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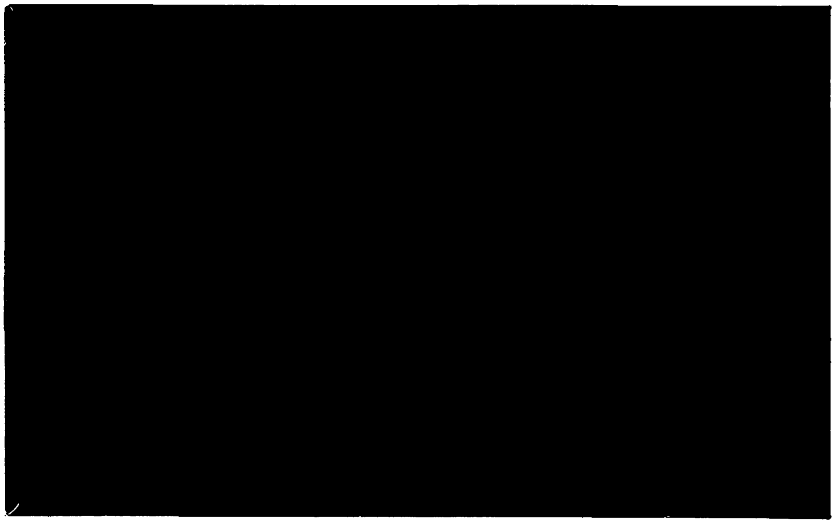

Exploitation, Agency, and Agrarian Contracts

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Our understanding of agrarian institutions has been greatly enhanced by the development of principal-agent models of agrarian relations. Largely as a result of these models, the literature on sharecropping, agrarian credit, and contract interlinkage has become ever more realistic bringing with them the lesson that many institutions observed in developing economies, and once deemed inefficient by neoclassical economists, play important economic roles in the absence of complete markets. However, one of the key characteristics of principal-agent models is that they are constrained Paretian efficient and hence describe outcomes that are socially efficient subject to the informational constraints of the model. In the typical principal-agent model of agrarian relations, the principal, usually a landlord, designs a contract subject to informational or incentive constraints and the further constraint that the agent, usually a peasant farmer, achieve his or her reservation utility. How the reservation utility is determined is external to the model, and in the words of Braverman and Stiglitz, landlords are treated as "...'expected utility' takers' ". And while these landlords certainly enjoy perfect monopsonistic power in one market (are "perfectly exploitative" in the sense of Basu (1989)), the fact that the peasant always has free access to an alternative (presumably competitive) market, with which the landlord effectively competes, makes it difficult to characterize these contracts as truly exploitive or extortionate. Moreover, as a number of authors have pointed out (e.g., Binswanger et al.), this expected utility taking assumption appears unrealistic because it does not recognize the asymmetric access to coercive mechanisms that the landlord class has in agrarian economies.

Many mechanisms exist by which the landlord class has historically reduced the reservation utility of the peasant class in agrarian economies: restricting peasant access to unoccupied lands; differential taxation of peasants not contracting with members of the landlord class; restricting market access of free peasant populations; and confining agricultural public goods (roads, infrastructure) to the farms of landlords (Boserup; Binswanger et al.). Each of these mechanisms has the feature that the landlord class acts through a different milieu than the credit or agrarian contract to shift the peasants' labor-supply curve downward thus making peasants more amenable to the contract terms offered by landlords. Basu (1986) has constructed a model of three-sided relationships between landlords, peasants, and merchants which demonstrates that landlords can take actions in their dealings with the merchants that might lower the reservation utility that peasants can expect to realize by dealing only with the merchants. For example, the landlord could threaten not to deal with a merchant dealing with a peasant with whom the landlord did not have a direct relationship. If the landlord is an important enough client of the merchant, this threat, if credible, could be sufficient to induce the merchant not to deal with said peasants, thus narrowing the peasant's alternatives. The key element in each of these examples is that landlords and the peasants often have indirect relationships through other individuals, institutions, and markets that are not the subject of the terms of the agrarian contract they are negotiating. The landlord, realizing this, would be irrational not to pursue any actions through these indirect channels which could enhance his returns from dealing with the peasant in the agrarian contract. Such activity, however, would not generally be constrained Paretian. Rather it would be more akin to rent-seeking or directly unproductive (DUP) activities which have no productive effect, but which instead only serve to enhance the landlord's ability to exploit the tenant.

This paper attempts to formalize some of these ideas in the framework of a simple principal-agent model of an agrarian contract between a landlord and a peasant tenant where the principal (the landlord) can take actions, which are costly to him or her, to reduce the peasant's reservation utility. In what follows, we first lay out our model and the optimization problem facing the landlord. We solve that optimization problem in three stages: First, following Grossman and Hart, we find the optimal payment structure required to get the peasant to adopt a particular action vector for a given level of the peasant's reservation utility. In so doing, we are able to address a related issue raised in the agrarian contracts literature -- when will it be beneficial for the landlord to deny peasant tenants access to yield enhancing technological innovations? Second, we solve the standard landlord-peasant contract, i.e., choosing the optimal action vector for a given reservation utility; and in the third stage we choose the optimal reservation utility and characterize how changes in the cost of exploiting the peasant affects the landlord's choices.

The Model

Our description of the model starts with a statement of the problem we propose to solve: A risk-neutral landlord and a risk-averse peasant tenant are contracting over the conditions required for the peasant to farm a given plot of land for the landlord. The landlord is the residual claimant for the crop grown and has the right to specify the contract terms. The landlord has access to a competitive market in which the crop can be sold at the going rate of p which the landlord takes as given. Crop production is uncertain, and there is moral hazard because the landlord cannot observe the peasant's commitment or allocation of effort. *Ex post* output, i.e., after the resolution of uncertainty, however, is observable and contractible. By an appropriate expenditure of effort through political or other extra-contract means the landlord can affect the peasant's next best alternative, i.e., the peasant's reservation utility. The peasant, however, takes this next best alternative as given and in considering whether to adopt the contract offered by the landlord only compares it with this alternative. We seek to characterize the optimal agrarian contract (from the landlord's perspective) that the landlord will offer the peasant under these circumstances.

There are two states of nature and crop production of a single output on the plot of land is uncertain. The probability of state 1 occuring is given by π_1 and the probability of state 2 occuring is given by π_2, and, of course, $\pi_1 + \pi_2 = 1$. For a fixed vector of inputs, $\mathbf{x} \in \Re_+^n$, the peasant's state-contingent output set is given by

$$Z(\mathbf{x},t) = \{(z_1, z_2): x \ can \ produce \ (z_1, z_2) \ given \ t\},$$

where z_i is output that occurs in state i and t is an indicator of the state of technology. This set is assumed to be convex and to satisfy free disposability in state-contingent outputs, i..e., $\mathbf{z} \quad Z(\mathbf{x},t)$ implies $\mathbf{z}' \quad Z(\mathbf{x},t)$ for $\mathbf{z}' \leq \mathbf{z}$. Uncertainty is resolved after the vector of inputs is committed. Therefore, the appropriate interpretation of Z(**x**,t) is that it gives the range of state-contingent outputs that can emerge after **x** is committed, and after uncertainty is resolved, i.e., either state-1 or state-2 occurs. A typical state-contingent output set is depicted in Figure 1, where production in state 1 is measured along the horizontal axis and production in state 2 is measured along the vertical axis. The set of feasible state-contingent outputs, for given **x**, consists of all output combinations on or below the illustrated frontier. It is important to remember that these outputs are state-contingent, i.e., only one of these outputs actually occurs. Suppose, for example, that input **x** is committed and point A, (z_1^*, z_2^*), in Figure 1 is chosen by the peasant: if state 2 occurs, then z_2^* is observed.

The information structure is as follows: Only the peasant observes the actual conditions under which production takes place, i.e., only the peasant can observe which state of nature occurs and what level of inputs are committed. Both the landlord and the peasant, however, know the production technology, Z(**x**, t), and each other's preferences. They also share common *a priori* beliefs about which state of nature will actually occur.

The peasant's *ex post* preferences are additive in returns and the vector of inputs committed to production:

$$w(y, \mathbf{x}) = u(y) - g(\mathbf{x}).$$

Here u is a twice differentiable, strictly increasing, and strictly concave von Neumann-Morgenstern utility function, y is the the peasant's consumption, and g is a strictly increasing and strictly convex function of the effort vector, **x**. The peasant is not directly concerned about output.

Given the peasant's preference structure, it is convenient to define the effort-cost function by:

$$C(\mathbf{z}, t) = \text{Min}\,\{g(\mathbf{x}): \mathbf{z} \quad Z(\mathbf{x},t)\}.$$

It is easy to show that $C(\mathbf{z}, t)$ will be convex and increasing in $\mathbf{z}$. We add the further assumption that it is twice continuouosly differentiable. Technical change is *cost reducing* if $C_t(\mathbf{z}, t) < 0$. For given y and $\mathbf{z}$, the peasant's expected utility is, therefore, given by:

$$\pi_1 u(y_1) + \pi_2 u(y_2) - C(z_1, z_2, t).$$

We will denote the peasant's reservation utility by $\bar{u}$, which is subject to the landlord's choice, but which the peasant takes as given. To give some notion of the type of indirect relationship between the landlord and the peasant which we are considering, suppose that the peasant's best alternative to contracting with the landlord is wage labor at a going nonstochastic wage of w. For simplicity, also suppose for the moment that the input vector is a scalar which we shall take to be his or her labor. The peasant's reservation utility is then:

$$\bar{u} = U(w) = \text{Max}_x\,\{u(wx) - g(x)\}.$$

Now suppose further that the landlord can exert sufficient political or extra-contract power to influence the going wage, say through taxation or by negotiating with wage contractors: in designing the contract a rational landlord possessing that ability will take it into account.

For the purposes of this paper, however, it will typically suffice to be less specific about how the landlord affects $\bar{u}$ and only presume that the landlord does have the ability to determine $\bar{u}$. That ability, however, is limited by the presumption that the landlord must incur a positive cost to affect $\bar{u}$. For example, in the wage-labour example above the landlord might be able to exert political influence to have earnings taxes imposed upon wage laborers. But exerting political influence necessarily has a positive opportunity cost. To formalize, suppose that the peasant's reservation utility absent landlord intervention is u^o: The landlord is assumed able to incur cost measured by $Af(\bar{u})$ to affect the peasant's reservation utility. $A > 0$, f is a strictly decreasing and convex function satisfying $Af(u^0) = 0$.

The agrarian contract between the peasant and the landlord is of the following form: the landlord nominates for each state of nature a payment y_i and asks the peasant to report both the unobservable state and the observable output z_i to receive that payment. If the peasant is to receive y_i she must report that state i occurred and the observable output must be z_i. We refer to $[(y_1,z_1), (y_2,z_2)]$ as the contract.

Specifying a state-contingent payoff-production contract creates an incentive problem, however, because under the presumed informational structure the landlord cannot observe the peasant's effort or which state of nature occurs. Only the peasant has this information. Therefore, the peasant may find it advantageous to misrepresent which state of nature actually occurs unless the landlord designs a contract that makes doing so irrational. Thus, the revelation principle implies that any implementable contract must satisfy the following truthtelling constraints:

$$\pi_1 u(y_1) + \pi_2 u(y_2) - C(z_1, z_2, t) \geq u(y_1) - C(z_1, z_1, t)$$
$$\pi_1 u(y_1) + \pi_2 u(y_2) - C(z_1, z_2, t) \geq u(y_2) - C(z_2, z_2, t)$$

(TT)

$$\pi_1 u(y_1) + \pi_2 u(y_2) - C(z_1, z_2, t) \geq \pi_1 u(y_2) + \pi_2 u(y_1) - C(z_2, z_1, t)$$

To understand why TT must hold, suppose that the last two inequalities hold but that the first does not. Under these circumstances the peasant always finds it advantageous to produce z_1 and to claim that state 1 has occurred. Hence, the contract $[(y_1, z_1), (y_2, z_2)]$ can never be fully implemented.

An immediate consequence of conditions TT and the properties of the peasant's effort-cost function is (all proofs are in an appendix):

Lemma 1: Any contract satisfying TT must also satisfy:

$$y_i - y_k > 0 \Leftrightarrow z_i - z_k > 0,$$
$$y_i - y_k = 0 \Leftrightarrow z_i - z_k = 0,$$
$$u_i - u_k > 0 \Leftrightarrow z_i - z_k > 0,$$
$$u_i - u_k = 0 \Leftrightarrow z_i - z_k = 0.$$

for (i, k) = (1,2).

Lemma 1 is easy to understand: It says that any contract the landlord is able to implement must have a monotonic relationship between the payment offered in state i and the output demanded in state i by the landlord. Visually, it is depicted in Figure 2. Suppose that point A represents the state-contingent production couple the landlord wants to implement. As drawn, A is above the bisector implying that output in state 2 is higher than output in state 1. Now suppose the landlord offers the peasant a payment structure given by point B which lies below the bisector. Regardless of the peasant's degree of risk aversion, the peasant will always be better off shirking effort and producing at point C on the bisector and always claiming to the landlord that state 1 occurred in order to receive the higher payment. By offering the peasant state-contingent payments associated with B, the landlord gives the tenant an economic incentive to shirk.

Lemma 1 does not indicate, however, which state is the high-output state and which state is the low-output state. For clarity's sake, we now introduce a purely technical assumption on the technology, which when coupled with Lemma 1 yields just such an ordering of states. Hence we refer to the assumption as SOA for state-ordering assumption:

Assumption (SOA):

$$\pi_1 C(z_k, z_k) + \pi_2 C(z_j, z_j) - C(z_k, z_j) > 0 \Leftrightarrow (z_j - z_k) > 0$$
$$\pi_1 C(z_k, z_k) + \pi_2 C(z_j, z_j) - C(z_k, z_j) = 0 \Leftrightarrow (z_j - z_k) = 0.$$

With SOA, it follows immediately that:

Lemma 2: Under SOA, any contract satisfying TT must also satisfy:

$$(y_1, z_1) < (y_2, z_2), \textit{ or}$$
$$(y_1, z_1) = (y_2, z_2)$$

In what follows, we always maintain SOA. Thus, state 2 is the high-output state and state 1 is the low-output state. We now can state formally the landlord's problem. The landlord chooses $(\overline{u}, z_1, z_2, y_1, y_2)$ according to:

$$\text{Max } W^p = (\pi_1(pz_1 - y_1) + \pi_2(pz_2 - y_2)) - Af(\overline{u})$$

subject to:

$$\pi_1 u(y_1) + \pi_2 u(y_2) - C(z_1, z_2, t) \geq \overline{u}$$
$$\pi_1 u(y_1) + \pi_2 u(y_2) - C(z_1, z_2, t) \geq u(y_1) - C(z_1, z_1, t)$$
$$\pi_1 u(y_1) + \pi_2 u(y_2) - C(z_1, z_2, t) \geq u(y_2) - C(z_2, z_2, t)$$
$$\pi_1 u(y_1) + \pi_2 u(y_2) - C(z_1, z_2, t) \geq \pi_1 u(y_2) + \pi_2 u(y_1) - C(z_2, z_1, t).$$

The first inequality represents the constraint that the agrarian contract must leave the peasant as least as well off as his next best alternative. The assumption is that even though the formulation of the agrarian contract may involve extra-contract exploitation on the part of the landlord, or "extortion" as these contracts are increasingly described, the peasant is not a slave. He or she is free to choose where they commit their effort. All we claim is that the landlord can affect the peasant's next best alternative. We have:

Lemma 3: For given $\overline{u}$, the landlord specifies a contract that yields the peasant exactly his or her reservation utility.

The Agency-Cost Function

Following Grossman and Hart, we intend to solve this problem in stages. To that end, we specify the *agency-cost problem* as choose (y_1, y_2) to

$$Min\{\pi_1 y_1 + \pi_2 y_2\}$$

subject to:

$$\pi_1 u(y_1) + \pi_2 u(y_2) - C(z_1, z_2, t) \geq \overline{u}$$
$$\pi_1 u(y_1) + \pi_2 u(y_2) - C(z_1, z_2, t) \geq u(y_1) - C(z_1, z_1, t)$$
$$\pi_1 u(y_1) + \pi_2 u(y_2) - C(z_1, z_2, t) \geq u(y_2) - C(z_2, z_2, t)$$
$$\pi_1 u(y_1) + \pi_2 u(y_2) - C(z_1, z_2, t) \geq \pi_1 u(y_2) + \pi_2 u(y_1) - C(z_2, z_1, t)$$

The agency-cost minimization problem gives the minimum cost of getting the peasant to produce a given state-contingent output vector that achieves his or her reservation utility and simultaneously satisfies TT. Because u is strictly concave and strictly increasing the agency-cost problem can always be rewritten after a change in variables as

$$Min\ \pi_1 h(u_1) + \pi_2 h(u_2)$$

subject to:

$$\pi_1 u_1 + \pi_2 u_2 - C(z_1, z_2, t) \geq \bar{u}$$

$$\pi_1 u_1 + \pi_2 u_2 - C(z_1, z_2, t) \geq u_1 - C(z_1, z_1, t)$$

$$\pi_1 u_1 + \pi_2 u_2 - C(z_1, z_2, t) \geq u_2 - C(z_2, z_2, t)$$

$$\pi_1 u_1 + \pi_2 u_2 - C(z_1, z_2, t) \geq \pi_1 u_2 + \pi_2 u_1 - C(z_2, z_1, t)$$

where $h(u_i) = u^{-1}(u(y_i))$ is a strictly increasing convex function. Thus, as Grossman and Hart point out, the agency-cost minimization problem is a simple convex minimization problem subject to a set of linear constraints; the Kuhn-Tucker conditions give necessary and sufficient conditions for optimality.

The *agency-cost function*, $Y: \Re_+^4 \times \Pi \rightarrow \Re$, is defined the greatest lower bound of the landlord's objective function in the agency-cost minimization problem if the constraint set is nonempty and is infinity if the constraint set is empty.

Under SOA, any contract that is implementable must have state 2 as the higher output state of nature. Therefore, in what follows, we can always restrict our attention to such cases without any loss of generality. It is, therefore, convenient to introduce some new notation. Let :

$$\vec{Z} = \{(z_1, z_2): z_1 \leq z_2\} \ .$$

Graphically $\vec{Z}$ is represented by everything on or above the bisector in **z** space.

With this notation and definition, we are now ready to show in a fashion similar to Weymark's reduction of the hidden information problem that the agency-cost problem has a simple closed-form solution under SOA.

Lemma 4: Suppose SOA and $z \in \vec{Z}$, then i) any allocation satisfying:

$$\pi_1 u_1 + \pi_2 u_2 - C(z_1, z_2, t) = u_1 - C(z_1, z_1, t)$$

satisfies all the incentive constraints to the agency-cost minimization problem;and ii)

$$\pi_1 u_1 + \pi_2 u_2 - C(z_1, z_2, t) = u_2 - C(z_2, z_2, t), \text{ and}$$

$$\pi_1 u_1 + \pi_2 u_2 - C(z_1, z_2, t) = \pi_1 u_2 + \pi_2 u_1 - C(z_2, z_1, t)$$

if and only if both outputs are equal.

Operationally Lemma 4 is one of the more important results in the paper. Therefore, we offer a direct proof of it in the paper. First we show that under SOA, the third constraint under TT is typically redundant because it can be obtained from a linear combination of the first two constraints. Multiply both sides of the first constraint under TT by π_2 and both sides of the second by π_1 and add the result together to get

$$\pi_1 u_1 + \pi_2 u_2 - C(z_1, z_2, t) \geq \pi_1 u_2 + \pi_2 u_1 - \pi_2 C(z_1, z_1, t) - \pi_1 C(z_2, z_2, t)$$

Now apply SOA to the right hand side of this expression with k=2 and j=1 to yield that the right hand side of this expression is greater than or equal to the right hand side of the third constraint under TT. Hence, under SOA the third is implied by the first two, and it is immediate that the third can bind only if both the first and the second constraints bind. Moreover, if the first two constraints are satisfied, so is the third. For a monotonic chain to the left:

$$\pi_2 (u_2 - u_1) = C(z_1, z_2, t) - C(z_1, z_1, t).$$

Substitute this result into the left-hand side the second constraint under TT to get the following requirement

$$\frac{\pi_1}{\pi_2}\left(C(z_1, z_1, t) - C(z_1, z_2, t)\right) \geq C(z_1, z_2, t) - C(z_2, z_2, t)$$

which is always satisfied for $z \in \vec{Z}$ under SOA. This establishes i) in Lemma 4. To establish ii), it is now sufficient to establish that the second constraint under TT can bind in the agency-cost minimization problem under SOA only if both outputs are equal. This is demonstrated graphically in Figure 3. There the reservation-utility constraint is represented by the negatively sloped line segment in utility space with slope equalling $-\pi_1/\pi_2$. All points on or above this line segment satisfy the constraint. By Lemma 3, any solution to the cost minimization problem must lie on the line segment. Because h is strictly convex and nondecreasing the level sets of the landlord are represented by negatively sloped curves strictly concave to the origin, and the landlord's preference direction is to the southwest. Along the bisector, the strict convexity of h implies that the landlord's level sets have slope $-\pi_1/\pi_2$. Now for $z \in \vec{Z}$, the set of points meeting the second constraint under TT exactly is given by the line segment parallel to the bisector

(1) $$u_2 = \frac{C(z_2,z_2) - C(z_1,z_2)}{\pi_1} + u_1$$

For $z \in \vec{Z}$ all points on or below this line segment meet the second constraint under TT. The set of points meeting the first constraint under TT exactly is given by

(2) $$u_2 = \frac{C(z_1,z_2) - C(z_1,z_1)}{\pi_2} + u_1$$

Under SOA for $z_2 > z_1$ the intercept of (1) is higher than the intercept of (2). This is illustrated graphically in the Figure. Now suppose that the optimal solution to the agency cost minimization problem is at the intersection between (1) and the reservation-utility constraint, the landlord's indifference curve must pass through this point of intersection. But now note that the first part of this lemma guarantees that the point of intersection between (2) and the reservation-utility constraint satisfies TT. Because h is strictly convex, the landlord must be able to achieve a higher indifference curve by moving from the intersection between (1) and the reservation utility constraint to the latter's intersection with (2). Hence, the optimal solution could never involve (1) holding.

From the preceding discussion, it follows that the solution to the agency-cost minimization problem is at the point of intersection between (2) and the reservation utility constraint. Thus,

Theorem 1: Suppose SOA and $z \in \vec{Z}$, the agency-cost function is given by the twice differentiable function:

$$Y\left(z_1, z_2; \pi_2, \bar{u}, t\right) = \left(1-\pi_2\right)h\left(\bar{u} + C\left(z_1, z_1, t\right)\right) + \pi_2 h\left(\bar{u} + C\left(z_1, z_2, t\right)/\pi_2 - \frac{1-\pi_2}{\pi_2}C\left(z_1, z_1, t\right)\right)$$

.

Theorem 1, as well as the lemmas leading up to it have been derived for the case of general peasant preferences. However, in what follows we shall find it convenient for expositional purposes to always maintain:

Assumption (U): Peasant preferences toward y are given by u(y) = ln y, and h(u) = exp(u).

Assumption U implies that the peasant's preferences toward uncertain outcomes is characterized by constant relative risk aversion, and with little loss of generality we have set the degree of risk aversion to 1. Most of the analysis that follows is not affected by this simplifying assumption and can be suitably generalized by the interested reader. This assumption allows us to write the following explicit form for Y:

$$\begin{aligned} Y\left(z_1, z_2; \pi_2, \bar{u}, t\right) &= \exp\left(\bar{u}\right)\left(\left(1-\pi_2\right)\exp\left(C\left(z_1, z_1, t\right)\right) + \pi_2 \exp\left(C\left(z_1, z_2, t\right)/\pi_2 - \frac{1-\pi_2}{\pi_2}C\left(z_1, z_1, t\right)\right)\right) \\ &\equiv \exp\left(\bar{u}\right)m\left(z_1, z_2; \pi_2, t\right) \end{aligned}$$

Theorem 1 is one of the central results of the paper. Its most important implications are summarized in the following Corollary:

Corollary 1: Suppose SOA, U, and $z \in \vec{Z}$, then

a) Y is strictly decreasing and strictly convex in $\bar{u}$, and $Y_u = Y$,

b) Y is increasing and convex in z_2;

c) the optimal solution to the agency-cost minimization problem is given by:

$$\begin{aligned} u_1 &= \bar{u} + C\left(z_1, z_1, t\right), \\ u_2 &= \bar{u} + C\left(z_1, z_2, t\right)/\pi_2 - \frac{1-\pi_2}{\pi_2}C\left(z_1, z_1, t\right). \end{aligned}$$

Property a) formally confirms why the landlord should be willing to commit resources to reducing the tenant's reservation utility: As the peasant's reservation utility falls the landlord's cost of getting the peasant to adopt any state-contingent output vector falls at an increasing rate. Hence, the landlord always gains from a costless reduction in the peasant's reservation utility. And property c) shows how: For each unit that the peasant's reservation utility falls, the landlord can reduce the peasant's utility in each state by a like amount. This is perhaps best visualized by reference to Figure 3: As the peasant's reservation utility falls the line segment representing the peasant's reservation utility constraint shifts downward, and the solution to the agency-cost problem moves down line segment (2). Because h is strictly convex and $u_2 > u_1$, in cost terms the landlord realizes a greater cost savings from the state-2 utility reduction than from the state-1 reduction.

Part b) of Corollary 1 establishes a monotonicity and convexity property in z_2 but none in z_1. To understand why agency costs must be increasing and convex in z_2 recall that z_2 is the higher output. As z_2 increases holding the level of z_1 fixed, the incentive problem facing the landlord becomes worse as the peasant now has an extra cost incentive to prefer shirking. Hence, the landlord has offer an added inducement to encourage the peasant to produce z_2. The convexity of $C(\mathbf{z}, t)$ implies that this inducement must grow at an increasing rate, hence the convexity of Y. Now it is also clear why one cannot also establish a general monotonicity condition for z_1. Raising z_1 has two opposing effects: It increases the costs to the peasant of the overall state-contingent output vector, this tends to raise agency cost; and by decreasing the difference between z_2 and z_1 it reduces the incentive problem by making shirking less attractive to the peasant, this tends to decrease agency cost.

Because increasing the riskiness of $\mathbf{z}$ seemingly exacerbates the incentive problem by making shirking more attractive to the peasant, one might conjecture that it would cause agency cost to rise. This conjecture, however, turns out to be false as a general premise. Consider the mean preserving spread of $\mathbf{z}$ defined by increasing z_2 by a small positive amount, δ, and decreasing z_1 by $-\frac{\pi_1}{\pi_2}\delta$. The associated perturbation in agency cost is:

$$\delta\left(\exp(u_2)\left[\frac{C_2(z_1,z_2,t)}{\pi_2}-\frac{C_1(z_1,z_2,t)}{\pi_1}\right]+\left[\exp(u_2)-\exp(u_1)\right]\left[C_1(z_1,z_1,t)+C_2(z_1,z_1,t)\right]\right)$$

The first expression inside the large parentheses measures whether the peasant's cost of producing the riskier output bundle is greater or smaller than the cost of the less risky output bundle. Consider Figure 4 where we have redrawn the isocost curve to the peasant. Suppose that initially the output bundle is at point A where the fair odds line is depicted as cutting the isocost curve from below, i.e., $\frac{C_2(z_1,z_2)}{\pi_2}-\frac{C_1(z_1,z_2)}{\pi_1}<0$. The mean preserving spread of the output bundle given by A is represented graphically as a northwesterly movement along the fair odds line from A. Such a movement leaves us below the isocost curve passing through A thus implying that the riskier output bundle is less costly to produce in this instance. Because the riskier output bundle is cheaper to produce, it should be cheaper to get the peasant to adopt it and thus agency cost should reduce. The second term in the large parentheses measures the increase in agency cost due to the increased incentive problem that the riskier output bundle entails (by increasing z_2 - z_1, it increases the gain from choosing (z_1, z_1)). It is always positive. So it follows that in this instance, the overall effect on agency cost is ambiguous. However, if the fair odds line had cut A from above, i.e., $\frac{C_2(z_1,z_2)}{\pi_2}-\frac{C_1(z_1,z_2)}{\pi_1}>0$, agency cost would have risen.

Following Peleg and Yaari, we define points like A in Figure 4 as being *risk aversely efficient* because it is easy to show that for such points, one could always find a risk-averse individual who would adopt it if they received all the benefits from production. By this definition:

Corollary 2: Suppose SOA, U, and $z \in \vec{Z}$: If **z** is not risk aversely efficient, then a mean preserving spread of **z** will increase agency cost.

Lemma 3 implies that the peasant's certainty equivalent for the state-contingent payment scheme (y_1, y_2) is $\exp(C(z_1, z_2, t) + \bar{u})$; its expected value is $Y(z_1, z_2; \pi_2, \bar{u}, t)$. Hence, the peasant's risk premium for the payment scheme (y_1, y_2) which we denote by $R(z_1, z_2; \pi_2, \bar{u}, t)$, is

$$R(z_1, z_2; \pi_2, \bar{u}, t) = Y(z_1, z_2; \pi_2, \bar{u}, t) - \exp(C(z_1, z_2, t) + \bar{u}) =$$
$$\exp(\bar{u})\left(\pi_2\left(\exp\left(C(z_1, z_2, t)/\pi_2 - \frac{1-\pi_2}{\pi_2}C(z_1, z_1, t)\right) - \exp(C(z_1, z_1, t))\right)\right)$$

Theorem 1 and Corollary 1 yield:

Theorem 2: Suppose SOA, U, and $z \in \vec{Z}$: An increase in $\bar{u}$ leads the landlord to offer the peasant a more risky payment scheme for given **z**; and a cost-saving technological innovation passed on to the tenants by the landlord leads the landlord to offer the peasants a less risky payment scheme if the marginal cost of producing state-2 output is decreasing in t.

The effect of technological progress on the level of agency costs is particularly interesting because it addresses an issue originally raised in the theoretical literature by Bhaduri who, in attempting to explain adoption patterns of the innovations associated with the Green Revolution, claimed that a landlord who simultanteously lent to the peasant and contracted with the peasant on agricultural production might find it advantageous to deny the peasant access to yield enhancing technology. His reasoning and arguments have been severely criticized by Newbery and Braverman and Stiglitz. However, both Newbery and Braverman and Stiglitz do recognize that a landlord might rationally deny the peasant access to yield enhancing technology if the new technology exacerbated the moral hazard problem. The properties of the agency-cost function enable us to shed some further light on this issue. If the agency-cost function is increasing in t when technical change is cost reducing, a rational landlord would want to deny the peasant access to the new technology. From Corollary 1, the only way that agency costs can be increasing in t when technological change is cost saving is if the agency-cost minimizing u_2 is increasing in t. Thus, cost-reducing technological change will be denied to the peasant only if it exacerbates the agency-cost problem by requiring the landlord to offer a higher u_2 to the peasant.

Direct calculation reveals that the change u_2 associated with a change in t is:

$$C_t(z_1,z_2,t)/\pi_2 - \frac{1-\pi_2}{\pi_2}C_t(z_1,z_1,t) = C_t(z_1,z_1,t) + \frac{C_t(z_1,z_2,t) - C_t(z_1,z_1,t)}{\pi_2}$$

Hence, it follows immediately that:

Corollary 3: Suppose SOA, U, and $z \in \vec{Z}$: The landlord will want to deny the peasant access to cost-reducing technical innovation only if the marginal cost of state-2 production is increasing in t over some portion of $[z_1, z_2]$.

Thus, a rational landlord would deny the peasant access to a cost-reducing technical innovation only if it increases the marginal cost of producing the state-2 contingent output, i.e., the technical innovation although overall cost reducing is actually regressive in producing the higher state output. Again the intuition here is clear. As before, the incentive problem is to prevent the peasant from misrepresenting state-2 as state-1. This task is made harder when technical change raises the marginal cost of producing z_2, for when this happens the peasant must receive an even higher state-2 payment to overcome the effect of the marginal-cost increase.

It is interesting to compare our findings with those of Braverman and Stiglitz. Their explanation hinges upon the effect technical change has upon the overall effort level: "With a sufficiently large negative effort response on the part of the tenants landlords . . . will resist the innovation." (p.320) Here the reasoning is more specific and hinges not upon the overall level of effort committed, but on how effort committed is allocated. If the technical innovation requires significantly more effort to be allocated to the production of z_2, the landlord may want to resist the innovation because it makes it more expensive to resolve the agency problem.

In closing our discussion of the effort cost problem, we want to state one further condition on the technology which will be useful in the remaining optimization problems. This condition, which we label SC for strong convexity, guarantees that the agency-cost function will be convex in **z**, thus enabling us to identify global optima in the following sections:

Assumption (SC): $C(z_1,z_2,t)-(1-\pi_2)C(z_1,z_1,t)$ is convex in z_1 over $z\in\vec{Z}$.

Corollary 4: Suppose SOA, U, SC, and $z\in\vec{Z}$, then the agency-cost function is convex in **z**.

We note in passing that a sufficient condition for SC to hold is that C(**z**,t) exhibit constant returns to scale.

An Optimal Agrarian Contract for an 'Expected-Utility' Taker

In this section, we shall proceed on the second stage of our journey and derive the analogue of the standard optimal agrarian contract.

Under SOA, it is immediate from previous developments that the solution to this problem is found by choosing $z\in\vec{Z}$ to solve:

$$V(\overline{u},p,t,\pi)=\underset{z_1,z_2}{Max}\left\{p(\pi_1 z_1+\pi_2 z_2)-Y(z_1,z_2;\pi_2,\overline{u},t)\right\}.$$

However, a little manipulation reveals that:

$$V(\overline{u},p,t,\pi)=\exp(\overline{u})v\left(\frac{p}{\exp(\overline{u})},t,\pi\right),$$

where

$$v\left(\frac{p}{\exp(\overline{u})},t,\pi\right)=\underset{z_1,z_2}{Max}\left\{\frac{p}{\exp(\overline{u})}(\pi_1 z_1+\pi_2 z_2)-m(z_1,z_2;t,\pi_2)\right\}.$$

At this point it is convenient to introduce some further notation, let $q=p/\exp(\overline{u})$, and

$$z(q) \in \arg\max\left\{\frac{p}{\exp(\bar{u})}(\pi_1 z_1 + \pi_2 z_2) - m(z_1, z_2; t, \pi_2)\right\}.$$

By the definition of z(q), it follows immediately that:

$$qEz(q) - m(z(q); \pi_2, t) \geq qEz(q^o) - m(z(q^o); \pi_2, t),$$

and

$$q^oEz(q^o) - m(z(q^o); \pi_2, t) \geq q^o\ Ez(q) - m(z(q); \pi_2, t),$$

where E is the expectations operator over π. Adding these inequalities and rearranging obtains:

$$(q^o - q)(Ez(q^o) - Ez(q)) \geq 0.$$

A similar manipulation also reveals that

$$\left(\frac{1}{q} - \frac{1}{q^o}\right)\left(m\left(z_1(q^o), z_2(q^o); \pi_2, t\right) - m\left(z_1(q), z_2(q); \pi_2, t\right)\right) \geq 0.$$

These two inequalities, in turn, imply:

Theorem 3: Under SOA and U for given $\bar{u}$: the expected value of the landlord's optimal output vector is nondecreasing in the crop price and nonincreasing in the peasant's reservation utility; and the landlord's expected cost (the peasant's expected payment) is nondecreasing in the crop price.

By maintaining SC, one can be assured that a unique maximum, which is characterized by the Kuhn-Tucker conditions, exists. It follows easily from preceding developments that:

Theorem 4: Under SOA, U, and SC for given $\bar{u}$::

a) $V(\bar{u}, p, t, \pi)$ is increasing in π_2,

b) if $C_{2t}(z_1, z_2, t) < 0$, $V(\bar{u}, p, t, \pi)$ is increasing in t,

c) $V(\bar{u}, p, t, \pi)$ is strictly decreasing in $\bar{u}$, and $V(\bar{u}, p, t, \pi)$ is concave in $\bar{u}$; and

d) $V(\bar{u}, p, t, \pi)$ is nondecreasing and convex in p with $V_p(\bar{u}, p, t, \pi) = Ez(q)$.

The intuition for each of these results, except 4.d, follows directly from that already developed for the effort-cost function, so we won't divert the reader's attention any further by discussing them again. To understand 4.d recognize that the optimization problem defining $V(\bar{u}, p, t, \pi)$ is mathematically identical to an expected profit maximization problem with a convex cost structure. Hence, standard duality results guarantee that the indirect objective function will be convex in p while the envelope theorem guarantees the second part of 4.d

Now note that we can remove the domain restriction on **z** by a slight redefinition of variables. In particular, define $\alpha \geq 0$ by the following identity:

$$z_2 \equiv z_1 + \alpha..$$

Substituting this identity into the objective function, the optimization problem becomes an even simpler nonlinear program only subject to nonnegativity constraints. The associated necessary first-order conditions are given by:

$$p - Y_1(z_1, z_2, \bar{u}, \pi, t) - Y_2(z_1, z_2, \bar{u}, \pi, t) \leq 0,$$
$$p\pi_2 - Y_2(z_1, z_2, \bar{u}, \pi, t) \leq 0,$$

with complementary slackness.

The first of these conditions is a state-arbitrage result for the landlord: It implies that the landlord should increase z_1 to the point where there is no marginal increase in expected profit to be had from increasing both state-contingent outputs by the same positive amount. For an interior solution, it says precisely that a one unit increase in both state-contingent outputs breaks even at the margin. The second condition is more transparent if we use Corollary 1 to rewrite it as:

$$p\pi_2 - \exp(u_2)C_2(z_1, z_2) \leq 0.$$

This expression can be recognized as the first-order condition for z_2 for a risk-averse peasant who is the residual claimant for the crop. Therefore, in the optimum, the landlord designs a contract that effectively makes the peasant the residual claimant in state 2. The reason is also apparent; as we have said several times before, the incentive problem the landlord faces under SOA is to induce the peasant to choose the state-contingent output vector (z_1,z_2) and not (z_1, z_1). The best way to do this is to give the peasant access to all marginal increases in the high-state output

If $\alpha > 0$, it follows immediately by adding the two first-order conditions that:

$$p(1-\pi_2) - Y_1(z_1, z_2, \bar{u}, \pi, t) \leq 0,$$

implying that z_1 also should be increased to the point where the landlord can make no positive expected profit by increasing it further. It does not imply, however, that the peasant should be made the residual claimaint of state-1 output as can be easily ascertained by using the results reported in Corollary 1.

For an interior solution, we have:

$$\frac{C_2(z_1, z_2, t)}{p\pi_2} = \frac{1}{\exp(u_2)},$$

and

$$\frac{C_1(z_1, z_2, t)}{p\pi_1} = \frac{1}{\exp(u_2)} + [\exp(u_2) - \exp(u_1)][C_1(z_1, z_1, t) + C_2(z_1, z_1, t)],$$

from which it immediately follows that:

$$\frac{C_2(z_1, z_2)}{\pi_2} - \frac{C_1(z_1, z_2)}{\pi_1} < 0. \tag{3}$$

Expression (3) implies that the optimal 'expected-utility taking' contract will involve a state-contingent production pattern that is risk aversely efficient, i.e., the fair odds line cuts the production point from below on the isocost curve. This fact has several interesting implications about the way in which the presence of moral hazard limits the freedom of the landlord to specify contract terms. Note first that if the landlord could ignore the incentive constraints imposed by the presence of moral hazard (and embodied in TT), then for a given level of effort cost, the landlord would always prefer a state-contingent production pattern with a higher expected output that is achieved by expanding z_2 and decreasing z_1 to the production pattern that is actually implemented. Perhaps this is best visualized with reference to Figure 4. Suppose that A represents the state-contingent production pattern specified in the agrarian contract. It is clear that, if the incentive effects of doing so could be ignored, the landlord would prefer the peasant to shift production to the northwest along the isocost curve because this raises the expected return from production without changing peasant's cost.

Now consider the effect of moving from A along the fair odds line to a more risky output pattern. Because A is risk aversely efficient, effort cost declines and hence expected return must go up if incentive effects can be ignored. (If incentive effects could be ignored the landlord could just lower the expected payment to the peasant by the amount effort cost declines.) But such a movement is not optimal by the definition of A as the optimal point. Again the reason that this happens, a more profitable alternative is foregone, is the presence of the incentive constraints. The movement from A to the interior of the isocost curve is not optimal precisely because it exacerbates the incentive problem by increasing the benefit from producing (z_1, z_1).

Summarizing, we have:

Theorem 5: Under SOA, U, and SC, an interior 'expected-utility taking' optimal contract is characterized by:

a) $p\pi_2 - \exp(u_2)C_2(z_1,z_2) = 0$;

b) $\frac{Y_1}{\pi_1} = \frac{Y_2}{\pi_2}$;

c) (z_1,z_2) is risk aversely efficient;

d) in the absence of TT, the landlord would prefer a state-contingent production pattern with a higher expected output; and

e) in the absence of TT, the landlord would prefer a riskier state-contingent production pattern.

The Optimal Level of Peasant Exploitation

The final stage of our optimization problem can be represented as:

$$W(p,\pi,t;A) = \underset{u}{Max}\left\{V\left(p,\overline{u},t,\pi\right) - Af\left(\overline{u}\right)\right\}.$$

Letting,

$$\bar{u}(A) = \arg\max\left\{V\left(p, \bar{u}, t, \pi\right) - Af\left(\bar{u}\right)\right\},$$

it follows immediately that:

$$\left(A^o - A\right)\left(\bar{u}\left(A^o\right) - \bar{u}(A)\right) \geq 0,$$

which tells us that as it grows more expensive to exploit peasants, the level of peasant exploitation falls, i.e., the peasant's reservation utility rises. Using this fact and Theorem 3 together yield:

Theorem 6: Under SOA and U: the optimal level of peasant exploitation is nonincreasing in A; and the optimal expected value of the crop is nonincreasing in A.

The second part of Theorem 6 follows from the fact that for given $\bar{u}$, the expected value of the crop is nonincreasing in the peasant's expected utility. Hence, anything that tends to increase the peasant's expected utility and which has no direct impact on expected crop size will also tend to decrease the expected crop size.

Under SC, a unique maximum exists to this problem which is competely characterized by the first-order conditions. It follows immediately from our discussion of the agency-cost function and the 'expected-utility taking' problems that:

Theorem 7: Under SOA, U, and SC:

a) $W\left(p, \pi_2, t; A\right)$ is nonincreasing and convex in A;

b) $W\left(p, \pi_2, t; A\right)$ is increasing in π_2;

c) if $C_{2t}\left(z_1, z_2, t\right) < 0$, $W\left(p, \pi_2, t; A\right)$ is increasing in t; and

d) $W\left(p, \pi_2, t; A\right)$ is nondecreasing and convex in p with $W_p\left(p, \pi_2, t; A\right)$ equal to the optimal expected crop size.

We now turn our attention to how changes in the crop price affect the landlord's choice of a contract. By Theorem 7.d, it is apparent that an increase in the market price leads the landlord to increase the expected crop size. However, it is inherently more interesting to examine what happens to the landlord's exploitative activities. By the first-order conditions:

$$V_u\left(p,\overline{u},t,\pi\right) - Af'\left(\overline{u}\right) = 0,$$

from which it easily follows that:

$$\overline{u}_p = \frac{-V_{up}\left(p,\overline{u},t,\pi\right)}{V_{uu}\left(p,\overline{u},t,\pi\right) - Af'\left(\overline{u}\right)}.$$

This expression is negative if $V_{up}\left(p,\overline{u},t,\pi\right) < 0$, and positive if this last inequality is reversed. Now return to the 'expected-utility taking' problem and recognize that by the envelope theorem it follows immediately that:

$$V_u\left(p,\overline{u},t,\pi\right) = -Y_u\left(z_1,z_2;\pi_2,\overline{u},t\right) = -Y\left(z_1,z_2;\pi_2,\overline{u},t\right),$$

where the second equality follows from Corollary 1.b. Direct calculation now reveals that:

$$V_{up}\left(p,\overline{u},t,\pi\right) = -\left(Y_1\left(z_1,z_2;\pi_2,\overline{u},t\right)\frac{\partial z_1}{\partial p} + Y_2\left(z_1,z_2;\pi_2,\overline{u},t\right)\frac{\partial z_2}{\partial p}\right)$$

Now use Theorem 5.b to establish that this last expression expression can be rewritten as:

$$-\pi_2 Y_2\left(z_1,z_2;\pi_2,\overline{u},t\right)\left(\pi_1\frac{\partial z_1}{\partial p} + \pi_2\frac{\partial z_2}{\partial p}\right).$$

We have already established that E**z** is increasing in p, therefore, it follows immediately that: $\pi_2\frac{\partial z_2}{\partial p} + \pi_1\frac{\partial z_1}{\partial p} > 0$, and Corollary 1.c establishes that Y_2 is always positive. Hence, we have established:

Theorem 8: The peasant's reservation utility is nondecreasing in the crop price.

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Proof: Direct calculation reveals that

$$R_t\left(z_1, z_2; \pi_2, \overline{u}, t\right) = R_u\left(z_1, z_2; \pi_2, \overline{u}, t\right) C_t\left(z_1, z_1, t\right) + h'\left(u_2\right)\left(C_t\left(z_1, z_2, t\right) - C_t\left(z_1, z_1, t\right)\right).$$

So long as the **peasant**'s utility exhibits decreasing absolute risk aversion the first right hand side term is negative (cost-saving implies that costs are decreasing in t), and by the fundamental theorem of calculus the second right-hand expression will also be negative if marginal cost of state-2 production is decreasing in t.