigate the impact of land inequality on conflict intensity. A fundamental distinction with the existing literature lies in the nature of inequality under consideration. While most scholars address the effects of inequality *between* the opposing factions, we focus on the impact of inequality *within* one side of the dispute. More specifically, we study how land inequality across landlords influences the intensity of the fight against a rebel group constituted by landless individuals.

This work also relates to the literature dealing specifically with land related conflicts. In an influential paper Grossman (1994) identifies the conditions under which a class of landlords find it profitable to redistribute land when confronted to landless individuals who optimally allocate their time between wage labour, looting, and farming. He shows that land redistribution occurs only when the costs of being looted and of policing such an activity are too high.

We set up a model in which two landlords face a pool of landless individuals with the same occupational options as in Grossman (1994). Landlords have two instruments to cope with the potential looters: redistributing land in order to reduce the pool of unemployed individuals and protecting their property by investing in defence[2]. Unlike Grossman, in our model land redistribution is the outcome of strategic behaviour between landlords. This feature captures the nature of interactions characterizing agrarian societies in weak states. The reduced ability of the central power to provide public goods and to enforce contracts allows a restricted class of landlords to dominate rural affairs. Looting activities are organized by a profit maximizing rebel group which allocates fighters across

[1] The motivations of rebels are also studied by De Nardo (1985), Gurr and Moore (1997), and Gates (2002).

[2] Several alternative tools may serve the same purpose, e.g. income redistribution through taxation, sharecropping contracts, or wage employment. These solutions, however, are subject to commitment issues as landless individuals might keep looting landlords' properties after income transfers occurred, or while employed as contracted labourers (for conflict related commitment problems see Fearon (1995) and Powell (2006)). Land redistribution is immune to this problem as it creates an opportunity cost for the potential looters. Moreover, wage contracts include monitoring costs when effort in agricultural production is not observable, output is characterized by uncertainty, and stealing or sabotage may occur (see for instance Platteau (1992: 211-213), for the example of Mauritania in the 1980's). Finally, Binswanger and Deininger argue that "the fear of impending land reform prompted landowners to reduce their dependence on hired or tenant labor through large-scale eviction . . . [Owners] converted their farms to undertake extensive livestock ranching, which requires very little labor" (1997: 1968).

the two landlords' land. In fact, even if started out of grievances, rebel groups may eventually fight for greed (Weinstein, 2005; Collier et al., 2003).

The main result of this paper is that conflict intensity may be non-monotonic in land inequality. In particular, the most severe conflicts occur for intermediate land inequality levels. Because of the public good nature of land redistribution, rising inequality from a symmetric initial land ownership also increases the degree of free-riding from the smaller landlord. For intermediate levels of land inequality, the burden for the larger landlord of scaling down conflict through redistribution exceeds the cost of fighting the rebels. Consequently, in this range, total land redistribution experiences a substantial drop. Since defence and land redistribution are substitutes, this implies an increase in the intensity of conflict. For larger land inequality levels, however, the bigger landlord internalizes sufficiently the public good to redistribute land on his own. This echoes Olson's (1965) result on inequality and public good provision.

A second result follows directly. We show that it may be in the smaller landlord's interest to transfer land to the larger landowner in order to increase the latter's incentive to redistribute land. This constitutes a Pareto improvement, as both landlords and landless individuals are better-off. By endogenously concentrating land ownership, the landlords overcome the underprovision of public good in a decentralized manner. A similar solution is proposed in Grossman (2002) where producers empower a tax-imposing king to protect their properties from a group of predators.

The remaining of the paper is organized as follows. We first present the model and characterize the equilibria. We then discuss the results of the comparative statics with respect to land inequality. In the last section we conclude.

2 The Model

2.1 General setting

Two landlords, 1 and 2, owning respectively a land plot of size T_1 and T_2, face an external threat stemming from a group of n unemployed individuals[3]. The landlords can redistribute land and/or protect their properties by the use of force. The value of non-farmed land is nil. Landlords simultaneously decide in an initial stage the amount of non-farmed land, r_1 and r_2, they respectively transfer to each unemployed individuals. The total amount of land redistributed therefore equals $n(r_1 + r_2)$. After redistribution the landlords spend all their available time, that we normalize to unity, to farming. We assume a one-to-one production function so that the production of landlord i equals $T_i - nr_i$ ($i \in \{1, 2\}$). Each unemployed agent specializes either in farming the plots of land transferred by the landlords ($r_1 + r_2$), or in migrating to the city to obtain the market wage w, or in fighting within an organized rebel movement. Unfarmed land eventually returns to the landlord who provided it. The organized rebel group optimally allocates fighters across landlords. In particular, t_i rebels loot the production of landlord i. Landlord i chooses his defence level, m_i, given a unit cost of defence c. We assume that the allocation of fighters and the landlords' defence decisions are taken simultaneously and that the fighting technology is described by a Contest Success Function (Tullock, 1967; Hirshleifer, 1989; 1995; Skaperdas, 1992; 1996; Grossman, 1995; Neary, 1997).

The timing can be formally resumed as follows:

Stage 1

[3] To avoid any problem linked to the discrete nature of n, we solve the problem as if it was a continuous variable since proceeding otherwise would add unnecessary complications.

- Each landlord $i \in \{1, 2\}$ decides the land to redistribute to every unemployed individual, r_i, and farms the remaining land, $T_i - nr_i$.

Stage 2

- Each landlord i chooses his defence level, m_i.
- Unemployed individuals decide whether to become peasants, P, migrants, M, or fighters, F.
- The rebel group decides the number of fighters t_i to send against each landlord i, given the total pool of fighters, n_F.
- Unfarmed land returns to the landlord who provided it.

The expected utility of landlord i is given by:

$$U_i = \frac{m_i(T_i - nr_i)}{m_i + t_i} - cm_i \tag{1}$$

where $\frac{m_i}{m_i+t_i}$ is the probability for landlord i of successfully protecting his property against t_i looters, given a defence level of m_i.
Let us denote by j the generic unemployed individual. If j decides to farm the plot of land that the landlords redistributed, his utility equals his farming product:

$$U_{P_j} = r_1 + r_2 \tag{2}$$

where subscript P_j captures j's specialization as a peasant. Equivalently, if j migrates (subscript M_j), his utility equals:

$$U_{M_j} = w \tag{3}$$

Similarly, the utility of j when specializing as a fighter (subscript F_j) is given by:

$$U_{F_j} = \frac{1}{t_1 + t_2}\left(\frac{t_1(T_1 - nr_1)}{m_1 + t_1} + \frac{t_2(T_2 - nr_2)}{m_2 + t_2}\right) \tag{4}$$

where the term in brackets represents the total returns from fighting for the rebel group that are shared equally among fighters.

2.2 Analysis

We solve the game using backward induction, starting from the last stage.

Stage 2

Landlord i chooses $m_i \geq 0$ to maximize (1). That yields:

$$m_i(t_i, r_i) = \sqrt{\frac{t_i(T_i - nr_i)}{c}} - t_i \tag{5}$$

At the same time, the rebel group allocates t_1 and t_2 to maximize (4). At optimality the marginal returns of fighting either landlord are equal:

$$m_1 \frac{(T_1 - nr_1)}{(m_1 + t_1)^2} = m_2 \frac{(T_2 - nr_2)}{(m_2 + t_2)^2} \tag{6}$$

Using (5) and (6) we derive the optimal allocation of fighters as a function of the total number of fighters n_F:

$$t_i = \frac{T_i - nr_i}{T_1 + T_2 - n(r_1 + r_2)} n_F \tag{7}$$

Substituting (5) - (7) in (4), we obtain the utility for a fighter j of joining the rebel group:

$$U_{F_j} = \sqrt{\frac{c(T_1 + T_2 - n(r_1 + r_2))}{n_F}} \tag{8}$$

Unemployed agents individually specialize in the highest yielding activity by comparing the returns (2), (3), and (8). The total number of fighters n_F that follows determines $t_i\,(r_1, r_2)$ in equation (7). Given the complexity of the problem, we make the following assumption:

Assumption 1. $w > \sqrt{\frac{c(T_1+T_2)}{n}}$

This rules out the case where all unemployed individuals join the rebel group. This implies that $n_F < n$ at optimality. In other words, even in the absence of redistribution, the urban wage is sufficiently high to dissuade some unemployed individuals from fighting. In Appendix A.7 we briefly address the consequences of relaxing this assumption.

Depending on the redistribution levels chosen by landlords, two different allocations of unemployed individuals can therefore arise. If farming is more profitable than migration ($r_1 + r_2 > w$), then unemployed individuals specialize in farming and fighting alone. At optimality the returns of both activities are equalized. Indeed, if for instance the return to fighting is higher than farming, some farmers find it profitable to switch activity, thus reducing the utility of fighting until returns are equalized. Setting (8) equal to total redistribution ($r_1 + r_2$) yields the total number of fighters, n_F. Substituting this value in (7) we obtain the number of fighters looting i's production:

$$t_i = t_i^P = \frac{c(T_i - nr_i)}{(r_1 + r_2)^2} \qquad\qquad i \in \{1, 2\} \tag{9}$$

where superscript P refers to the scenario in which some individuals become peasants.

For wage levels exceeding the returns to farming, all unemployed individuals either migrate or join the rebel group. Accordingly, t_i equals:

$$t_i = t_i^M = \frac{c(T_i - nr_i)}{w^2} \qquad\qquad i \in \{1, 2\} \tag{10}$$

where superscript M refers to the scenario in which some individuals migrate.

Notice that the optimal value of $m_i\,(r_1, r_2)$ is obtained by substituting the corresponding value of t_i in equation (5).

From the above analysis a first intermediate result follows:

Lemma 1. *Total resources allocated to conflict (m_i, m_j, t_i, t_j) are decreasing with land redistribution, (r_1, r_2).*

The proof is provided in Appendix A.1

Having fully described the players' behaviour in the second stage of the game, we climb up the decision tree and derive the optimal levels of land redistribution r_1^* and r_2^*.

Stage 1

Landlord i maximizes his utility as described in equation (1), given $m_i(r_1, r_2)$ as determined in (5), and $t_i(r_1, r_2)$ as described by (9) and (10), depending on the redistribution levels.
This yields the following problem:

$$max_{r_i}\left[\frac{t_i(r_1,r_2)}{c}\left(\sqrt{\frac{c(T_i-nr_i)}{t_i(r_1,r_2)}}-c\right)^2\right] \quad \text{where} \quad t_i=\begin{cases} t_i^P & \text{if} \quad r_1+r_2>w \\ t_i^M & \text{if} \quad w>r_1+r_2 \end{cases} \tag{11}$$

The best response function of landlord i is therefore given by:

$$r_i=\begin{cases} r_i^P(r_{-i})=max\left\{\sqrt{\frac{c\left(cn+8nr_{-i}+8T_i\right)}{4n}}-\frac{c}{2}-r_{-i};0\right\} & \text{if } r_i^M(r_{-i})+r_{-i}\geq w \quad (11.1)\\ r_i^M(r_{-i})=0 & \text{if } r_i^P(r_{-i})+r_{-i}<w \quad (11.2)\\ argmax\left\{U_i(r_i^\vartheta(r_{-i}),r_{-i})\right\} \text{ where } r_i^\vartheta(r_{-i})=\{r_i^M(r_{-i}),r_i^P(r_{-i})\} & \text{otherwise} \quad (11.3)\end{cases}$$

Let us consider more closely the conditions in (11.1), (11.2), and (11.3). Notice first that if total land redistribution is not sufficient to induce unemployed individuals to farm, the optimal redistribution is nil since transferring land is costly. This implies $r_i^P \geq r_i^M$. When the condition in (11.1) is fulfilled, $t_i = t_i^P$ even if landlord i provides r_i^M. In other words, even if i does not redistribute land, total redistribution is enough for some unemployed individuals to become farmers $(r_{-i} > w)$. Consequently, $r_i = r_i^P$. The condition in (11.2) captures the opposite situation. Indeed, if redistribution r_i^P does not induce any unemployed individual to farm, then i provides rather r_i^M. Finally, when the landlord's redistribution choice determines the rebels' behaviour (t_i^P or t_i^M) for a given r_{-i}, he follows the utility maximizing strategy (r_i^P or r_i^M). In this last case the best response function may display a discontinuity.

Lemma 2. *Landlords' reaction functions exhibit at most a single discontinuity.*

A formal proof of Lemma 2 is provided in Appendix A.2.

We construct a graphical representation of landlord i's potential best response in Figure 1. The reaction function is segmented in two parts, r_i^M and r_i^P. The downward sloping line $r_1 + r_2 = w$ describes the set of redistribution levels that would make the unemployed individuals indifferent between farming and migrating. Any redistribution (r_i, r_{-i}) below this line represents a waste of land, as no unemployed individuals would farm it. Regions I and III correspond to the conditions in (11.2) and (11.1), respectively. Lemma 2 implies that if a discontinuity in the reaction function occurs, it is necessarily in zone II (boundaries included).
An outward or inward shift of the w-line (large or low wages) may reduce, or even eliminate zone II, which in turn would grant the continuity of the reaction function.

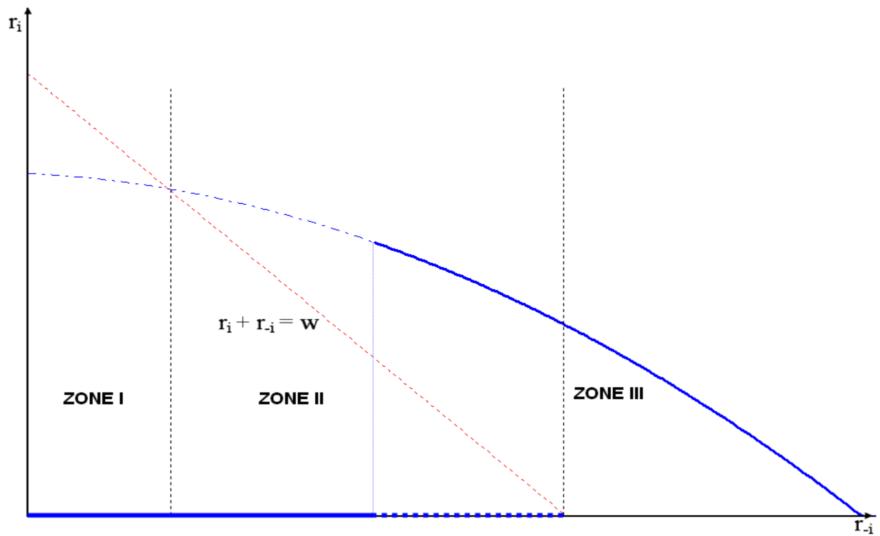

Figure 1: 'Redistribution' best response function of landlord i

2.3 Equilibria

The above discussion indicates that the reaction functions might be non-monotonic. As a consequence, multiple equilibria may arise. In the remainder of this section we describe the possible equilibria in pure strategies. We do not consider mixed strategy equilibria as they do not add any major insight to our results.

P-Equilibrium: positive land redistribution

A P-equilibrium is defined as a pair (r_i^{P*}, r_{-i}^{P*}) satisfying the following two conditions:

$$\begin{cases} U_i^P(r_i^{P*}, r_{-i}^{P*}) \geq U_i(r_i, r_{-i}^{P*}) \qquad \forall r_i \qquad i \in \{1,2\} \\ r_1^{P*} + r_2^{P*} \geq w \end{cases} \tag{12}$$

There exists no profitable deviation from the equilibrium strategy, and the total land redistribution guarantees the specialization of some individuals in farming[4].

Proposition 1. *Assume $T_i \geq T_{-i}$. If $c > \frac{(T_i - T_{-i})^2}{n(T_i + T_{-i})}$, then $r_i^{P*} > 0$ and $r_{-i}^{P*} > 0$. Otherwise,* $r_{-i}^{P*} = 0$.

The condition in Proposition 1 follows directly by imposing a non negativity constraint on the land redistribution level in a P-equilibrium:

[4] In the remaining of the paper we adopt the following notation: U_i^{P*} denotes the utility of i in a P-equilibrium when such an equilibrium exists, r_i^{P*} is the redistribution value such that $r_i^{P*} = r_i^P\left(r_{-i}^{P*}\right)$. Similarly, U_i^{M*} denotes the utility of i in a M-equilibrium when such an equilibrium exists, and r_i^{M*} is the redistribution value such that $r_i^{M*} = r_i^M\left(r_{-i}^{M*}\right)$.

$$r_{-i}^{P*} = \frac{T_{-i} - T_i + \sqrt{cn(T_i + T_{-i})}}{2n} > 0 \tag{13}$$

Only if the condition in Proposition 1 is fulfilled both landlords provide a positive land redistribution in a P-equilibrium. Notice that for symmetric initial land ownership ($T_1 = T_2$) this condition is always fulfilled. Larger inequality in land ownership across the two landlords violates the condition. For these levels of inequality, a P-equilibrium may exist in which only the larger landlord redistributes land.

M-Equilibrium: no land redistribution

A M-equilibrium is defined as a pair (r_i^{M*}, r_{-i}^{M*}) satisfying the following two conditions:

$$\begin{cases} U_i^M(r_i^{M*}, r_{-i}^{M*}) \geq U_i(r_i, r_{-i}^{M*}) & \forall r_i \qquad i \in \{1,2\} \\ r_1^{M*} + r_2^{M*} < w \end{cases} \tag{14}$$

There exists no profitable deviation in terms of land redistribution, and total redistribution makes migration always superior to farming. By using (11.2) we can directly conclude that the second condition will necessarily hold if the first one is satisfied since $r_1^{M*} + r_2^{M*} = 0$.

The two pure strategy equilibria may combine yielding three different equilibrium configurations: a P-equilibrium, a M-equilibrium, or the co-existence of both equilibria. We have drawn those three different equilibrium configurations on Figure 2.

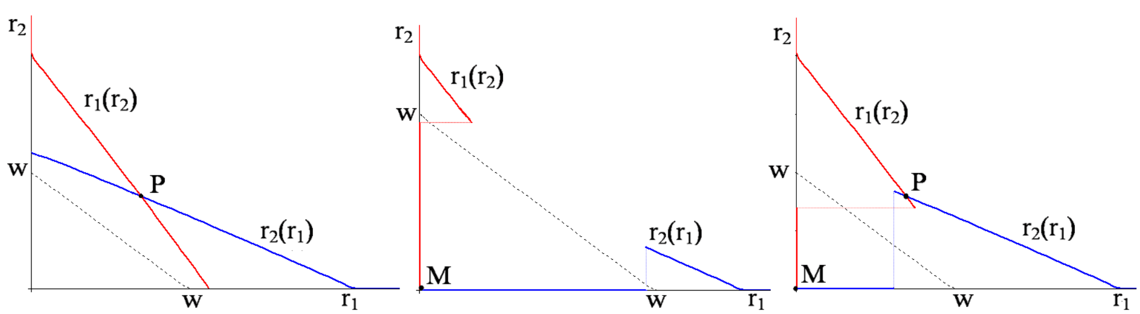

Figure 2: Equilibrium configurations

The following proposition establishes equilibrium existence:

Proposition 2. *A P-equilibrium exists if and only if $U_i^{P*} \geq U_i^M\left(r_i^{M*}, r_{-i}^{M*}\right)$, with $T_i \geq T_{-i}$. If a P-equilibrium does not exist, then a M-equilibrium exists.*

The proof is reported in Appendix A.3.

In the next section we conduct comparative statics analysis to highlight the effects of land inequality.

3 Effect of Inequality

For the purpose of this section, it is useful to report the utility of landlord i in the three potential equilibria. Using (11), and r_1 and r_2 as given by (13) we obtain i's utility in a P-equilibrium with both landlords redistributing positive amounts of land.

$$U_i^{P*} = \frac{\left(\sqrt{T_i + T_{-i}} - \sqrt{cn}\right)^3}{2\sqrt{T_i + T_{-i}}} \tag{15}$$

If the condition in Proposition 1 is fulfilled, then $r_{-i}^{P*} = 0$. By (11) and (11.1) we obtain i's utility in a M-equilibrium:

$$U_i^{P*} = \frac{5cn}{2} + T_i - \sqrt{cn(cn + 8T_i)} + \frac{(cn)^{3/2}}{\sqrt{cn} - \sqrt{cn + 8T_i}} \tag{16}$$

Finally, using (11) and (11.2) we obtain:

$$U_i^{M*} = \frac{T_i\,(w - c)^2}{w^2} \tag{17}$$

We model inequality in land ownership by increasing landlord i's land, keeping fixed total land T. In other words, any change in the land ownership of landlord i, ΔT_i is exactly counterbalanced by a change $\Delta T_{-i} = -\Delta T_i$. A first result of the comparative statics exercise on inequality is presented in the following proposition.

Proposition 3. *Assume $T_i = T_{-i}$ and a P-equilibrium exists. If there exists a level of inequality $\left(T_i^{'}, T_{-i}^{'}\right)$ with $T_i^{'} > T_{-i}^{'}$ such that $U_i^{P*} = U_i^{M*}$, then there always exists another level of inequality $\left(T_i^{''}, T_{-i}^{''}\right)$ with $T_i^{''} \in \left[T_i^{'}, T\right]$ such that $U_i^{P*} > U_i^{M}\left(r_i^{M*}, r_{-i}^{M*}\right)$, $\forall\ T_i \in \left[T_i^{''}, T\right]$.*

For the proof see Appendix A.4.

Proposition 3 focuses on values of parameters for which a P-equilibrium exists under symmetric land ownership. If we increase the land of landlord i, keeping total land constant, the utility of i in the P-equilibrium as displayed in (15) remains constant. This results from two offsetting effects. On the one hand i's utility increases as a result of having more land. On the other hand, however, as the other landlord's plot is smaller than in the symmetric case, the rebel group has an incentive to reallocate some fighters against i. This, in turn, pushes the smaller landlord to reduce his land redistribution. Indeed, in our model land redistribution may be interpreted as a public good, as it reduces *for both landlords* the number of fighters in the rebel group. The smaller the landlord, the smaller the share of public good enjoyed, the lower the individual optimal land redistribution. As a consequence, i's optimal redistribution increases, thereby reducing his utility.
If no land redistribution occurs, i's utility as reported in (17), increases in T_i. Indeed, the increment in land is only partially offset by the increase in fighters looting i's land.
We plot (15) and (17) in Figure 3. On the x-axis i's land ranges from $T_i = T/2$ to $T_i = T$, keeping total land fixed. On the y-axis, i's utility is reported. The flat dashed line illustrates (15), while the positively sloped solid line stands for (17).

From the above discussion it follows that increasing inequality in land ownership makes it more likely for the larger landlord not to redistribute. Proposition 2 shows that whenever the larger

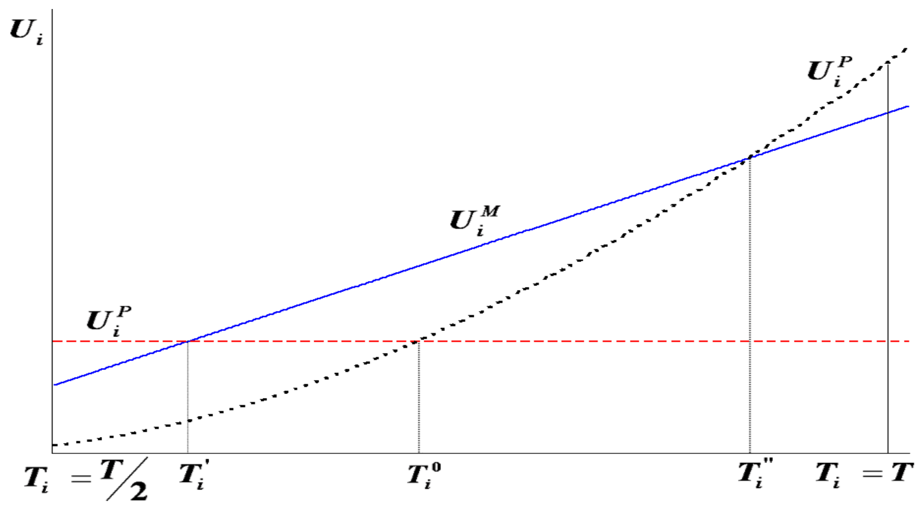

Figure 3: Utility of modifying inequality in land ownership.

landlord finds it optimal not to redistribute, the smaller landlord does not redistribute either. In Figure 3, $T_i = T_i^{'}$ depicts the land inequality level, for which landlord i is indifferent between redistributing or not. For values of T_i slightly larger than $T_i^{'}$, no landlord redistributes land.

Interestingly, land redistribution decreasing with inequality contradicts Mancur Olson's intuition, according to which public good provision increases in inequality (Olson, 1965). The availability to landlords of two instruments (land redistribution and defence) serving the same purpose explains this divergence in results. In fact, as land inequality rises, the smaller landlord increasingly free-rides on the public good provision of the larger landlord. Eventually, land redistribution becomes too costly as compared to defence.

In Proposition 3 we show that if the P-equilibrium collapses for some inequality level, then it *always* exists for some larger level of inequality. Indeed, further increasing inequality makes the condition in Proposition 1 binding. The smaller landlord's optimal land redistribution level becomes nil irrespectively of i's behaviour. For this inequality level depicted by T_i^0 in Figure 3, the smaller landlord fully free-rides on the land redistribution of i. Landlord i's utility of redistributing positive amounts of land is then given by (16) instead of (15). In Appendix A.4, we show that (16) is increasing and convex in T_i. Indeed, when the condition in Proposition 1 is binding, further increasing T_i implies that i enjoys larger shares of the public good, without affecting the degree of free-riding by the other landlord. This explains why i eventually finds it profitable to redistribute land on his own, thus implying the existence of a P-equilibrium.

In Figure 3, i's utility of redistributing alone is illustrated by the convex dotted curve. In $T_i = T_i^{''}$, landlord i is indifferent between redistributing land or not. Any larger inequality level makes i better off by redistributing alone.

The non-monotonicity of land redistribution in inequality implied by Proposition 3 leads to the following result.

Corollary 1. *Most intense conflicts occur for intermediate levels of land ownership.*

This follows directly from Proposition 3 and Lemma 1. Recall that spending in defence and land redistribution are substitutable instruments to cope with potential looting. More land redistribution reduces the pool of potential fighters, hence decreasing the optimal defence level. For intermediate levels of inequality, the burden for the larger landlord of scaling down conflict through redistribution exceeds the cost of fighting the rebels. Since the smaller landlord never redistributes on his own (refer to Appendix A.3), conflict intensity peaks for this range of inequality.

In the above discussion we pointed out a discrepancy between our findings and Olson's intuition. The following proposition partly reconciles the two results.

Proposition 4. *Total land redistribution is larger when provided by a single landlord.*

For the proof see Appendix A.5.

For large land inequality, landlord i's stake in the public good is sufficiently big for his land provision to exceed any land redistribution supported by the two landlords. The Olson effect indeed prevails as soon as the costs for the larger landlord of fighting the rebels are higher than the cost of providing land on his own. An interesting implication is that inequality may be welfare improving. Next proposition addresses this issue.

Proposition 5. *Assume there exists a level of inequality $\left(T_i^{'}, T_{-i}^{'}\right)$ with $T_i^{'} > T_{-i}^{'}$ such that $U_i^{P*} = U_i^{M*}$. Then, there always exists a $\hat{T}_{-i} \in \left[T_{-i}^{''}, T_{-i}^{'}\right]$ such that a transfer $X = \hat{T}_{-i} - T_{-i}^{''}$ from landlord $-i$ to landlord i is Pareto improving.*

For the formal proof see Appendix A.6.
Proposition 5 states that for some intermediate inequality levels, inducing no land redistribution at equilibrium, a transfer from the smaller to the larger landlord represents a Pareto improvement. The intuition behind this result lies once again on the public good nature of land redistribution. If the transfer induces the large landlord to start redistributing land on his own ($T_i \geq T_i^{''}$), then the small landlord also enjoys this public good. Therefore, if the cost of the land transfer supported by the small landlord does not exceed the benefit derived from the public good, its implementation is Pareto improving. Indeed, the large landlord's utility increases in land. Moreover, unemployed individuals experience an increase in welfare as more land is redistributed. Finally, conflict intensity drops as fewer resources are wasted in fighting.

4 Conclusions

In this paper we investigate the relationship between land inequality, land redistribution, and conflict intensity. Because land redistribution is a public good, strategically interacting landlords underprovide it. This results in overspending in defence and inefficient fighting. We show that conflict intensity is non-monotonic in land inequality. In particular, the most severe conflicts occur for intermediate land inequality levels. In this range, the smaller landlord's free riding may trigger a total collapse of land redistribution. For large land inequality the Olson effect prevails: the large landlord internalizes sufficiently the benefits of the public good so as to provide it on his own. Interestingly, starting from an intermediate land inequality level, a Pareto improving land transfer from the smaller to the larger landlord may exist, which induces the latter to redistribute land. The utility loss (in terms of land) suffered by the transferor is more than offset by the utility of enjoying the public good.

Notice that an even larger Pareto-improvement would occur if the two landlords coordinated their land redistribution. If a sufficiently powerful institution (e.g. a strong state) was able to coordinate the landlords' decisions by acting as a central planner, the problem of under provision of public good would be solved.

A Appendix

A.1 Proof of Lemma 1

Proof. Using expressions (7), (9) and (10) in (5) we obtain:

$$m_i^P = \frac{(r_1 + r_2 - c)(T_i - nr_i)}{(r_1 + r_2)^2} \qquad \text{if } r_1 + r_2 \geq w \qquad i \in \{1, 2\} \tag{A-1}$$

$$m_i^M = \frac{(w - c)(T_i - nr_i)}{w^2} \qquad \text{otherwise} \tag{A-2}$$

It is straightforward that $\partial m_i^P / \partial r_i$, $\partial m_i^P / \partial r_{-i}$, $\partial m_i^M / \partial r_i$ are all negative. Moreover, $\partial m_i^M / \partial r_{-i} = 0$. To complete the proof, notice that $m_i^P \leq m_i^M$, $\forall (r_1 + r_2) \geq w$. □

A.2 Proof of Lemma 2

In order to prove Lemma 2 consider first the following result:

Lemma 3. *The difference in the utility of player i from playing $r_i^P(r_{-i})$ or $r_i^M(r_{-i})$ is monotonically increasing in r_{-i}.*

Proof. Using (11) and (10) we have:

$$U_i^M(r_i^M(r_{-i}), r_{-i}) = \frac{(T_i - nr_i^M)(w - c)^2}{w^2} \tag{A-3}$$

Therefore, $\partial U_i^M(.)/\partial r_{-i} = 0$. Rewriting $U_i^P(r_i^P(r_{-i}), r_{-i})$ by replacing t_i^P as given by (9) in (11), we obtain:

$$U_i^P(r_i^P(r_{-i}), r_{-i}) = \frac{(T_i - nr_i^P)}{(r_i^P + r_{-i})^2} \Big(r_i^P + r_{-i} - c \Big)^2 \tag{A-4}$$

It is straightforward that $\partial U_i(.)/\partial r_{-i} \geq 0$ if $r_i^P(r_{-i}) + r_{-i} \geq c$. Observe, however, that if $r_i^P(r_{-i}) + r_{-i} < c$ then $m_i^P = 0$ (see Equation (A-1)), which implies that all production is looted and the utility of the landlord is nil.

Given that a discontinuity in the reaction function of player i can only arise for $r_{-i} < w$, and landlord i's best response to any $r_{-i} \geq w$ is to play $r_i^P(r_{-i})$, then either $r_i^P(r_{-i})$ is the relevant reaction function $\forall r_{-i} < w$, or else there exists a value $\bar{r}_{-i}$ below which $r_i(r_{-i}) = r_i^M(r_{-i})$. □

Lemma 3 together with the continuity of $r_i^M(r_{-i})$ and $r_i^P(r_{-i})$ as given by (11.1), and (11.2) are enough to establish Lemma 2.

A.3 Proof of Proposition 2

Proof. Let us prove the first statement, starting from the $\Leftarrow$ part. By the definition of a reaction function $U_i^{P*} > U_i\left(0, r_{-i}^{P*}\right)$. Furthermore, notice that $U_i^M\left(r_i^{M*}, r_{-i}^{M*}\right) \leq U_i\left(0, r_{-i}^{P*}\right)$. Indeed, either $w \geq r_{-i}^{P*}$ and $U_i^M\left(r_i^{M*}, r_{-i}^{M*}\right) = U_i^M\left(0, r_{-i}^{P*}\right)$, or $w < r_{-i}^{P*}$ and $U_i^M\left(r_i^{M*}, r_{-i}^{M*}\right) < U_i^P\left(0, r_{-i}^{P*}\right)$. By transitivity, $U_i^{P*} > U_i^M\left(r_i^{M*}, r_{-i}^{M*}\right)$.

Let us turn to $\Rightarrow$ part. If $w \geq r_{-i}^{P*}$, then $U_i^M\left(r_i^{M*}, r_{-i}^{M*}\right) = U_i^M\left(0, r_{-i}^{P*}\right)$. By transitivity $U_i^P\left(r_i^{P*}, r_{-i}^{P*}\right) \geq U_i^M\left(0, r_{-i}^{P*}\right)$. This implies that no profitable deviation exists from r_i^{P*}. If $w < r_{-i}^{P*}$, then $\nexists r_i$ such that $r_i + r_{-i}^{P*} < w$. It follows that a P-equilibrium exists.

For the second statement in Proposition 2, we already showed that if $U_i^P\left(r_i^{P*}, r_{-i}^{P*}\right) < U_i^M\left(r_i^{M*}, r_{-i}^{M*}\right)$, then a P-equilibrium does not exist. We first show that $r_i\left(r_{-i}^{M*}\right) = r_i^{M*}$. We then show that this implies $r_{-i}\left(r_i^{M*}\right) = r_{-i}^{M*}$. Consider first the case in which $w \geq r_{-i}^{P*}$. Since $U_i^P\left(r_i^{P*}, r_{-i}^{P*}\right) < U_i^M\left(r_i^{M*}, r_{-i}^{M*}\right)$, then $U_i^M\left(0, r_{-i}^{P*}\right) > U_i^P\left(r_i^{P*}, r_{-i}^{P*}\right)$. Moreover, as $\frac{\partial U_i^P}{\partial r_{-i}} > 0$ and $U_i^M\left(r_i^{M*}, r_{-i}^{M*}\right) = U_i^M\left(0, r_{-i}^{P*}\right)$, it follows that $U_i^M\left(r_i^{M*}, r_{-i}^{M*}\right) > U_i^P\left(r_i^P(r_{-i}^{M*}), r_{-i}^{M*}\right)$, for $r_i^P(r_{-i}^{M*}) + r_{-i}^{M*} \geq w$. If $r_i^P(r_{-i}^{M*}) + r_{-i}^{M*} < w$, then i's best response is given by $r_i^M\left(r_{-i}^{M*}\right) = r_i^{M*}$.

Let us next consider the complementary case in which $w < r_{-i}^{P*}$.

Notice that $U_i^P\left(r_i^{M*}, r_{-i}^{P*}\right) > U_i^M\left(r_i^{M*}, r_{-i}^{M*}\right)$, as in $\left(r_i^{M*}, r_{-i}^{P*}\right)$ the positive land redistribution provided by $-i$ reduces t_i. Moreover, by definition of a reaction function, $U_i^P\left(r_i^{P*}, r_{-i}^{P*}\right) > U_i^P\left(r_i^{M*}, r_{-i}^{P*}\right)$. By transitivity, $U_i^P\left(r_i^{P*}, r_j^{P*}\right) > U_i^M\left(r_i^{M*}, r_{-i}^{M*}\right)$. Since this contradicts the initial assumption, it must be true that if $w < r_{-i}^{P*}$, then a P-equilibrium exists.

We next prove that $r_i\left(r_{-i}^{M*}\right) = r_i^{M*} \Rightarrow r_{-i}\left(r_i^{M*}\right) = r_{-i}^{M*}$. This corresponds to showing that $U_i^P\left(r_i^P(0), 0\right) < U_i^M(0,0) \Rightarrow U_{-i}^P\left(r_{-i}^P(0), 0\right) < U_{-i}^M(0,0)$. Using (11), (11.1) with $r_{-i} = 0$, and (11.2) we obtain:

$$\frac{5cn}{2} + T_i - \sqrt{cn(cn+8T_i)} + \frac{(cn)^{3/2}}{\sqrt{cn} - \sqrt{cn+8T_i}} < \frac{T_i\,(w-c)^2}{w^2} \tag{A-5}$$

where the last term of (A-5) represents $U_i^M(0,0)$ and the remaining terms stand for $U_i^P\left(r_i^P(0), 0\right)$. If we divide both sides of (A-5) by T_i, the RHS becomes a constant. It can be shown that the derivative of the LHS is increasing in T_i, which is a sufficient condition to have $U_i^P\left(r_i^P(0), 0\right) < U_i^M(0,0) \Rightarrow U_{-i}^P\left(r_{-i}^P(0), 0\right) < U_{-i}^M(0,0)$, since we assumed $T_i \geq T_{-i}$. □

A.4 Proof of Proposition 3

Proof. Consider a set of parameters $\{T, w, n, c\}$, such that $T_i = T_i^{'} = T/2$. For this set of parameters, $U_i^M(r_i^{M*}, r_{-i}^{M*}) = U_i^P(r_i^{P*}, r_{-i}^{P*})$. Moreover, $U_i^P(r_i^{P*}, r_{-i}^{P*}) > U_i^P(r_i^P(0), 0)$ as $\partial U_i^P(.)/\partial r_{-i} > 0$. Since $U_i^M(r_i^{M*}, r_{-i}^{M*})$ is linear in T_i (see equation (17)), it follows that $U_i^M(r_i^*, r_{-i}^*)|\{T_i = T\} = 2U_i^M(r_i^*, r_{-i}^*)|\{T_i = T/2\} = 2U_i^P(r_i^{P*}, r_{-i}^{P*})|\{T_i = T/2\}$. Using equations (15) and (16), we can show that $U_i^P(r_i^{P*}, r_{-i}^{P*})|\{T_i = T\} > U_i^M(r_i^{M*}, r_{-i}^{M*})|\{T_i = T\}$ if the following inequality holds:

$$\frac{5cn}{2} + T - \sqrt{cn(cn+8T)} + \frac{(cn)^{3/2}}{\sqrt{cn} - \sqrt{cn+8T}} > \frac{\left(\sqrt{T} - \sqrt{cn}\right)^3}{\sqrt{T}} \tag{A-6}$$

After tedious algebraic manipulations, it can be shown that this condition always holds in the relevant range of parameters $T \geq T_i > cn$. For lower values of T_i, m_i^{P*} as expressed in (A-1) when replacing for the optimal redistribution level (A-8) is negative. This implies $m_i^{P*} = 0$, which gives $U_i^{P*} = 0$. In other words, if the cost of defence c or/and the number of potential fighters n are too large as compared to the available land T, both protecting land and redistributing it are too costly.

To complete the proof, we still need to show that $U_i^P(r_i^{P*}, r_{-i}^{P*})|\{r_{-i}^{P*} = 0\}$ is (a) increasing and (b) convex in T_i. Indeed, this is sufficient to prove the existence and unicity of $T_i^{''}$ since:

1. $U_i^P(r_i^{P*}, r_{-i}^{P*})|\{r_{-i}^{P*} = 0\}$ is continuous in T_i

2. $\frac{\partial U_i^M(r_i^{M*}, r_{-i}^{M*})}{\partial T_i}$ is constant

3. $U_i^M(r_i^{M*}, r_{-i}^{M*}) > U_i^P(r_i^{P*}, r_{-i}^{P*})|\{r_{-i}^{P*} = 0\}$ in $T_i = T/2$

4. $U_i^P(r_i^{P*}, r_{-i}^{P*})|\{r_{-i}^{P*} = 0\} > U_i^M(r_i^{M*}, r_{-i}^{M*})$ in $T_i = T$.

(a) $U_i^P(r_i^{P*}, r_{-i}^{P*})|\{r_{-i}^{P*} = 0\}$ is increasing in T_i if:

$$\frac{\partial U_i^P(r_i^{P*}, r_{-i}^{P*})|\{r_{-i}^{P*} = 0\}}{\partial T_i} = 1 - \frac{4cn}{\sqrt{cn(cn+8T_i)}} + \frac{4(cn)^{3/2}}{\sqrt{cn+8T_i}(\sqrt{cn} - \sqrt{cn+8T_i})^2} > 0 \tag{A-7}$$

Putting all terms over a common denominator, this reduces to $16\,(T_i - cn)^2 > 0$, which is always true in the relevant range of parameters $T_i > cn$.

(b) To prove convexity, we need:

$$\frac{\partial^2 U_i^P(r_i^{P*}, r_{-i}^{P*})|\{r_{-i}^{P*} = 0\}}{\partial T_i^2} = \frac{cn}{\big(cn(cn+8T_i)\big)^{3/2}} + \frac{cn - 3\sqrt{cn}\sqrt{cn+8T_i}}{(cn+8T)^{3/2}(\sqrt{cn+8T_i} - \sqrt{cn})^3} > 0$$

which simplifies to:

$$(cn+8T_i)(\sqrt{cn+8T_i} - 3\sqrt{cn}) > 0$$

The last condition is always true in the relevant range of parameters ($T_i > cn$). □

A.5 Proof of Proposition 4

Proof. Total land redistribution in a P-equilibrium with $r_i^{P*} > 0$ and $r_{-i}^{P*} > 0$ equals:

$$r_i^{P*} + r_{-i}^{P*} = \sqrt{\frac{c\,T}{n}} \tag{A-8}$$

In a P-equilibrium with $r_i^{P*} > 0$ and $r_{-i}^{P*} = 0$ (when the condition in Proposition 1 is violated), land redistribution is given by:

$$r_i^{P*} + r_{-i}^{P*} = \frac{\sqrt{c(cn+8T_i)}}{2\sqrt{n}} - \frac{c}{2} \tag{A-9}$$

It can be shown that (A-8) is always smaller than (A-9), provided that the condition in Proposition 1 is violated. □

A.6 Proof of Proposition 5

Proof. Consider the utility of landlord $-i$ when $T_{-i} = T_{-i}^{''} = T - T_i^{''}$.

Since $r_i = r_i^{P*} > w$ for $T_{-i}^{''}$, then by Proposition 3 $r_i = r_i^{M*} = 0$ for $T_{-i}^{''} + \epsilon$ by Proposition 3, with ϵ infinitesimally small. This implies $U_{-i}^P(r_i^{P*}, 0)|T_{-i} = T_{-i}^{''} > U_{-i}^M(r_i^{M*}, r_{-i}^{M*})|T_{-i} = T_{-i}^{''} + \epsilon$. The utility of landlord $-i$ thus experiences a discontinuity in land inequality at $T_{-i}^{''}$. Increasing T_{-i} in the interval $\{T_{-i}^{''}, T_{-i}^{'}\}$ increases the utility of landlord $-i$ continuously. We therefore conclude that a $\hat{T}_{-i}$ must exist in this interval. □

A.7 Low wage scenario (case c)

In this section we lift Assumption 1. When $w \leq \sqrt{\frac{c(T_1+T_2)}{n}}$, *all* unemployed individuals become fighters if (i) the payoff of a fighter when everyone joins the rebel group is higher than the utility of migration, w, and (ii) this payoff is higher than farming, $r_1 + r_2$. We graph this scenario in Figure 4. The downward sloping solid line represents the land necessary to incentive an individual to farm: $r_1 + r_2 = \sqrt{\frac{c(T_1+T_2)}{n}}$.

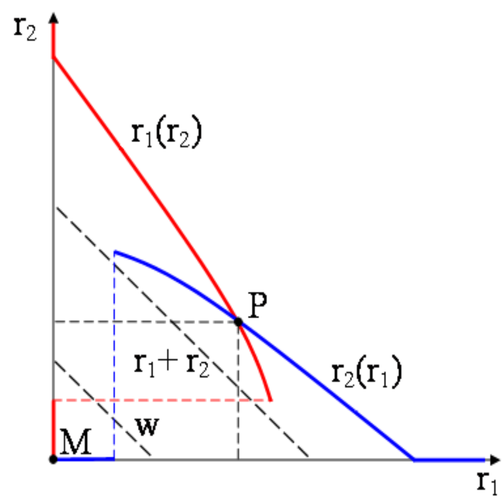

Figure 4: Reaction functions under case c

Replacing n_F by n in (7), and using (5) in (1), we derive landlord i's utility as:

$$u_L^F = \left(1 - \sqrt{\frac{cn}{T_i + T_{-i} - n(r_i + r_{-i})}}\right)^2 (T_i - nr_i) \tag{A-10}$$

It can be shown that i's best response in terms of land redistribution if $r_{-i} \leq \sqrt{\frac{c(T_1+T_2)}{n}}$ is given by:

$$r_i^F(r_{-i}) = 0 \tag{A-11}$$

This replaces $r_i^M(r_{-i})$ in the case under consideration.

The results derived under Assumption 1 hold in this setting as well. Notice, however, that when landlords fail to provide enough land redistribution to sustain the P-equilibrium (P in Figure 4), conflict intensity reaches its peak. In fact, because of the low exit opportunity, all unemployed individuals join the rebel group. As a consequence the level of landlords' defence is also higher than under Assumption 1.

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