Robin Hood's Compromise

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Abstract

Land inequality has long been a key concern for economists and policy makers. Beside promoting equity, redistributing land to the tiller is generally believed to reduce agency costs and increase productivity. This paper analyses an unusual type of redistribution, that is, we take from the very rich –as usual–but give to the rich instead of the poor. We show that also this type of reform reduces agency costs, increases productivity and workers' welfare. Compared to the classic redistribution "to the tiller" it does worse in terms of equity, does not give the poor a collaterizable asset but it is likely to be more sustainable, both economically and politically.

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1 Introduction

Land inequality has long been a key concern for policy makers and in the last fifty years most countries have undergone redistributive land reforms. The issue is particularly pressing in the developing world, where agriculture accounts for a large share of income and is the source of livelihood for most of the poor.

Beside reducing inequality and social unrest, the general consensus is that redistributing land "to the tiller" is likely to have a strong positive impact on productivity and growth.[1] Agency problems, the argument goes, link inequality and productivity. By its own nature, agricultural work requires effort which is hard to monitor and whose effect on outcomes cannot be separated from other exogenous factors. Large landowners who must hire labour for production therefore face a standard moral hazard problem,[2] whereas farmers who cultivate their own plot do not.[3] In this context, redistribution can increase productivity.[4]

The existing empirical evidence does indeed suggest that small family farms are more productive than large farms relying on hired labour (Berry and Cline 1979, Binswanger *et al* 1995, Rosenzweig and Binswanger 1993), and that, using country level panel data, land inequality has a negative effect on growth (Birsdall and Londono 1997, Deininger

[1] Beside the agency issues discussed below, there is a large political economy literature that models the relationship between asset inequality and growth. For a review of theoretical and empirical research on these issues see Aghion *et al* (1999), Banerjee and Duflo (2000), Benabou (1996).

[2] First best incentives can be provided by offering a "fixed rent" contract such that the worker pays a (yearly) rent and keeps all the output. Such contracts are however suboptimal when the worker is risk averse as he would bear all the risk (Stiglitz 1974) or when he faces limited liability since if production is low he might not be able to pay the rent (Shetty 1988, Mookherjee 1997, Banerjee *et* al 2002).

[3] There are some caveats. First, agency problems still exist to the extent that the new owner needs to borrow to finance cultivation since lenders are at most as good as previous landlords in inferring effort devoted to cultivation (Mookherjee 1997). If the inefficiency derives from risk aversion, redistribution can actually lower welfare if after the reform the worker is still risk averse but loses his only source of insurance (the landlord). If risk aversion depends on wealth, it might be less of a concern post reform (Banerjee 2000).

[4] If productivity differentials do indeed exist, land sales should arbitrage it out. The literature argues that these do not occur for a number of reasons: (i) the landless worker needs to borrow to buy the land but credit markets are highly imperfect again because of asymmetric information; (ii) land has value over and above the expected return from cultivation, e.g. to hedge inflation or to reduce the tax burden (iii) land is more valuable for the rich because, in large quantities, it confers political power (Baland and Robinson (2001), Binswanger *et al* (1995) Deininger and Feder (1998), Mookherjee 1997).

and Olinto 2000). Moral hazard seems to be at least partly responsible: farmers achieve higher yields and choose different techniques on the plots they own rather than on the ones they rent (Shaban 1987, Bandiera 2002).

While inequality is a multidimensional issue, policy makers and scholars alike have almost exclusively focussed on inequality between different rural classes and, consequently, on redistributive policy from the class of large landowners to landless peasants. In contrast, this paper investigates the link between productivity and the distribution of land *within* the class of large landowners. Land concentration among the wealthiest exhibits strong variation across countries, even among those with similar degree of inequality overall. In Brasil (Gini =84.1) seventy percent of cultivated land belongs to the largest five percent of landowners, in Colombia (Gini=82.9) to the largest sixteen percent. Differences across continents are more striking, the corresponding figures for India and Korea, for instance, are twenty-four and forty percent.[5]

The question we address is whether, given a fixed mass of landless peasants, inequality among landowners affects peasants' welfare and productivity. Standard economic reasoning suggests that concentration is bad for both. A monopsonistic landlord hires less workers and produces less than the socially optimal outcome while the inefficiency diminishes as more landlords hire from the same pool. Agency issues, however, give the old problem an unusual flavour. We show that the increase in workers' welfare which derives from competition among landlords often results in stronger incentives and hence an increase in productivity on the *intensive* margin, that is for each worker. Overall then, redistributing land among landlords might ameliorate agency problems.

There is some indirect evidence that inequality *within* class might matter over and above the effect of inequality *between* classes. First, the productivity differential between small and large farms is largest where the difference in size is largest, that is Latin America where a few landlords own very large holdings (Berry and Cline, 1979). Second, existing estimates of agency costs, which are based on Asian data, are far too small to account for the productivity differentials in Latin America (Banerjee, 2000). In this paper we argue that, due to the lack of competition among landlords, agency problems might be more serious when most of the land belongs to (very) few.

Redistributing land to the tiller clearly offers more advantages. Most importantly,

[5]Data from World Census of Agriculture (FAO). The figures underestimate concentration since holdings are defined as units of land (not necessarily contiguous) under a common management. To the extent that a group of large holdings which belong to the same owner are managed by different people the data provide lower bounds. However, most holdings are, at least nominally, managed by the owner which justifies the simplification in the text. The size of landholdings in the largest category varies accordingly, from 1000ha in the Latin American countries to 5-10ha in India and Korea.

it deals with the agency problem directly, has a much stronger impact on equity and provides the poor with a collaterizable asset that can be used for other forms of investment, e.g. in human capital. The type of redistribution analyzed in this paper, however, might be cheaper and politically easier to implement.

Evidence from a number of countries indicates that classic full-scale land redistributions are generally unsuccessful, unless they are associated with a drastic change of regime (Binswanger *et al* 1995). First, full scale redistributions are very costly: the State must compensate landowners since, by definition, landless beneficiaries cannot. Second, due to the lack of credit and other complementary inputs, the poorest beneficiaries which are the main targets of such reforms, are often forced to sell back. Finally, large scale reform are opposed by the landowners class as a whole, which, although small by number, is politically very strong.

While these concerns are still relevant when redistributing *within* the class of landowners, they are likely to be less serious. Compared to landless peasants, small landowners have better access to credit which reduces the need for government subsidies and the incidence of distress sales. Indeed, while being unsuccessful at redistributing to landless peasants as discussed above, redistribution policies have often managed to transfer land to the rural middle class (Binswanger *et al* 1995:2729-31, Deininger and Feder 1998:33). Finally, redistributing within the class of landowners breaks its cohesion and hence is likely to face less political resistance. In contrast to a full scale redistribution, which hurts all landowners, in this case some of them gain. To the extent that, as argued above, rural workers gain also, small scale reforms align the interests of the low and middle classes.

We analyze the consequences of reducing inequality at the top of the distribution in a model where landowners hire workers to cultivate their land and cultivation is subject to moral hazard. Workers have identical skills but different reservation utility which yields a standard positively sloped labour supply curve. Workers are subject to limited liability, which makes incentive provision costly (Mookherjee 1997, Banerjee *et* al 2002). Reducing inequality among landowners reduces their market power in the labour market and, as is standard, increases the employment level and workers' pay in equilibrium. Less intuitively, the rise in workers' pay provides stronger incentives and hence increases productivity.

Reducing inequality and increasing competition among landlords leads to an increase in productivity via decreasing the landlords' market power relative to the workers'. Results are therefore similar to those in Banerjee *et al* (2002), who analyze the effect of tenancy reform, i.e. of exogenous changes of the tenant's reservation utility, in a one-principal/one-agent model. How does tenancy reform compare to the redistributive policy which is the focus of this paper? On the costs side tenancy reform dominates;

it does not entail redistribution and hence is much cheaper to implement. On the benefits side the comparison is much less clear cut once the landlords' response is taken into account. While there is evidence that tenancy reform increased output in West Bengal (Banerjee *et* al 2002) and reduced poverty in other Indian states where it has been implemented (Besley and Burgess, 2000), it was ineffective or even reduced tenants' welfare in a number of Latin American countries where landlords reacted by cutting down production or by replacing tenants with casual workers whose rights were not affected by the reform (deJanvry and Saudolet 1989, Binswanger *et* al 1995:2729, Deininger and Feder 1998:31). The question is ultimately an empirical one.

The remainder of the paper is organized as follows. The next section presents the model and its results. In Section 3 we discuss the effects of redistribution on productivity and welfare whereas Section 4 extends the analysis to many principals. We conclude in section 5 and the appendix contains all proofs which are not in the text.

2 The Model

2.1 Set-up

There are two Principals (owners) and many Agents (workers) in the Labour market. The agents supply labour, according to a labour supply function $L(v)$, where v is the utility that work provides. In particular, assume a cumulative distribution $F(u)$ of reservation utilities in the population. If work provides utility of v, then all agents with $u \leq v$ are willing to work. Hence, the supply of labour $L(v)$ equals $F(v)$. Since $L(v)$ is a labour supply function, we assume is it concave, that is $L_{vv} \leq 0$.

The demand side is as follows; Principals own assets. Each worker can operate one asset (for example, one unit of land). Each worker generates a surplus level S and has to be paid v (principals cannot discriminate between workers). The principal can then generate a payoff of $S - v$ from each worker. The principals compete for workers by picking their own demand for labour, given the other principal's demand and given $v(L)$, the inverse supply function (which satisfies $v_L > 0$ and $v_{LL} \geq 0$). In other words, the principals play a Cournot competition. Each chooses labour demand L_i, in order to maximize $L_i(S - v(L_i + L_j))$. Each principal has though a limited amount of assets, N_i, and has therefore to optimize given a capacity constraint, $L_i \leq N_i$.

We now turn to the description of the technology, that is, how S is generated and how principals remunerate workers by paying a utility of v. Recall that each agent operates one asset.[6] The returns of work on the asset depend on the state of nature and on the agent's non-contractible effort. The state of nature can be good or bad (it is the

[6]This assumption is not important for our results but it is the simplest technological assumption.

same for all assets and workers). Work yields 1 in the good state and 0 in the bad state. The probability of the good state depends on the effort e exerted by the agent, according to a function $p(e)$, $p(e) \in (0,1)$, $p'(e) > 0$, $p''(e) \leq 0$. Effort is not observable by the principal and entails disutility for the agent of $d(e)$, $d'(e) > 0$, $d''(e) \geq 0$. The project's expected total surplus $S(e)$ is therefore equal to $p(e) - d(e)$. To guarantee an interior solution, we assume that $p(e) - d(e) > 0$ for any e, i.e. it is profitable to undertake the project at any effort level.

When a worker works for a principal, the latter pays g and b in the good and bad state respectively. The agent is endowed with some wealth w and is subject to a limited liability constraint, which requires that in each state of nature, $x + w \geq 0$ where $x \in \{g, b\}$. Obviously, $g \geq b$ and hence the relevant constraint has $b \geq -w$. The limited liability constraint guarantees that in any state of nature the agent does not pay more than his wealth.[7]

We assume that both parties are risk neutral. In particular, the agent's utility is assumed to be linear in income and for simplicity we assume that a payment $x \in \{g, b\}$ yields utility x. Given $\{g, b\}$, the agent chooses e to maximize $p(e)g + (1 - p(e))b - d(e)$. Denote the maximizing level by $\bar{e}$; $\bar{e}$ solves the incentive compatibility constraint, $g - b = \frac{d'(\bar{e})}{p'(\bar{e})}$. Working for the principal yields therefore an indirect utility level for the agent of $v(g, b) = p(\bar{e})g + (1 - p(\bar{e}))b - d(\bar{e})$.

Thus, when a utility level $\bar{v}$ is determined in the Cournot competition between the principals, each principal has to supply an indirect utility of $\bar{v}$, via $\{g, b\}$. That is, $v(g, b) = \bar{v}$. In return, the principal receives the surplus $S(\bar{e})$. Note that the surplus level is therefore not fixed. If the competition between principals on workers affects the level of utility that agents expect to receive via $\{g, b\}$, it may also affect their choice of effort $\bar{e}$, and consequently, the surplus $S(\bar{e})$. As a result, when principals choose how much labour to demand, they also consider how it affects the surplus generated on each asset.

To recapitulate, the timing of the game is as follows:

Stage 1: P_i choose L_i subject to a capacity constraint, $N_i \geq L_i$. An equilibrium level of utility $\bar{v}$ is determined as $\bar{v} = v(L_1 + L_2) = F^{-1}(L_1 + L_2)$.

Stage 2: Given $\bar{v}$, each P_i chooses (g_i, b_i) subject to $v(b, g) = \bar{v}$ (a participation constraint) and $b \geq -w$ (a limited liability constraint).[8]

[7] The limited liability constraint also guarantees that contracts are renegotiation-proof.

[8] The incentive compatibility constraint, $g - b = \frac{d'(e)}{p'(e)}$, is already taken into consideration via the definition of $v(b, g)$.

2.2 Results

We analyze the game by backward induction and solve first for the optimal contract $\{g, b\}$ that principals provide to workers in the second stage of the game. Since principals must provide the same utility $\bar{v}$ in equilibrium, and since they cannot discriminate between workers, it is sufficient to analyze the principal-agent interaction between one principal and one worker. We can then carry this analysis to the first stage and find the equilibrium in the Cournot competition and by doing so characterize the subgame perfect equilibria of the game.

2.2.1 The moral hazard problem

Consider a standard principal-agent interaction, in which the principal receives 1 in the good state and 0 in the bad state, pays (g, b) to the worker in these states respectively, and knows that an effort level of e induces a probability $p(e)$ that the good state arises. Such a principal then chooses (g, b) to solve the problem C_1:

$$\max_{g,b} p(e)(1-g) + (1-p(e))(-b)$$

subject to participation, incentive and limited liability constraints respectively:

$$p(e)g + (1-p(e))b - d(e) = \bar{v} \tag{PC}$$

$$g - b = \frac{d'(e)}{p'(e)} \tag{IC}$$

$$b \geq -w \tag{LL}$$

Note that the first-best level of effort maximizes total surplus $S(e) = p(e) - d(e)$, and is denoted by e^*. We can now check whether the solution of C_1 achieves the first best level of effort. In order to do so, the first lemma presents the formulation of the problem slightly differently:

Lemma 1 *The solution to C_1 is analogous to the solution of the problem C_2 :*

$$\max_{e} S(e) - \bar{v}$$

subject to a limited liability constraint:

$$\bar{v} + d(e) - p(e)\frac{d'(e)}{p'(e)} \geq -w$$

Proof: Given a payment of g in the good state and a payment of b in the bad state, the payoff of the principal is $p(e)(1-g) + (1-p(e))(-b) = p(e)(1-(g-b)) - b$. The incentive compatibility constraint has $g - b = \frac{d'(e)}{p'(e)}$ which implies that essentially the principal maximizes $p(e)(1-\frac{d'(e)}{p'(e)})-b$. Given the binding participation constraint, $p(e)(g-b)+b-d(e)=\bar{v}\rightarrow b=\bar{v}+d(e)-p(e)\frac{d'(e)}{p'(e)}$. Plugging the expression for b in the principal's payoff implies that the principal maximizes $p(e)(1-\frac{d'(e)}{p'(e)})-(\bar{v}+d(e)-p(e)\frac{d'(e)}{p'(e)})=p(e)-d(e)-\bar{v}$. That is, the principal maximizes $S(e)-\bar{v}$, subject to a limited liability constraint, that is, $b\geq -w$, or $\bar{v}+d(e)-p(e)\frac{d'(e)}{p'(e)}\geq -w$.■

Given the formulation of C_2, it is now easy to characterizes the solution to the principal's problem, and how it is sensitive to the limited liability constraint.

Lemma 2 *For any $\bar{v}$, there exist a treshold level of wealth $w^*(\bar{v})$ such that if $w>w^*(\bar{v})$, the limited liability constraint does not bind and in equilibrium $e=e^*$, i.e. the equilibrium level of effort maximizes total surplus . If $w<w^*(\bar{v})$, the limited liability constraint binds and in equilibrium $e(\bar{v},w)<e^*$, that is, the equilibrium level of effort is strictly less than first best.*

Proof: Assume that the constraint does not bind. This implies that the principal essentially maximizes $S(e)=p(e)-d(e)$, implying that he chooses e^*, the first-best effort level, which solves $p'(e^*)=d'(e^*)$. This solution can hold if at e^*, indeed $w\geq p(e^*)\frac{d'(e^*)}{p'(e^*)}-d(e^*)-\bar{v}=S(e^*)-\bar{v}$. On the other hand, if $w<S(e^*)-\bar{v}\equiv w^*(\bar{v})$, the limited liability constraint binds. The solution for e has to satisfy the constraint, i.e., the principal chooses e so that $p(e)\frac{d'(e)}{p'(e)}-d(e)=w+\bar{v}$. It is left to show that this solution, $e(\bar{v},w)$, is lower then first best. Consider the function $p(e)\frac{d'(e)}{p'(e)}-d(e)$. Taking a derivative of $p(e)\frac{d'(e)}{p'(e)}-d(e)$ w.r.t. e, we get:

$$\begin{aligned}\frac{\partial}{\partial e}(p(e)\frac{d'(e)}{p'(e)}-d(e)) &= p'(e)\frac{d'(e)}{p'(e)}+p(e)\frac{d''(e)p'(e)-p''(e)d'(e)}{(p'(e))^2}-d'(e)\\ &= p(e)\frac{d''(e)p'(e)-p''(e)d'(e)}{(p'(e))^2}>0\end{aligned}$$

since $p(e)$ is concave and $d(e)$ is convex. Since $e(\bar{v},w)$ solves $p(e)\frac{d'(e)}{p'(e)}-d(e)=w+\bar{v}<w^*(\bar{v})+\bar{v}$, the value of $p(e)\frac{d'(e)}{p'(e)}-d(e)$ is lower at $e(\bar{v},w)$ than at e^*, implying that $e(\bar{v},w)<e^*$.■

Intuitively, as long as the agent is wealthy enough, the principal can provide incentives by punishing him in the bad state. If the agent is poor, however, the limited liability constraint imposes an upper bound to the punishment that can be inflicted in the bad state. Then, in order to provide powerful incentives, the principal must offer a reward in the good state. Since rewards are costly, he will then prefer to provide low powered incentives, resulting in an inefficient, low level of effort.

The next corollary performs comparative statics analysis on the cutoff point $w^*(\bar{v})$, and on the solution $e(\bar{v},w)$ when $w<w^*(\bar{v})$:

Corollary 1 *(i) The cutoff point* $w^*(\bar{v})$ *decreases in* $\bar{v}$; *(ii) When* $w < w^*(\bar{v})$, *the effort level* $e(\bar{v}, w)$ *increases in* $\bar{v}$; *(iii)* $S(e)$ increases in e for $e < e^*$ and hence $S(e(\bar{v}, w))$ increases *in* $\bar{v}$.

Proof: (i) The proof of Lemma 2 defines $w^*(\bar{v}) = S(e^*) - \bar{v}$ and hence $w^*(\bar{v})$ decreases in $\bar{v}$. (ii) $e(\bar{v}, w)$ solves $p(e)\frac{d'(e)}{p'(e)} - d(e) = w + \bar{v}$. As shown in the proof of Lemma 2, $p(e)\frac{d'(e)}{p'(e)} - d(e)$ increases in e and hence $e(\bar{v}, w)$ increases in $\bar{v}$.(iii) $S(e)$ achieves its maximum at first best e^* and hence increases in e for $e < e^*$. Since $e(\bar{v}, w) < e^*$, $S(e(\bar{v}, w))$ increases in $\bar{v}$.■

The corollary suggests that in less developed countries, in which the wealth of workers w is relatively low and the limited liability constraint is likely to bind, the 'reservation utility' $\bar{v}$ can play a role in increasing effort and productivity. A higher value of $\bar{v}$ both allows to achieve the first best effort level for more values of w, and given a binding constraint, to increase the effort level for each value of w. This 'reservation utility' is determined endogenously though in our model, when the principals compete for agents in the first stage of the game. We now turn to analyze this stage.

2.2.2 The Cournot competition

>From the solution to the moral hazard second stage problem, the principals know that given a reservation utility $\bar{v}$, the surplus they receive is $S(e(\bar{v}, w))$ if $w < w^*(\bar{v})$ and $S(e^*)$ otherwise.

Each principal i therefore chooses L_i in order to maximize:

$$\max_{L_i} L_i(S(e(v(L_i + L_j), w)) - v(L_i + L_j))$$

given L_j, the inverse labour supply function $v(L_1 + L_2)$, and subject to:

$$L_i \leq N_i.$$

where $e(v(L_i+L_j)) = \left\{ \begin{array}{c} e(\bar{v}, w) \text{ if } w < w^*(\bar{v}) \\ e^* \text{ if } w > w^*(\bar{v}) \end{array} \right\}$ for $v(L_i+L_j) = \bar{v}$ and $S(e) = p(e) - d(e)$.

We assume that the principals can be ordered by their asset holdings. WLOG, assume that principal 1, denoted by P_1, is the small owner. That is, $N_1 \leq N_2$. The total assets in the economy are denoted by $N = N_1 + N_2$. The parameters of the model are therefore $\{N_1, N, w\}$. N_1 and N characterize the level of equality in asset holdings among owners. The level of w signifies how poor is the economy on the one hand, or it can also describe how unequal is the distribution of wealth between workers and asset owners.

In order to understand the intuition for the results, let us derive the first order condition for the principal's optimization problems. In particular, consider the Lagrangian:

$$\max_{L_i} L_i(S(e(v(L_i + L_j), w)) - v(L_i + L_j)) + \lambda_i(N_i - L_i)$$

Taking a derivative w.r.t. L_i, we get:

$$S(e(v(L_i + L_j), w)) - v(L_i + L_j) + L_i(S_e e_v v_L - v_L) - \lambda_i = 0$$

The first two elements on the left, $S(e(v(L_i + L_j), w)) - v(L_i + L_j)$, or in short, $S - v$, denote the payoff of the principal from each worker. Thus, increasing the labour demand, results in additional payoff generated from additional assets.

The second element, $L_i(S_e e_v v_L - v_L)$, denotes the change in the payoff generated from each asset, as a result from increasing the demand from labour. Increasing the demand for labour, implies that the utility provided v has to be higher as well, in order to attract workers with higher intrinsic reservation utilities. This has two effects. The standard effect, which implies that all the infra-marginal workers already working for the principal have to be paid more. This is captured by the negative term $-L_i v_L$. An additional effect however arises from the moral hazard problem, which is unique to the context of asymmetric information and incentive theory. As shown in the previous section, a higher utility that is provided to the agents results in a higher effort level. Since effort levels are at most at first best, this also implies a higher surplus extracted by the principal (see corollary 1). That is, S increases with a higher demand for labour. This is captured by the positive term $L_i S_e e_v v_L$. Finally, the last term is the Lagrange multiplier, which denotes how binding is the capacity constraint.

We next show that the essence of the standard Cournot competition is maintained even in the context of asymmetric information.

Lemma 3 *In equilibrium, if the capacity constraint does not bind for P_i, the best response demand decision $L_i(L_j)$ has $\frac{\partial L_i}{\partial L_j} < 0$, that is, labour demands are strategic substitutes.*

Proof: see the appendix.■

Intuitively, when P_1 increases his labour demand, he imposes an externality on P_2; P_2 has to pay more for his agents. As explained, this has a 'good' effect (the moral hazard effect of increasing productivity, $L_i S_e e_v v_L$) and a 'bad' effect (of providing each worker with a higher payment, $-L_i v_L$). Which effect dominates? taking another look at the first order condition and setting $\lambda_i = 0$, we can see that $S_e e_v v_L - v_L < 0$ in equilibrium. Otherwise, since the payoff $S - v$ generated from any e is positive, this condition cannot be satisfied with equality. In other words, in equilibrium, increasing the level of e (through v) reduces the payoff of the principal. This implies that the 'bad' effect dominates the 'good' effect, and consequently, to offset the externality imposed by P_1, P_2 has to lower his labour demand.

This property allows us to characterize a unique equilibrium solution given the parameters of the model. We now specify the equilibrium in the Cournot competition. In order to focus on the less developed countries, we assume that $w = 0$, and analyze the resulting total employment level as a function of the distribution of assets in the economy.

Proposition 1 *The following are the subgame perfect equilibria of the Cournot competition for labour:*

(i) When $N_1 < \tilde{N}$ and $N < \tilde{N}(N_1)$, there is a unique equilibrium in which both capacity constraints bind. The total level of employment is N.

(ii) When $N_1 < \tilde{N}$ and $N > \tilde{N}(N_1)$, there is a unique equilibrium, in which only the capacity constraint of P_1 binds. The total level of employment is $N_1 + \bar{L}_2(N_1)$.

(iii) When $N_1 > \tilde{N}$, then neither capacity constraint binds. In the unique equilibrium, the total level of employment is $\bar{L}$, and each principal employs $\bar{L}/2$.

The solution in equilibrium, depends on the level of N_1 and N. When there are not enough assets in the economy, both principals may be tied by their capacity constraint. This equilibrium is not in particularly interesting and we will ignore it throughout the analysis. From now on we focus on the case of $N > \tilde{N}(N_1)$.

When the level of N is indeed high enough, this allows the 'larger' principal, P_2, to be able to choose his labour demand strategically and not be bound by the capacity constraint. There are two cases. If N_1 is high enough, then also the 'small' principal can choose his optimal number of employees. In this case, the solution is symmetric, and is not affected by N_1, since the constraint does not bind. When N_1 is too small however, the capacity constraint for P_1 binds, in which case the best response of P_2 depends on N_1.

Different employment levels obviously result in different utility $\bar{v}$ provided to the agents in equilibrium. The first stage of the game endogenizes therefore the 'reservation utility' of the agents, which they receive via their contracts in the second stage. This is the highest intrinsic reservation utility among those who actually choose to work. As the result illustrates, this may depend on the distribution of assets in the economy. Moreover, as shown in the previous section, different values of $\bar{v}$ result in different effort levels, i.e., productivity. The next section analyzes the effect of the distribution of assets on the effort exerted by the agents, the total surplus generated in the economy and the total welfare.

3 The effect of redistribution

3.1 Productivity and total surplus.

Assume still that $N > \tilde{N}(N_1)$, and consider the effect of redistribution from the large principal to the small one. That is, an equalizing redistribution. If none of the constraints binds for the initial level of N_1, then redistribution has no effect. The equilibrium employment level does not depend on N_1 once N_1 is high enough, and is therefore constant. However, if the constraint of the small principal binds, then changing N_1 has an effect on employment and as a result on productivity.

In particular, consider increasing N_1 while maintaining N (we keep the ordering of the principals fixed, so $N_1 < N - N_1$). From Lemma 3 we know that when N_1 increases, $\bar{L}_2(N_1)$ decreases, since the two are strategic substitutes. What happens however to total employment, and as a result to total surplus? Moreover, is there any distribution of assets that achieves first best effort levels? The next result answers these questions.

Proposition 2 *Consider $N{>}\tilde{N}(N_1)$ and $N_1 \leq \tilde{N}$. When N_1 increases, total employment and total surplus increase. When N_1 is high enough, the first best level of effort may also be achieved, implying that employment is at its maximum and so is the total surplus.*

Proof: see the appendix.■

Intuitively, when the participation constraint of the small principal binds and redistribution occurs, unless $N_1 \to \tilde{N}$, his participation constraint still binds. This implies that $L_1 = N_1$ increases, while $\bar{L}_2(N_1)$ decreases. However, since neither principal internalizes the full effect of his actions on his counterpart, $\bar{L}_2(N_1)$ does not decrease in the full amount in which N_1 increases. Thus, as the appendix shows, total employment, denoted by $\bar{L}$, $\bar{L} = \bar{L}_2(N_1) + N_1$ increases as well. In particular, when N_1 increases so that neither constraint binds, total employment increases. That is, the symmetric non binding equilibrium yields the highest employment level, which also results, as we will see below, in the highest total surplus.

Total surplus is expressed by $S(e(v(\bar{L}), w)) \cdot \bar{L}$. Taking the derivative of this expression w.r.t. N_1 :

$$\frac{\partial}{\partial N_1} S(e(v(\bar{L}), w)) \cdot \bar{L} = \frac{\partial \bar{L}}{\partial N_1}(S_e e_v v_L \bar{L} + S) > 0$$

since $\frac{\partial \bar{L}}{\partial N_1} > 0$. This is obvious since when total employment increases, not only more agents work, but also each of them enjoys a higher utility in order to equate supply and demand, which is translated into higher level of effort and hence a higher surplus generated by each worker.

The size of N_1 can be linked to the strength of the competition between the principals. In the extreme case, when $N_1 \to 0$, P_1 imposes no competitive threat on P_2, who behaves like a monopolist. The higher is N_1, and in particular when it is close enough to N_2 to allow for a symmetric, non-binding equilibrium, competitive pressures increase, to benefit the workers and as a by-product to induce more efficient production.

Finally, when the competitive pressure exerted by P_1 is high enough, both principals are induced to increase their labour demand and hence to increase the utility offered in equilibrium beyond $S(e^*) - w$. This pushes workers to the first best effort level, while maintaining a positive payoff to the principals.

3.2 Welfare

In this section we consider how the welfare of both the principals and the workers changes as a result of redistribution. This may bear implications on the possibility of redistribution in the presence of political pressures, or market power.

Proposition 3 *When N_1 increases, the welfare of each worker increases whereas the joint welfare of the principals decreases with redistribution. The welfare of the large principal decreases but the welfare of the small principal increases if the initial level of N_1 is low enough.*

Proof: Consider the welfare of the workers as a function of N_1. Since when N_1 increases all the inframarginal workers receive a higher utility, and all others receive their intrinsic reservation utilities, the welfare of the workers must increase.

Consider now the joint welfare of the principals $L(S(e(v(L)) - v(L))$. This is obviously maximized by the monopolist, i.e., when all the assets are held by P_2. This implies that when $\bar{L} > L_2(0)$, joint welfare decreases with $\bar{L}$.

Now consider the welfare of P_1, $N_1(S(e(v(\bar{L})) - v(\bar{L}))$.

$$\frac{\partial N_1(S(e(v(\bar{L})) - v(\bar{L}))}{\partial N_1} = S(e(v(\bar{L})) - v(\bar{L}) + N_1 \frac{\partial \bar{L}}{\partial N_1}(S_e e_v v_L - v_L)$$

The first element, $S(e(v(\bar{L})) - v(\bar{L})$, is positive. This is the additional payoff that P_1 gets from employing more workers. However, the total employment also increases, by $\frac{\partial \bar{L}}{\partial N_1} > 0$, implying that the principal's payoff from each asset changes by $S_e e_v v_L - v_L < 0$. Then, if $N_1 < \bar{N}_1$, the small principal's welfare increases with redistribution whereas if N_1 is high enough, redistributive measures may be harmful.

For the large principal:

$$\frac{\partial \bar{L}_2(N_1)(S(e(v(\bar{L})) - v(\bar{L}))}{\partial N_1} = \frac{\partial \bar{L}_2(N_1)}{\partial N_1}(S(e(v(\bar{L}))-v(\bar{L}))+\bar{L}_2(N_1)\frac{\partial \bar{L}}{\partial N_1}(S_e e_v v_L - v_L) < 0$$

The large principal, P_2, obviously loses from redistribution since he employs less workers and also gets less payoff from the infra-marginal workers.■

This result has two possible interpretations. The first implies that although redistribution increases efficiency in the market, it cannot be executed by the market. That is, since the joint welfare of the principals decreases with redistribution, there is no price that enables the large principal to sell his land or assets to the small principal, which the small principal is willing to pay. This is similar to the standard monopoly/duopooly theory in which the market forces push towards a cartel. Our result only maintains that this holds in the presence of asymmetric information as well.

The result that the market forces push towards a cartel implies that a government intervention such as regulation or land reforms are needed. As discussed in the introduction, land reforms are hard to implement. But usually, governments try to implement land reforms which transfer land from owners to workers, that is, 'extreme' or 'drastic' land reforms. The land reforms that we suggest here are more moderate. They can come in the form of quotas, such as land ceilings, or in the form of moderate redistribution, that is, redistribution *among owners.*

The model suggests therefore that anti-trust measures might have an efficiency enhancing role over and above the elimination of monopoly rents. Rules such as land ceilings which are meant to maintain a more equal distribution of natural resources might promote efficiency in addition to equality. Indeed, in all sectors where moral hazard is an issue and agents are subjects to limited liability all rules which limit asset concentration can indirectly increase productivity through the provision of high powered incentives

Also, we believe that moderate land reforms, such as redistribution among owners only, are more *politically viable* than extreme land reforms. When we consider the political environment of developing (and also developed) countries, big scale redistributions are often unfeasible. All asset owners lose from such a reform whereas the agents benefit. However, the concentrated group of owners may find it easier to coordinate their actions and lobby politicians, relative to the dispersed group of agents. Hence, powerful owners may succeed in preventing any redistribution to agents. On the other hand, small scale reforms among owners, may be easier to implement politically. These small scale redistribution programs benefit some of the owners as well, as Proposition 3 illustrates. In particular, the small owners whose share increase may lobby for such reforms, along with the agents. Although big scale reforms may be more efficiency enhancing than the small scale reforms discussed in this paper, when we consider political feasibility, small scale reforms seem a more viable option.

4 Many principals

In this section we show the robustness of the results to many principals, i.e., that the general insights on the relationship between inequality, productivity and surplus extend to the case of $k > 2$ principals. We rank principals according to the size of their assets holdings, that is $N_1 < N_2 < ... < N_k$. The structure of the game is the same as with two principals, where in the first stage principals simultaneously choose labour demand, which determines the reservation utility that each principals provides to his workers via the contract $\{g, b\}$.

As in the two principals case, the structure of the equilibrium depends on which capacity constraints bind. Note that since principals are ranked according to the size of their holdings, when the capacity constraint binds for principal j it also binds for all $i < j$. We can therefore prove the following:

Proposition 4

(i) Given a $k-$tuple of asset holdings, there exists an equilibrium, in which there are b binding capacity constraints, $b \in \{0, 1, ..., k\}$.

(ii) When the distribution of assets is symmetric and N is high enough, $b = 0$. When the equilibrium has $b = 0$, the larger is k, the larger is the surplus in the economy.

(iii) Any equalizing transfer, from a principal whose constraint is non-binding to a principal whose constraint is binding increases total employment and surplus.

Proof: see the appendix.

As in the two principals case an equalizing redistribution generates a competition effect; the principal who receives the transfer competes more fiercely with the others. This increases agents' productivity.

Moreover, part (ii) relates efficiency to the number of principals in the market. Keeping the total number of assets fixed, as long as there are enough assets to maintain a symmetric non-binding equilibrium, increasing the number of principals k increases employment and efficiency. Thus, when we converge to competitive markets, indeed employment is at its maximum, as in the standard market structure theory.

5 Discussion and Conclusion.

This paper has analyzed the impact of inequality within the landowners class on the welfare and productivity of landless workers. In contrast to most contributions in the area, it focuses on intra- rather than inter- class inequality.

Reducing the concentration of landholdings reduces each landlord's power in the labour market thus, as is standard, increasing the workers' welfare and productivity on the extensive margin. We have shown that, in addition, increasing competition among landlords results in stronger incentives and higher productivity for each worker. The argument relies on the fact that workers face limited liability and that, therefore, incentive provision must entail a transfer of resources, an "information rent" from landlords to workers. Since each landlord does not internalize the effect of her decisions on fellow landlords, increasing the level of competition among them leads to higher rent and hence stronger incentives for the workers. This is good news for the recently popular market assisted land reforms, which have been criticized on the grounds of not being able to redistribute land to the tiller, and hence have little effect on productivity.

Reducing inequality at the top of the distribution and hence the cohesiveness of the landowners class offers other advantages that have not been explicitly modelled in this paper. Anecdotal evidence shows that the landowners class has obtained customized infrastructure and tax privileges throughout history. To the extent that it makes collusion harder, the type of reform discussed in this paper reduces the political power of landlords and hence their power to lobby for policies in their favour.

Although redistributing from "the richest to the rich" is likely to be cheaper, more sustainable and politically easier to implement than the classic redistributive policies in favour of the landless, it fares worse on the grounds of equity and efficiency to the extent that land could be used as collateral for other forms of investment.

Whenever a full scale redistribution is not feasible, however, reducing inequality at the top might nevertheless help increase the welfare of rural workers and their productivity. Moreover, in a dynamic model the increase in workers' pay combined with the decrease in landlords' power might promote savings and wealth accumulation (Mookherjee and Ray 2001). To the extent that full scale redistributions fail because the beneficiaries are too poor, reducing inequality among landowners might therefore prepare the stage for a more comprehensive redistributive policy.

References

[1] Aghion, P., Caroli, E., Garcia-Penalosa, C. (1999) "Inequality and Economic Growth: The Perspective of the New Growth Theories" Journal of Economic Literature; 37(4), December , pages 1615-60.

[2] Baland,J.M. and Robinson,J. (2001) "Land and Power" (mimeo, University of California at Berkeley).

[3] Bandiera, O. (2002) "Land Distribution, Incentives and the Choice of Production Techniques: Theory and Evidence from Rural Nicaragua", CEPR Discussion Paper 3141, STICERD Development Economics Discussion Paper 34.

[4] Banerjee,A.V.,Gertler,P.J. and Ghatak,M. (2002) "Empowerment and Efficiency: Tenancy Reform in West Bengal", *Journal of Political Economy*, 110(2), 239-280.

[5] Banerjee,A.V. (1999) Land Reforms: Prospects and Strategies Massachusetts Institute of Technology, Department of Economics Working Paper: 99/24.

[6] Banerjee,A.V. and E.Duflo (2000) "Inequality and Growth: What Can the Data Say?" NBER Working Paper No.7793

[7] Benabou, R. (1996) "Inequality and Growth" Bernanke, B. and Rotemberg, J. eds. NBER macroeconomics annual 1996. Cambridge and London: MIT Press, pages 11-74.

[8] Berry, R.A., and Cline, W.R. (1979) Agrarian structure and productivity in developing countries. Geneva: International Labor Organization.

[9] Besley, T. and Burgess, R. (2000) "Land Reform, Poverty Reduction, and Growth: Evidence from India" *Quarterly Journal of Economics*; 115(2), pages 389-430

[10] Binswanger, H., Deininger, K., and Feder, G. (1995). "Power, Distortions, Revolt and Reform inAgricultural Land Relations," in: Behrman, J. and Srinivasan, T.N. (Eds.), Handbook ofDevelopment Economics,III (Ch. 42): 2659-2772, Elsevier Science

[11] Birdsall, N. and Londono, J. (1997) "Asset Inequality Matters: An Assessment of the World Bank's Approach to Poverty Reduction" American Economic Review; 87(2), pages 32-37.

[12] De Janvry, A., and Sadoulet, E. (1989) 'A study in resistance to institutional change: the lost game of Latin American land reform',World Development,17:1397-1407

[13] Deininger, K. and Feder, G. (1998) Land Institutions and Land Markets, World Bank Working Paper no 2014 - Handbook of Agricultural Economics (B. Gardner and G. Rausser, Eds), forthcoming

[14] DEININGER, K. AND OLINTO, P. (2000) Asset Distribution, Inequality, and Growth, World Bank, Development Research Group, Working Paper #2375

[15] MOOKHERJEE,D. (1997). "Informational Rents and Property Rights in Land,"' in J. Roemer, ed., Property Rights, Incentives and Welfare, New York: MacMillan Press.

[16] MOOKHERJEE D. AND RAY D (2001). "Contractual Structure and Wealth Accumulation" *American Economic Review,* forthcoming.

[17] ROSENZWEIG, M. AND BINSWANGER, H. (1993) "Wealth, Weather Risk and the Composition and Profitability of Agricultural Investments" Economic Journal; 103(416), pages 56-78.

[18] SHABAN,R.A. (1987). "Testing Between Competing Models of Sharecropping", *Journal of Political Economy*, 95(5), 893-920.

[19] SHETTY,S. (1988). "Limited Liability, Wealth Differences and the Tenancy Ladder in Agrarian Economies," *Journal of Development Economics*, 9(1), 1-22.

[20] STIGLITZ,J.E. (1974). "Incentives and Risk Sharing in Sharecropping," *Review of Economic Studies*, 41(2), 219-55.

6 Appendix

6.1 Prelims.

Recall that the surplus function is $S(e) = p(e) - d(e)$ whereas the indirect utility function of the agent, given the limited liability constraint and the incentive compatibility constraint is $u(e) = p(e)\frac{d'(e)}{p'(e)} - d(e)$. Our assumptions concerning these functions are that $p'(e) > 0$, $p''(e) < 0$, $d'(e) > 0, d''(e) > 0$, from which it follows that $\frac{\partial}{\partial e}\left(\frac{d'(e)}{p'(e)}\right) > 0$. Recall also that $e^* = \max_e S(e)$, hence $p'(e^*) = d'(e^*)$. The following will prove useful for all the proofs below:

(i) $S(e)$ is concave:

Proof: $\frac{\partial^2 S(e)}{\partial e^2} = p''(e) - d''(e) < 0$.

(ii) under very mild restrictions on p''' and d''', $u(e)$ is convex:

Proof: $\frac{\partial^2 u(e)}{\partial e^2} = p'\frac{\partial}{\partial e}\left(\frac{d'}{p'}\right) + p\frac{p'^2(d'''p' - d'p''') - 2p'p''(d''p' - p''d')}{p'^4} > 0$.

We assume these restrictions are valid in what follows.

(iii) In any equilibrium $e \leq e^*$.

Proof: Assume to the contrary that $e > e^*$. The principals' payoff from any asset is equal to $S(e)$ $-u(e) = p(e)(1 - \frac{d'(e)}{p'(e)})$. Note that, since $\frac{d'(e^*)}{p'(e^*)} = 1$, $S(e^*)$ $-u(e^*) = 0$. Also $\frac{\partial}{\partial e}\left(\frac{d'(e)}{p'(e)}\right) > 0$, so that $\frac{d'(e)}{p'(e)} > 1$ at any $e > e^*$. Thus, it follows that for $e > e^*$, $S(e)$ $-u(e) < 0$, which cannot be an equilibrium because the principals could profitably deviate by offering, for instance, e^*.

(iv) Define e^m as e that solves $S'(e) = u'(e)$. Clearly, $e^m < e^*$ at which $S'(e) = 0$. Then, $S'(e) - u'(e) < 0$ for any $e \in (e^m, e^*)$.

Proof: $S - u$ is a concave function with a maximum at e^m. Since $e^* > e^m$, the value of the function decreases with e.

(v) $e_{vv} < 0$: Denote $f(e) = p(e)\frac{d'(e)}{p'(e)} - d(e)$. Hence, $e = f^{-1}(v+w) \equiv e(v+w)$. Note that $f_e > 0$ and $f_{ee} > 0$ implying that $e_v = e_w > 0$ and $e_{vv} = e_{vw} = e_{ww} < 0$. ■

6.2 Proofs.

Lemma 3 *In equilibrium, if the capacity constraint does not bind for P_i, the best response demand decision $L_i(L_j)$ has $\frac{\partial L_i}{\partial L_j} < 0$, that is, labour demands are strategic substitutes.*

Proof of Lemma 3:

Consider the FOC for P_2 with $\lambda_2 = 0$. We take a total differentiation of the FOC:

$$[A]dL_1^* + [S_e e_v v_L - v_L + A]dL_2^* = 0$$

for

$$A = S_e e_v v_L - v_L + L_2(S_{ee}{e_v}^2 v_L^2 + S_e e_{vv} v_L^2 + S_e e_v v_{LL} - v_{LL})$$

Hence,

$$\frac{dL_2^*}{dL_1^*} = \frac{A}{-(S_e e_v v_L - v_L) - A}$$

Note that $S_e e_v v_L - v_L < 0$, otherwise the FOC has no solution when $\lambda_2 = 0$. Then, by the preliminaries, $S_{ee} < 0$ and $e_{vv} < 0$, whereas $v_{LL} > 0$ by the assumption that this is the inverse labour supply function. Hence, $A < 0$, implying that $\frac{dL_2^*}{dL_1^*} < 0$.■

Proposition 1 *The following are the subgame perfect equilibria of the Cournot competition for labour:*

(i) When $N_1 < \tilde{N}$ and $N < \tilde{N}(N_1)$, there is a unique equilibrium in which both capacity constraints bind. The total level of employment is N.

(ii) When $N_1 < \tilde{N}$ and $N > \tilde{N}(N_1)$, there is a unique equilibrium, in which only the capacity constraint of P_1 binds. The total level of employment is $N_1 + \bar{L}_2(N_1)$.

(iii) When $N_1 > \tilde{N}$, then neither capacity constraint binds. In the unique equilibrium, the total level of employment is $\bar{L}$, and each principal employs $\bar{L}/2$.

Proof of Proposition 1

Given the second stage of the game, the principals know that if $v > \bar{v}$, then $S(e(v)) = S(e^*) = p(e^*) - d(e^*)$ whereas if $v < \bar{v}$, then $e(v) = f^{-1}(v)$ and $S(e(v)) = p(e(v)) - d(e(v))$. This implies that for $v > \bar{v}$, $e_v = 0$ whereas otherwise it is positive.

The problem of Principal i is to solve:

$$\max_{L_i} L_i(S(e(v(L_i + L_j)) - v(L_i + L_j)) + \lambda_i(N_i - L_i),$$

Denote $L = L_i + L_j$. The first order condition with respect to L_i is:

$$S(e(v(L)) - v(L) + L_i(S_e e_v v_L - v_l) - \lambda_i = 0 \qquad (1)$$

which has to hold along with the capacity constraint.

Step 1: It cannot be an equiilbrium in which the 'large' principal binds and the small principal does not bind.

The reason is as follows. If the 'large' principal's constraint binds, it implies that $L_2 > N_2 > N_1$. If the small one does not bind, then it implies that $L_1 < N_1$. That is, it has to be that $L_1 < L_2$. However, since $\lambda_2 > 0$ and $\lambda_1 = 0$, by the FOC:

$$L_1 = \frac{S(e(v(L)) - v(L)}{v_L - S_e e_v v_L} > L_2 = \frac{S(e(v(L)) - v(L) - \lambda_2}{v_L - S_e e_v v_L},$$

a contradiction.

Hence, there are three possible equilibrium solutions. Either both capacity constraints bind, or both do not bind, or the 'small' principal only binds.

Step 2: Characterization of the equilibria:

(i) Assume that both constraints bind. In this case, $L_1 = N_1$ and $L_2 = N_2$ and hence $v(L) = v(N_1 + N_2)$. From the FOCs, indeed the lagrange multipliers are positive. This equilibrium holds when

(ii) Assume that both constraints do not bind, i.e., $\lambda_1 = \lambda_2 = 0$. This implies that each principal solve:

$$L_i = \frac{S(e(v(L)) - v(L)}{v_L - S_e e_v v_L} \tag{2}$$

The right-hand-side of the (2) depends only on L. Hence, the equilibrium solution is symmetric, in which $L_1 = L_2$. This implies that $L_l = \frac{L}{2}$. Denote the solution of L to the equation

$$\frac{L}{2} = \frac{S(e(v(L)) - v(L)}{v_L - S_e e_v v_L}$$

by L^*. This equilibrium holds if $L^* < 2N_i$ for all i.

(iii) Assume that $\lambda_2 = 0$ whereas $\lambda_1 > 0$. Then, $L_1^* = N_1$ and

$$L_2 = \frac{S(e(v(N_1 + L_2)) - v(N_1 + L_2)}{v_L - S_e e_v v_L}$$

where we find λ_1 by

$$N_1 = \frac{S(e(v(N_1 + L_2)) - v(N_1 + L_2) - \lambda_1}{v_L - S_e e_v v_L}$$

Denote the solution to this equation by L_2^*. This equilibrium holds if $2N_1 < L^*$ and if $L_2^* < N_2$ (this implies that the equilibrium in which both bind is sustained when $2N_1 < L^*$ and $L_2^* > N_2$). Note that $L_1^* < L_2^*$ since the FOC has to be satisfied for P_1 as well. In both cases, the FOC's right-hand-side is the same but for P_1 there is also a $-\lambda_1$ term. Moreover, if indeed $L_1^* < L_2^*$ then it must be that $\lambda_1 > 0$ by the FOC's and the non-symmetric solution.■

Proposition 2 *Consider* $N > \tilde{N}(N_1)$ *and* $N_1 \leq \tilde{N}$. *When* N_1 *increases, total employment and total surplus increase. When* N_1 *is high enough , the first best level of* *effort may also be achieved, implying that employment is at its maximum and so is the total surplus.*

Proof of Proposition 2

Let total employment be define as L^*. In the symmetric case, as long as redistribution keeps the order that P_1 has less or the same land as P_2, we get the same symmetric solution and hence $\frac{dL^*}{dN_1} = 0$. Similarly, in the case in which both bind, total employment is $N_1 + N_2$ which is fixed. Any redistribution that would maintain the same type of equilibrium, does not matter. Hence, L^* is fixed and $\frac{dL^*}{dN_1} = 0$. Consider then the equilibrium in which the capacity constraint of P_1 binds. Then, $\frac{dL^*}{dN_1} = \frac{dN_1 + dL_2^*}{dN_1} = 1 + \frac{A}{-(S_e e_v v_L - v_L) - A} = \frac{A - (S_e e_v v_L - v_L) - A}{-(S_e e_v v_L - v_L) - A} = \frac{-(S_e e_v v_L - v_L)}{-(S_e e_v v_L - v_L) - A} > 0.$

Now, we can consider total surplus: $T(N_1) = L^*(N_1) \cdot S(N_1)$:

$\frac{dT(N_1)}{dN_1} = \frac{dL^*}{dN_1} S + \frac{dS}{dN_1} L = \frac{dL^*}{dN_1} S + S_e e_v v_L \frac{dL^*}{dN_1} L = \frac{dL^*}{dN_1}(S + S_e e_v v_L L) > 0.$

Let us find now for which parameters the first best level may be achieved.

Recall that first best effort level e^* is achieved whenever $v > p(e^*) - d(e^*) - w$ (in our basic model, we set $w = 0$ in order to save on parameters, but now we will keep w general). Note that the symmetric equilibrium in which both do not bind achieves the highest effort level, and does so when $2N_1 \geq L^*$. It is also the limit of the non-symmetric equilibrium when $2N_1 \longrightarrow L^*$. Hence, it is enough to analyze the case of the nonsymmetric equilibrium for all $N_1 \in (0, \frac{L^*}{2})$. The equilibrium level v is such that $v(L_2^* + N_1) = G(L_2^* + N_1)$ where $G = F^{-1}$. At first best, $e_v = 0$. Hence, the equilibrium solution is

$$L_2^* = \frac{S(e(v(N_1 + L_2^*)) - v(N_1 + L_2^*)}{v_L} = \frac{S(e^*) - v(N_1 + L_2^*)}{v_L}$$

consider when $\bar{v}$ is reached. Then,

$$L_2^* = \frac{S(e^*) - \bar{v}}{v_L} = \frac{w}{v_L}$$

and

$$L_2^*(N_1) + N_1 = F(S(e^*) - w).$$

Hence, it has to be that $N_1 \geq F(S(e^*) - w) - L_2^*(N_1)$. Consider for example the case $v = bL$. Then

$$L_2^* = \frac{w}{b}$$

and therefore it has to be that

$$N_1 \geq \frac{S(e^*) - w}{b} - \frac{w}{b} = \frac{S(e^*) - 2w}{b}. \blacksquare$$

Proposition 4

(i) Given a $k-$tuple of asset holdings, there exists an equilibrium, in which there are b binding capacity constraints, $b \in \{0, 1, ..., k\}$.

(ii) When the distribution of assets is symmetric and N is high enough, $b = 0$. When the equilibrium has $b = 0$, the larger is k, the larger is the surplus in the economy.

(iii) Any equalizing transfer, from a principal whose constraint is non-binding to a principal whose constraint is binding increases total employment and surplus.

Proof of Proposition 5

Consider k principals, ordered by $N_1 < N_2 < ... < N_K$.

Consider the maximization problem of P_i :

$$\max_{L_i} L_i(S(e(v(L) - v(L)) + \lambda_i(N_i - L_i),$$

where $L = \sum_{j=1}^{k} L_j$. The FOC has:

$$L_i = \frac{S(e(v(L)) - v(L)}{v_L - S_e e_v v_L}$$

In a symmetric solution:

$$L^* = \frac{k[S((e(v(L^*)) - v(L^*))]}{v_L - S_e e_v v_L}$$

where L^* denotes total employment.

(i) In a symmetric solution, $\frac{dL^*}{dk} > 0$. To see this, we first show that $\frac{S((e(v(L))-v(L))}{v_L - S_e e_v v_L}$ is a decreasing function:

$\frac{d}{dL}\frac{S((e(v(L))-v(L))}{v_L - S_e e_v v_L} = \frac{(S_e e_v v_L - v_L)(v_L - S_e e_v v_L) - (S-v)(v_{LL} - S_{ee} e_v^2 v_L^2 - S_e e_{vv} v_L^2 - S_e e_v v_{LL})}{(v_L - S_e e_v v_L)^2}$

The first element is negative, whereas $(s - v) > 0$ and $v_{LL} - S_{ee} e_v^2 v_L^2 - S_e e_{vv} v_L^2 - S_e e_v v_{LL} = v_{LL}(1 - S_e e_v) - S_{ee} e_v^2 v_L^2 - S_e e_{vv} v_L^2 > 0$ since $v_{LL} < 0$, $1 - S_e e_v > 0$, $S_{ee} < 0$, $e_{vv} < 0$.

Now, $\frac{dL^*}{dk} = \frac{S((e(v(L))-v(L))}{v_L - S_e e_v v_L} + k\frac{d}{dL}\frac{S((e(v(L))-v(L))}{v_L - S_e e_v v_L} \rightarrow \frac{dL^*}{dk} = \frac{\frac{S((e(v(L))-v(L))}{v_L - S_e e_v v_L}}{(1 - k\frac{d}{dL}\frac{S((e(v(L))-v(L))}{v_L - S_e e_v v_L})} > 0.$

(ii) Characterization of asymmetric equilibria: suppose that there exists an equilibrium in which i binds. Then it must be that also $i - 1$ binds. To see this, it is the same as in the proof of Proposition 1 for two principals. Hence, in general, there exist equilibria in which b principals bind, $b \in \{0, 1, ..., k\}$. Clearly, $L_i = N_i$ for $i \leq b$. For $i > b$, the equilibrium solution is symmetric by the FOC, and solves:

$$L_j = (k - b)\frac{S(e(v(L)) - v(L)}{v_L - S_e e_v v_L}$$

Obviously, the existence of these equilibria depends on the distribution of assets. In particular, with a completely equal distribution of assets, and high enough N, $b = 0$. The more unequal is the distribution for a given N, the more likely it is that b is higher.

(iii) An equilibrium in which b bind has lower L^* compared to an equilibrium in which $b - 1$ bind. Consider therefore an 'equalizing transfer', that is a transfer that shifts resources from the non-binding principals, to the highest binding principal, in particular, principal b. Assume first that the transfer is such that the participation constraint still binds for b. Then, taking a total differentiation of the FOC of principal $j > b$, we get:

$$A(\sum_{i=1}^{b-1} dN_i + dN_b + \sum_{h=b+1,h\neq j}^{k} dL_h^*) + [S_e e_v v_L - v_L + A]dL_j^* = 0 \tag{3}$$

for

$$A = S_e e_v v_L - v_L + L_j(S_{ee} {e_v}^2 v_L^2 + S_e e_{vv} v_L^2 + S_e e_v v_{LL} - v_{LL})$$

Note however that $dN_i = 0$ for all $i < b$, and that by symmetry, $dL_h^* = dL_j^*$ for all $j, h > b$. Then, re-arranging (3), we get:

$$\begin{aligned} AdN_b + [S_e e_v v_L - v_L + (k-b)A]dL_j^* &= 0 \rightarrow \\ \frac{dL_j^*}{dN_b} &= \frac{A}{-[S_e e_v v_L - v_L + (k-b)A]} < 0 \rightarrow \\ dL^* &= dN_b(1 + \frac{A(k-b)}{-[S_e e_v v_L - v_L + (k-b)A]}) \\ &= dN_b(\frac{-(S_e e_v v_L - v_L)}{-[S_e e_v v_L - v_L + (k-b)A]}) > 0 \end{aligned}$$

which obviously implies that total surplus increases as well.

Now consider a transfer that takes N_b to the value at which it does not bind any more. By continuity, this increases total surplus and induces the same surplus also if N_b is slightly higher, so it is still the case that $b-1$ constraints bind.

From this point, we can keep on with equalizing transfers, that maintain the order of the principals, and each time relax one constraint (due to the nature of the requirements about the distribution of N that supports each type of equilibria, this is possible to do). Each stage in the process increases total surplus, and at the end, the surplus amounts to that of an equal distribution, and is higher than any other distribution with binding constraints.■