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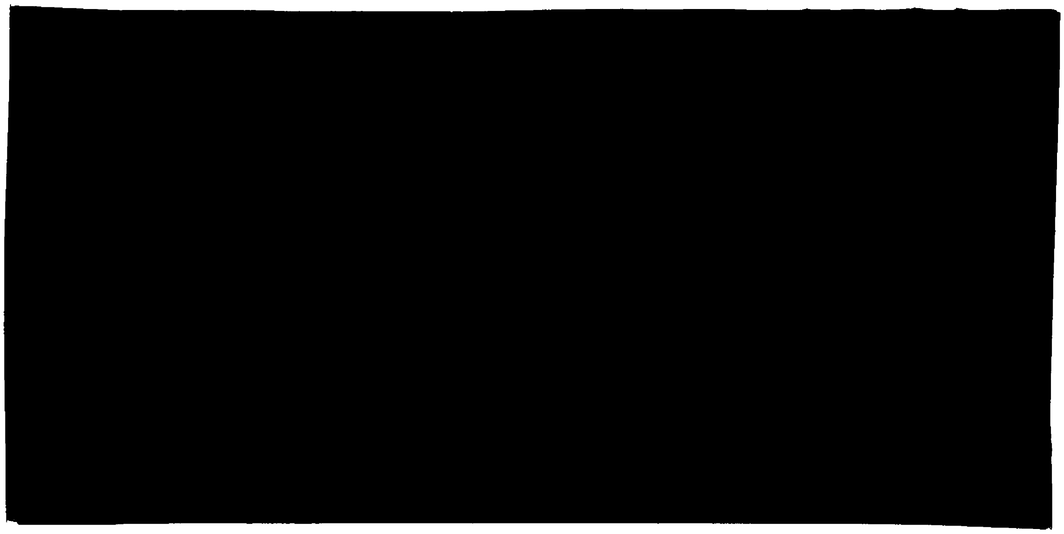

EXPLOITATION AND AGENCY IN AGRARIAN CONTRACTS

by

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Our understanding of agrarian institutions has been greatly enhanced by principal-agent models of agrarian relations. Largely as a result of these models, the literature on sharecropping, agrarian credit, and contract interlinkage has become more realistic while teaching us that many institutions observed in developing economies, and once deemed inefficient by neoclassical economists, play important economic roles in the absence of complete markets.

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 "...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 the resulting contracts as truly exploitative or extortionate. Landlords as a class benefit from their monopsony power, but individual landlords do not exploit the particular peasants with whom they contract. Furthermore, the equilibrium outcomes of these models are constrained Paretian efficient describing outcomes that are socially efficient subject to the informational constraints of the model.

A number of authors (e.g., Binswanger et al.) have pointed out that this expected utility taking assumption is unrealistic because it does not recognize the asymmetric access to coercive mechanisms that the landlord class has in agrarian economies. Historically, the landlord class has used many mechanisms to reduce the peasant class' reservation utility 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 shares 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 any contract offered by landlords.

Basu (1986) 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 client of the merchant, this threat might induce the merchant not to deal with the peasant, thus narrowing her alternatives. The key element in each of these examples is that landlords and peasants often have indirect relationships through other entities 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 the agrarian contract. Such activity, however, is not generally constrained Paretian. Rather it would be a form of rent-seeking or directly unproductive profit-seeking (DUP) activity which produces no output, but which does consume resources while enhancing the landlord's ability to exploit the tenant.

In many agrarian societies, even more direct forms of exploitation have prevailed. Institutions such as peonage and serfdom remove the peasant's option of exit, and imply that the utility level obtainable by the peasant will be determined by interaction with the individual landlord, on terms which necessarily imply direct exploitation. The most extreme form of exploitation is chattel slavery. Here exploitation takes the form of direct physical coercion (or, at least, the threat of such coercion). Hence, the slave-owner can drive utility to very low levels in order to extract the maximum possible surplus. Even in these circumstances, however, the serf or slave is not a completely helpless victim and the landlord/slave-owner must construct payment schedules that provide incentives to elicit the desired behavior.

Fogel and Engerman analyse the slave economy of the Antebellum South. They show (Appendix B) that even though slaves were in some cases better fed than free wage workers, they were nonetheless worse off on balance because of the higher work intensity imposed upon them. They also give instances where slaves received piece-work payments and other incentive payment schemes that would not arise if slave-owners could costlessly extract maximum work-intensity:

> 'Pecuniary incentives were no more an incidental feature of slavery than force. Both were indispensable to the existence of the plantation system. The absence of either could have made the cost of production under the plantation system greater than the gains from large-scale production' (pp. 241-2).

Given these observations, it is apparent that there is a trade-off between the use of positive incentives and the use of costly coercive measures. Even in the absence of voluntary participation, and in the presence of direct exploitation, a contractual model should be employed.

Because the landlord's exploitative investment is a DUP activity, a principal-agent formulation of agrarian contracting in the presence of such investment countenances two forms of market imperfection: the landlord's exploitative activity and the asymmetric-information (moral-hazard) problem underlying the principal-agent formulation of the agrarian contracting problem. Second-best theory would suggest that removing only one of these imperfections may not be social welfare improving. In particular, removing moral hazard need not improve social welfare. Hence, in the presence of extra-contract exploitative investment on the part of landlord, moral hazard in agrarian relations may play a positive social role by limiting the landlord's ability to exploit the peasant. One obvious case occurs when, absent moral hazard, the landlord's exploitative investment reduces social welfare below what would occur if the peasant and the landlord did not contract and the landlord committed nothing to exploitation. In such a case, the presence of moral hazard problems severe enough to prevent contracting would be welfare improving.

This paper attempts to formalize some of these ideas in 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 an expected utility taking 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 and in the value of the crop affects the landlord's choices. Among other results we establish that the level of peasant exploitation is increasing in the value of the crop grown and decreasing in the cost of exploitation. And finally we develop the social-welfare properties of the agrarian contracting *cum* exploitation problem. We demonstrate that there exist instances where moral hazard plays a positive social role by limiting the landlord's incentive to exploit the peasant, yielding an equilibrium outcome Pareto-superior to both the agrarian contract obtained in the absence of moral hazard and the situation in which there is no contract and no exploitation.

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 contract envisioned is general enough to include any borrowing or lending between the peasant and the landlord as well as wage payments for farming the land. 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. 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 channels 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 the offered contract with this alternative.

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

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

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., $\mathbf{z} \in Z(\mathbf{x},t)$ implies $\mathbf{z'} \in Z(\mathbf{x},t)$ for $\mathbf{z'} \le \mathbf{z}$. Uncertainty is resolved after the vector of inputs is committed. Therefore, the appropriate interpretation is that $Z(\mathbf{x},t)$ 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 $Z(\mathbf{x},t)$ is depicted in Figure 1, where state-1 production is measured along the horizontal axis and production in state 2 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, $\left(z_1^*, z_2^*\right)$, 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:

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

It is easy to show that C(**z**, t) is convex and increasing in **z**; we also assume that it is twice continuously differentiable. Technical change is *cost reducing* if $C_t(\mathbf{z}, t) < 0$. In what follows, the analysis will be greatly simplified if we place a restriction on the technology that allows us to partition the two states of nature into a "good" state and a "bad" state. At present the choice of which state is good or bad is completely arbitrary, so with little loss of generality we choose state 2 to be the good state and state 1 to be the bad state. The technical restriction which formally guarantees this is:

$$\begin{aligned} &\pi_1 C(z_k, z_k, t) + \pi_2 C(z_j, z_j, t) - C(z_k, z_j, t) > 0 \Leftrightarrow (z_j - z_k) > 0 \\ &\pi_1 C(z_k, z_k, t) + \pi_2 C(z_j, z_j, t) - C(z_k, z_j, t) = 0 \Leftrightarrow (z_j - z_k) = 0. \end{aligned} \qquad \textbf{SOA}$$

SOA stands for state ordering assumption. To understand its intuitive underpinnings, suppose that we choose $z_j > z_k$, and that we wish to have z_j produced in what we now choose to label the 'good' state (state 2) and z_k produced in the 'bad' state. SOA requires that the increase in cost associated with switching from producing the low output in both states to producing (z_k, z_j) be lower than what emerges from randomizing between z_k and z_j along the bisector. Hence, it simultaneously requires a relatively low marginal cost of state 2 production (hence, the notion that state 2 is the good state) and strongly decreasing returns to scale as one moves out the certainty output ray to (z_j, z_j) from (z_k, z_k). (We note, in particular, that this returns to scale property is only imposed along the certainty output ray and no other output ray.) Since the move from (z_k, z_k) to (z_j, z_j) can always be decomposed into a move from (z_k, z_k) to (z_k, z_j) and then to (z_j, z_j) , it follows immediately that this requirement of strongly decreasing returns to scale along the certainty output ray, given that the marginal cost of state 2 is relatively low, must emerge from the marginal cost of producing in state 1 being relatively high, and hence the notion that state 1 is the bad state. Simply put, SOA just requires that in the region of certainty the marginal cost of raising output in state 2 is always going to be less than the marginal cost of raising output in state 1. SOA is maintained throughout the paper. For given **y** and **z**, the peasant's maximum expected utility is, therefore,

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

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 next best alternative 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:

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

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 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 economically limited because the landlord must commit resources 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, if only in terms of the cost of the landlord's time committed to moral and other types of suasion. To formalize, suppose that the peasant's reservation utility absent landlord intervention is u^o: The landlord is assumed to incur cost, measured by Af $(\bar{u})$, to lower the peasant's reservation utility below u^o, where $A > 0$, and over $\bar{u} < u^o$ f is a decreasing and convex function satisfying $Af(u^o) = 0$ and $Af'(u^o) = 0$. In what follows, we shall often refer to A, rather loosely, as the landlord's cost of exploitation.

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 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:

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

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

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

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

Lemma 1: Any contract satisfying TT must also satisfy:

$$(y_1, z_1) < (y_2, z_2), or$$
$$(y_1, z_1) = (y_2, z_2).$$

Lemma 1 is easy to understand: It says that any contract the landlord can 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 while claiming 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.

We now can state formally the landlord's problem. The landlord chooses $(\overline{u}, z_1, z_2, y_1, y_2)$ according to:

$$\text{Max } \left(\pi_1(pz_1 - y_1) + \pi_2(pz_2 - y_2)\right) - Af(\overline{u})$$

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 involves extra-contract exploitation on the part of the landlord, or "extortion", the peasant can choose where to commit effort. All we claim is that the landlord can affect the peasant's next best alternative. The last three inequalities, of course, correspond to TT. We have:

Lemma 2: For given $\bar{u}$, the landlord specifies a contract that yields the peasant exactly his or her reservation utility.

Lemma 2 establishes that, in addition to choosing $\bar{u}$, the landlord ultimately chooses the peasant's welfare level.[1]

The Agency-Cost Function

We solve the landlord's 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:

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

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

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

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

The agency-cost problem yields the minimum cost of getting the peasant to produce a given state-contingent output vector that achieves a given tenant reservation utility while satisfying 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 $h(u_i) = u^{-1}(u_i)$ is a strictly increasing convex function. The *agency-cost function*, $Y(z_1,z_2;\pi_2,\bar{u},t)$, is defined as the solution to the agency-cost minimization problem.

By Lemma 1 only contracts with $z_2 \geq z_1$ are implementable by the landlord. Therefore, we can always restrict our attention to such cases. It is, therefore, convenient to introduce some new notation. Let :

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

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

Our next lemma shows that the agency-cost problem has a simple closed-form solution over $\vec{Z}$.

Lemma 3: Suppose and $z\in\vec{Z}$: 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 this constraint must bind in any optimal solution.

Lemma 3 is easily explained: The incentive problem that the landlord faces is to keep the tenant from shirking by always choosing to produce the lower output in both states. Because z_2 will always be at least as large as z_1, the landlord does not have to worry about preventing the tenant from shirking by producing z_2 in both states because this actually requires a higher committal of effort than the contract the landlord wants to implement. So to avoid tenant shirking, the landlord for a given (z_1,z_2) must design the payment scheme so that at the margin the tenant has no reason to prefer shirking. A contract that satisfies the equality in Lemma 3 just leaves the tenant indifferent between shirking and not shirking. Hence, it represents the best the landlord can possibly do for given (z_1,z_2).

From lemma 2 and lemma 3, it is immediate that the solution to the agency-cost problem is at the point of intersection between the tenant's reservation utility constraint and the constraint depicted in lemma 3. Hence,

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

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

Theorem 1, as well as the lemmas leading up to it have been derived for the case of general peasant preferences. However, to simplify calculations we shall 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 exhibit 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. U allows us to write the following explicit form for Y:

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

Corollary 1: Suppose 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.

Corollary 1.a shows why the landlord should 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. 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.

The peasant's certainty equivalent for the state-contingent payment scheme (y_1, y_2) is $\exp(C(z_1, z_2, t) + \bar{u})$ while its expected value is, of course, $Y(z_1, z_2; \pi_2, \bar{u}, t)$. Hence, the peasant's risk premium for the payment scheme (y_1, y_2) is

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

Theorem 1, Corollary 1, and this recognition yield:

Theorem 2: Suppose U and $z \in \vec{Z}$: An increase in $\bar{u}$ leads the landlord to offer the peasant a payment scheme with a higher risk premium.

The effect of technical progress on agency costs is particularly interesting because it addresses an issue originally broached by Bhaduri who, in attempting to explain adoption patterns associated with the Green Revolution, claimed that a landlord simultaneously lending to and contracting 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 roundly criticized by Srinivasan, Newbery, and Braverman and Stiglitz. However, Newbery and Braverman and Stiglitz recognize that a landlord might rationally deny the peasant access to yield enhancing technology if the new technology exacerbates the moral hazard problem. The properties of the agency-cost function enable us to shed some light on this issue. If the agency-cost function is increasing in t for cost reducing technical change, a rational landlord would want to deny the peasant access to the new technology. From Theorem 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.

The change in agency-cost minimizing u_2 associated with a change in t is:

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

Hence,

Corollary 2: Suppose 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 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 the innovation exacerbates 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 is 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 $z \in \vec{Z}$.

Under this assumption, Theorem 1 implies:

Corollary 4: Suppose 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 globally is that C(**z**,t) exhibit constant returns to scale. Thus, if one imposes constant returns upon Z(**x**,t), all results stated below as being conditional upon SC apply globally. Moreover, one should also note that at the optimal solution to the expected utility taking problem discussed below, effort cost will be locally convex.

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

In this section, we derive the analogue of the standard optimal agrarian contract. This problem is solved by choosing $z \in \vec{Z}$ to:

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

However, a little manipulation reveals that:

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

where

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

This redefinition allows us to use standard comparative techniques from the theory of the firm to determine how expected crop size and expected landlord cost (the tenant's expected payment) respond to changes in p and $\bar{u}$. Let $q = p/\exp\left(\bar{u}\right)$, and

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

It follows immediately that:

$$qE\mathbf{z}(q) - m(\mathbf{z}(q); \pi_2, t) \geq qE\mathbf{z}(q^0) - m(\mathbf{z}(q^0); \pi_2, t),$$

and

$$q^0E\mathbf{z}(q^0) - m(\mathbf{z}(q^0); \pi_2, t) \geq q^0\ E\mathbf{z}(q) - m(\mathbf{z}(q); \pi_2, t),$$

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

$$(q^0 - q)(E\mathbf{z}(q^0) - E\mathbf{z}(q)) \geq 0.$$

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 imply:

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

The landlord responds to an increase in the crop price by asking the peasant to produce a higher expected output which necessarily requires a greater committal of effort. At the margin, to induce the peasant to increase the higher effort level the landlord must offer the peasant a higher expected payment.

By maintaining SC, one can be assured that a unique maximum, which is characterized by the Kuhn-Tucker conditions, exists. In fact, under SC, V and Y are convex conjugates so that a dual relationship between them also exists. It follows easily from preceding developments and standard optimization arguments that:

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

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

b) $V(\bar{u}, p, t, \pi)$ is decreasing in $\bar{u}$ with $V_u = -Y$, and $V(\bar{u}, p, t, \pi)$ is concave in $\bar{u}$; and

c) $V(\bar{u}, p, t, \pi)$ is nondecreasing and convex in p with $V_p(\bar{u}, p, t, \pi) = E\mathbf{z}(q)$.

If an optimum exists for the expected utility taking problem, all parts of Theorem 4 except the second part of 4.b will apply even in the absence of SC. However, the second part of 4.b is particularly important because it establishes that:

Corollary 5: Under U and SC, the landlord's expected payment to the peasant is nondecreasing in the peasant's reservation utility.

If the peasant's reservation utility rises, the landlord must respond by offering the peasant a higher expected payment to encourage her to defer taking the alternative contract represented by the increase in the reservation utility. Thus, the main technical implication of SC is to rule out a perverse response by the landlord to a change in the peasant's reservation utility. Conceptually, it is possible, although intuitively it seems very unlikely, for an increase in the peasant's reservation utility to lead the landlord to reorganize the productive component of the contract to require a lower enough effort committal on the part of the peasant so that he (the landlord) could afford to offer the peasant a lower expected payment.

Define $\alpha \geq 0$ by the following identity:

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

Substituting this identity into the landlord's objective function simplifies the associated optimization problem by reducing it to a simple nonlinear program which is only subject to nonnegativity constraints. The associated necessary (and under SC sufficient) first-order conditions for z_1 and α are:

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

with complementary slackness.

The first of these conditions can be interpreted as a state-arbitrage result for the landlord: It implies that the landlord should increase **z** to the point where there is no marginal increase in expected profit to be had from getting the tenant to increase 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:

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

This expression is the first-order condition for the choice of z_2 for a risk-averse peasant who is the residual claimant for the crop. Therefore, the optimal agrarian contract effectively makes the peasant the residual claimant in state 2. The reason is also apparent; the incentive problem is to induce the peasant to choose the state-contingent output vector (z_1, z_2) and not (z_1, z_1). One way to do this is to make the peasant the residual claimant for all marginal increases in the high-state output. Perhaps the most important implication of this characteristic of the optimal contract is that it rules out a linear payment schedule (for example, a simple sharecropping scheme) except in the trivial case where the tenant is made the residual claimant in both states.

If $\alpha > 0$, it follows immediately 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 verified by computing Y_1 using Theorem 1.

Summarizing:

Theorem 5: Under U, and SC, an interior 'expected-utility taking' optimal contract satisfies:

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

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

The Profit Maximizing Level of Peasant Exploitation

The final stage of the landlord's optimization problem can be represented:

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

Our first order of business is to determine whether exploitation, which we now formally define as the landlord choosing $\overline{u} < u^o$, is profitable for the landlord. Our assumption that the marginal cost of exploitation is negligible at u^o and Theorem 4 insure that:

$$V_u\left(p,u^o,t,\pi\right) - Af'\left(u^o\right) < 0,$$

leading to the conclusion that some exploitation will be optimal. The properties of V and f guarantee that the solution to the exploitation problem is unique. Now letting,

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

one can use arguments similar to those used to establish Theorem 3 that:

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

whence,

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

which tells us that as the cost of exploiting peasants grows, the level of peasant exploitation falls, i.e., the peasant's reservation utility rises. Using this fact and Theorem 3 yield:

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

The third part of Theorem 6 follows because Theorem 3 establishes that for given $\bar{u}$, the expected value of the crop is nonincreasing in the peasant's reservation utility. Hence, anything that increases the peasant's reservation utility and which has no direct impact on expected crop size also tends to decrease the expected crop size. Landlords naturally respond to increases in the cost of exploiting the peasant by scaling back on the scale of the agricultural operation and allowing the peasant's access to more attractive non-agrarian alternatives.

Using Corollary 5 in conjunction with Theorem 6 obtains:

Corollary 6: Under U and SC, the expected payment to the peasant is nondecreasing in A.

Landlords respond to a decrease in the cost of exploitation by exploiting the peasant more and by reducing the expected compensation to the peasant.

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 U and SC:

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

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

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

The intuitive implications of Theorem 7 have already been discussed in earlier sections so we defer further discussion at this point. Note, however, that if an optimum exists all conditions in Theorem 7 except for $W(p,\pi_2,t;A)$ being convex in A are satisfied even in the absence of SC.

We now consider how changes in the crop price affect the landlord's contract choice. By Theorem 7.c, an increase in the market price leads to an increase in the expected crop size. Because the landlord acts to maximize his expected profit from the agrarian contract *cum* exploitation, this result is rather obvious. However, what is inherently more interesting, and less obvious, is how changes in the external market as reflected by changes in p impinge upon the landlord's exploitative activities. By the first-order conditions:

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

from which it easily follows that:

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

This expression is negative if $V_{up}\left(p,\bar{u},t,\pi\right) < 0$, and positive if this last inequality is reversed. Using Theorem 4.b:

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

whence

$$V_{up}\left(p,\bar{u},t,\pi\right) = -\frac{d}{dp}Y\left(z_1,z_2;\pi_2,\bar{u},t\right)$$

for fixed $\bar{u}$. The second part of theorem 3 establishes that the peasant's expected payment is nondecreasing in p. Combining that result with this expression establishes:

Theorem 8: Under U, the peasant's reservation utility (exploitation) is nonincreasing (nondecreasing) in the crop price.

Landlords respond to more favorable market opportunities for the crop by increasing their exploitative activities at the same time that they expand the size of the agrarian operation. As the crop price rises, landlords naturally find it favorable to try and get the tenant to produce more of the crop on average. And to make the tenant more amenable to doing so, the landlord invests more in exploitative activities being able to finance the increased investment in exploitative activities from expanded crop revenues. In interpreting Theorems 6 and 8, it is important to remember that in Lemma 2 we established that the landlord always forces the peasant to the reservation utility level. Thus, Theorems 6 and 8 represent direct statements about the level of the peasant's welfare. As the cost of exploitation rises, the peasant's welfare rises, but as the crop price rises the peasant's welfare falls.

On the other hand, a fall in the cost of exploitation and a rise in the crop price need not have the same effects on the expected payment to the peasant. In fact,

Theorem 9: Under U and SC, if the landlord's exploitation cost function is linear, an increase in the crop price results in a decrease in the peasant's expected payment. When $(-f''/f') > 1$, an increase in the crop price results in an increase in the peasant's expected payment.

As the crop price increases, two things happen: First, the expected value of the crop increases as the landlord takes advantage of the increased opportunities for profit in the crop market. At the same time, as Theorem 8 shows, the landlord also increases his exploitation of the peasant by driving down her reservation utility. As expected crop size increases, the landlord wants the peasant to commit a higher level of effort for a given level of exploitation. This direct effect tends to increase the landlord's payment to the peasant. However, as reservation utility falls the landlord, by Corollary 5, can afford to pay the peasant less and still keep her employed in crop production thus tending to diminish the peasant's expected payment. If the landlord's marginal cost of exploitation is constant, the landlord's desired level of exploitation rises rapidly as the crop price increases: The increased exploitation effect dominates and pushes down the total expected payment to the peasant. However, when the marginal cost of exploitation rises sufficiently rapidly, an increase in the crop price leads to only a small change in exploitation and the direct effect associated with the larger expected crop size tends to dominate.

The striking conclusion is that with rising output prices expected payments to the peasants may rise even though exploitation increases simply because the landlord may want the peasant to work much harder for a given level of reservation utility, and increased exploitation is very costly at the margin. This result is consistent with the well-known, and somewhat controversial, empirical results reported by Fogel and Engerman which suggest that slaves engaged in the production of cotton were better fed than free farm workers, but were nevertheless worse off because of more intensive exploitation. In the context of our model, one might then conjecture that Fogel and Engerman's results arose from slaveowners experiencing great difficulty in increasing their degree of exploitation. Or put another way, slaveowners may have already pushed exploitation to its profitable limit. At a casual level, one might also note that the oppressive rule of southern slavery had engendered large-scale and organized attempts to liberate slaves by transporting them clandestinely to the 'free' North. Given the presence of such organized institutions as the Underground Railroad, any significant increase in exploitation would be associated with the potentially large opportunity costs associated with tracking down and returning 'run slaves'.

More generally, it may be observed that the changes in the pattern of slavery associated with increasing demand for cotton were along the lines predicted by the model presented here. Increased efforts were devoted by individual slaveowners and slave-state politicians to preventing escapes and strengthening the power of masters over slaves.

Our final comparative-static analysis concerns the effect that technical change has upon the landlord's exploitative activities. Can it be that progressive or cost reducing technical change can actually make peasants worse off? It would certainly seem so, because apart from the "Bhaduri effect" discussed above, one expects progressive technical change to reduce effort cost thus potentially increasing the landlord's profit. As the landlord's profit from the expected utility taking contract goes up, he or she has more resources out of which to finance exploitative activities and one should not be surprised to see landlords invest more heavily in exploitation. And at the margin, exploitative activities should be more profitable precisely because they make tenants willing to supply even more effort to the now more productive agrarian activities. Using the same procedure as above it follows that:

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

so that the peasant's welfare is decreasing in t if $V_{ut}\left(p,\bar{u},t,\pi\right) < 0$, and as before it follows that:

$$V_{ut}\left(p,\bar{u},t,\pi\right) = = -\frac{d}{dt}Y\left(z_1,z_2;\pi_2,\bar{u},t\right)$$

$$= -Y_t - \left(Y_1\frac{\partial z_1}{\partial t} + Y_2\frac{\partial z_2}{\partial t}\right)$$

$$= -Y_t - \frac{Y_2}{\pi_2}\left(\pi_1\frac{\partial z_1}{\partial t} + \pi_2\frac{\partial z_2}{\partial t}\right)$$

where the third equality follows by Theorem 5.b. The second term on the right of the final equality represents the effect discussed above. By Corollary 1.b, this term is negative if technical change encourages an expansion in the size of agrarian operations. Considered alone, it suggests that progressive technical change would encourage increased exploitation by the landlord. The first term on the right of the last equality represents the direct effect that technical change has on agency cost. If technical change does not significantly exacerbate the incentive problem the landlord faces, or if it ameliorates it, this term will be positive. And considered alone, it would suggest that progressive technical change would diminish exploitation by the landlord. The reason that this happens is that as incentive problems diminish, exploitation by the landlord as a means of combatting the adverse incentive effects of moral hazard becomes less profitable at the margin. We have:

Theorem 10: Under U and SC, the peasant's reservation utility (exploitation) decreases (increases) with technical change if agency cost is increasing in t and expected crop size is increasing in the expected utility taking problem.

Exploitation, Agency, and Social Welfare

So far, little has been said about the welfare consequences of exploitative activity on the part of the landlord. Obviously, exploitative activity hurts peasants, but a general assessment of the welfare consequences of exploitative activity requires a comparison of landlord gains and peasant losses. A simple criterion to use in making welfare comparisons, via the Kaldor compensation test, is to determine whether the landlord could successfully bribe peasants to produce the landlord's desired output (under exploitation) in the absence of exploitation. The payment landlords would have to make to bribe peasants in this fashion would be:

$$Y(z_1, z_2; \pi_2, u^o, t) - Y(z_1, z_2; \pi_2, \bar{u}, t),$$

where $\mathbf{z}$ and $\bar{u}$ are evaluated at the landlord's solution to the exploitation problem. The landlord could only afford this bribe if

$$W(p, \pi_2, t; A) \geq Y(z_1, z_2; \pi_2, u^o, t) - Y(z_1, z_2; \pi_2, \bar{u}, t),$$

or

(1) $$p(\pi_1 z_1 + \pi_2 z_2) - Y(z_1, z_2; \pi_2, u^o, t) - Af(\bar{u}) \geq 0,$$

where $\mathbf{z}$ and $\bar{u}$ are again evaluated at the landlord's solution to the exploitation problem.

Our interest is in evaluating (1) under two different assumptions about the informational structure of the model. First, we consider the case when no informational asymmetry is present, so that the landlord and peasant can contract directly on z. In this case, $Y(z_1, z_2; \pi_2, u^o, t)$ in expression (1) is replaced by $\exp(C(z_1, z_2, t) + u^0)$. (The reader can easily verify that $Y(z_1, z_2; \pi_2, u^o, t)$ in the absence of informational asymmetries reduces to $\exp\left(C(z_1,z_2,t)+u^0\right)$.) In an appendix, we report an example which shows that this version of expression (1) may be negative at the landlord's most preferred **z** and $\bar{u}$.

Next, we consider the case where the landlord cannot observe the state of nature or the peasant's effort so that expression (1) is evaluated using the agency-cost function derived above, and for given **z** we observe that the level of exploitation chosen by the landlord will always be higher when information is asymmetric. To see why, note that the first-order condition for the landlord for given **z** when information is asymmetric using Corollary 1.b is:

$$Y\left(z_1,z_2;\pi_2,\bar{u},t\right) = \mathrm{A}f'(\bar{u}),$$

while when information is symmetric the first-order condition is:

$$\exp\left(C(z_1,z_2,t)+\bar{u}\right) = \mathrm{A}f'(\bar{u}),$$

which implies that $\bar{u}$ is greater under symmetric information than under asymmetric information because $Y\left(z_1,z_2;\pi_2,\bar{u},t\right)$ - $\exp\left(C(z_1,z_2,t)+\bar{u}\right)$ is the peasant's risk premium for fixed $\bar{u}$. It, therefore, follows that both the landlord and peasant will be worse off when information is asymmetric. (Recall that the landlord can never achieve a greater level of profit under asymmetric information than symmetric information because of the presence of the constraints represented by TT.) However, this conclusion is not, in general, true when **z** is chosen to maximize the landlord's expected profit.

One obvious case in which the information asymmetry leads to a socially superior outcome is that in which expression (1) is negative in the symmetric case, but in which the information asymmetry is so severe that there does not exist any incentive-compatible contract yielding the landlord a positive profit. More generally, it is possible that the asymmetric case will yield a positive profit and a net social welfare gain, while the symmetric case will generate either a smaller social welfare gain or a social welfare loss. Examples illustrating each of these possibilities are given in the Appendix.

The reason this happens is that the contractual problems arising from the information asymmetry are so difficult to resolve that they effectively brake the landlord's attempts at exploiting the peasant. As the ability of the landlord to exploit the peasant grows, one, therefore, could easily conjecture that it will become increasingly likely that information asymmetries underlying the moral hazard problem will play a more prominent social role in limiting loses from exploitative behavior. Consider, for example, the polar case where the landlord's marginal cost of exploiting the peasant is very low and constant. At the margin, the landlord is almost always assured of making a gain from investing in exploitative activity, and the landlord's first order of business will always be to push the peasant to minimum subsistence. Now if no information asymmetry is present, the landlord can also expropriate all the surplus that the peasant produces above his or her subsistence level--the ultimate Marxian solution. Now in this same case suppose that it was completely infeasible for the landlord to monitor or observe the peasant's behavior. Even though the landlord has the ability to drive the peasant to the brink of bare subsistence, his inability to negotiate a solution to the agency problem, and thus to profitably contract, negates his exploitative ability.

Conclusion

This paper represents an initial attempt to incorporate exploitative behavior on the part of landlords into principal-agent models of agrarian relations. The model has been kept purposely simple, only considering two states of nature. Even so, we are able to establish a number of striking results characterizing how indirect exploitative activities by landlords may impinge upon agrarian contracts. Among other things we have shown that both exploitation and agrarian size are likely to increase as the competitively determined price of the crop grows. On the other hand, both exploitation and agrarian size tend to diminish as the cost of exploitation falls. Technical change can either diminish or increase exploitation depending upon its effect upon agency cost and agrarian size. Moreover, in the presence of exploitative activity by landlords, information asymmetries which lead to significant agency problems may play a positive social role in limiting the landlord's ability to exploit the peasant.

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Appendix: Proof of Results

Lemma1: The first two constraints under TT reduce to:

$$\pi_2\left(u(y_2)-u(y_1)\right)\geq C(z_1,z_2,t)-C(z_1,z_1,t),$$

and

$$\pi_1\left(u(y_1)-u(y_2)\right)\geq C(z_1,z_2,t)-C(z_2,z_2,t).$$

Suppose that $z_2 > z_1$. Because $C(z_1,z_2,t)$ is increasing in **z**, the right-hand side must be strictly positive in the first expression implying $u(y_2)-u(y_1)>0$ implying $y_2 > y_1$. Now suppose that $z_1 > z_2$, the same logic applied to the second expression implies $\left(u(y_1)-u(y_2)\right)>0$ and hence $y_1 > y_2$. Now suppose that $z_1 = z_2$, these expressions can only be satisfied if $y_1 = y_2$. This establishes that the contract must be monotonic. Now add the first two constraints under TT and apply SOA.

Lemma 2: Suppose that the peasant's participation constraint does not bind. Then the landlord can define an alternative payment scheme (y_1*, y_2*) such that $u(y_2) - u(y_2^*) = \delta = u(y_1) - u(y_1^*)$ where δ is arbitrarily small but strictly positive. This new scheme will satisfy TT and yield the landlord a higher profit implying that the original payment scheme could not have been optimal.

Lemma 3: First we show that the third constraint under TT is 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, the third constraint is implied by the first two, and thus the third can bind only if both the first and the second bind. Moreover, if the first two constraints are satisfied, so is the third. The equality in the Lemma can be rewritten:

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

This expression with the second constraint under TT yields:

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

which is always satisfied for $z \in \vec{Z}$ by SOA. This establishes the first part of the Lemma; to establish the remainder it is sufficient to show that the second constraint under TT can bind only if $z_1 = z_2$. This is demonstrated graphically in Figure 3. There the reservation-utility constraint is represented by the negatively sloped line segment with slope $-\pi_1/\pi_2$. All points on or above this line segment satisfy the constraint. By Lemma 2, any solution 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

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

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

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

By SOA, for $z \in \vec{Z}$ the intercept of (A.1) is higher than the intercept of (A.2). This is illustrated graphically in the figure. Now suppose that the optimal solution to the agency cost problem is at the intersection between (A.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 (A.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 (A.1) and the reservation utility constraint to the latter's intersection with (A.2). Hence, the optimal solution could never involve (A.1) holding. Now suppose that A.2 does not bind, then the landlord can always decrease agency cost by lowering u_2 and increasing u_1 by arbitrarily small amounts.

Theorem 1: Lemma 3 establishes that the participation constraint and

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

must both bind in the solution to the agency-cost problem. Solving for u_1 and u_2, respectively gives:

$$\bar{u} + C(z_1, z_1, t),$$

and

$$\bar{u} + C(z_1, z_2, t) / \pi_2 - \frac{1 - \pi_2}{\pi_2} C(z_1, z_1, t).$$

Theorem 2: Differentiating $R(z_1, z_2; \pi_2, \bar{u}, t)$ with respect to $\bar{u}$ gives:

$$R_u\left(z_1, z_2; \pi_2, \bar{u}, t\right) = R\left(z_1, z_2; \pi_2, \bar{u}, t\right).$$

Theorem 3: Follows immediately from the inequalities in the text.

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

a) if $C_{2t}\left(z_1, z_2, t\right) < 0$ the landlord's objective function is increasing in t, and hence the indirect objective function $V\left(\bar{u}, p, t, \pi\right)$ must also be increasing in t.

b) The landlord's objective function is is decreasing in $\bar{u}$ by the properties of the agency-cost function, and hence the indirect objective function must be decreasing as well. Corollary 1.a establishes that the landlord's objective function is strictly concave in $\bar{u}$, and SC implies that the landlord's objective function is also concave in **z**. Standard results in optimization theory, e.g. Chambers (Lemma 14, p.316) imply that the indirect objective function is also concave in $\bar{u}$.

c) $V\left(\bar{u}, p, t, \pi\right)$ Using the same basic notation developed in the text, notice that $p^o > p$ implies that $q^o > q$ for fixed $\bar{u}$. Now suppose that the crop price increases from p to p^o and the landlord has the same *ex post* output vector implemented then the landlord's expected profit increases by $(p^o - p)E\mathbf{z}(q)$. The landlord will only rationally change the *ex post* output vector if it increases expected profit. To establish convexity, consider $p^* = \mu p + (1-\mu)p^o$ for $0 < \mu < 1$. It follows that:

$$pE\mathbf{z}(p) - Y\left(z_1(p), z_2(p); \pi_2, \bar{u}, t\right) \geq pE(\mathbf{z}(p^*)) - Y\left(z_1(p^*), z_2(p^*); \pi_2, \bar{u}, t\right),$$

and

$$p^oE\mathbf{z}(p^o) - Y\left(z_1(p^o), z_2(p^o); \pi_2, \bar{u}, t\right) \geq p^oE(\mathbf{z}(p^*)) - Y\left(z_1(p^*), z_2(p^*); \pi_2, \bar{u}, t\right).$$

Multiply this first expression by μ and the second expression by (1 - μ) and add them together to establish convexity. To establish the derivative property apply the envelope theorem.

Theorem 5: Follows directly from the expressions in the text.

Theorem 6: Obvious.

Theorem 7: The proof of parts a) and c) follow the same logic as the convexity proof in Theorem 4. Part b) follows because Theorem 4.a establishes that under the stated condition the landlord's objective function is nondecreasing in t, and hence the indirect objective function must inherit this same property.

Theorem 8: Obvious.

Theorem 9: Our interest is in calculating

$$\frac{d\,Y\left(z_1(p), z_2(p); \pi_2, \overline{u(p)}, t\right)}{dp}.$$

Results reported in the text imply:

$$\frac{dY}{dp} = -\,V_{up}\left(p, \bar{u}, t, \pi\right) + \mathrm{Y}\,\overline{u_p}$$

$$= \overline{u_p}\left(Y + V_{uu}\left(p, \bar{u}, t, \pi\right) - Af''\left(\bar{u}\right)\right).$$

By Theorem 8, $\overline{u_p}$ is positive so that the sign of the overall effect will be determined by the term in parentheses. Direct calculation reveals that:

$$\mathrm{V}_{\mathrm{uu}} = -Y - \frac{Y_2}{\pi_2}\left(\pi_1 \frac{\partial z_1}{\partial \bar{u}} + \pi_2 \frac{\partial z_2}{\partial \bar{u}}\right).$$

The term in parentheses on the right-hand side of this expression equals the effect on expected crop size of an increase in the peasant's reservation utility from the expected-utility taking problem. By Theorem 3, this term is negative. Substituting, we have:

(a) $$\frac{dY}{dp} = \overline{u}_p \left(-\frac{Y_2}{\pi_2} \left(\pi_1 \frac{\partial z_1}{\partial \overline{u}} + \pi_2 \frac{\partial z_2}{\partial \overline{u}} \right) - Af''(\overline{u}) \right).$$

Hence, we conclude that when f is a linear function the landlord's expected payment to the peasant must decrease with the crop price since the peasant's reservation utility is forced down as a result of the increase in the crop price. Under SC, Theorem 4.b establishes that $V_{uu} \leq 0$. Hence,

$$-\frac{Y_2}{\pi_2} \left(\pi_1 \frac{\partial z_1}{\partial \overline{u}} + \pi_2 \frac{\partial z_2}{\partial \overline{u}} \right) \leq Y,$$

while the first-order conditions for the landlord's profit maximizing problem requires:

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

Applying the envelope theorem to the expected-utility taking problem establishes that:

$$V_u = -Y$$

upon using Corollary 1.b. Now combining these last three results we have established that:

$$-\frac{Y_2}{\pi_2} \left(\pi_1 \frac{\partial z_1}{\partial \overline{u}} + \pi_2 \frac{\partial z_2}{\partial \overline{u}} \right) \leq -Af'(\overline{u}).$$

Now if $(-f''/f') > 1$ it follows that:

$$-Af' < Af''.$$

These last two inequalities establish that the parenthetical term in (a) above is negative. Hence, payments must rise because we have already established that reservation utility falls.

Theorem 10: Obvious.

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[1] An alternative interpretation of the model is that the landlord has the ability to choose the peasant's welfare level.

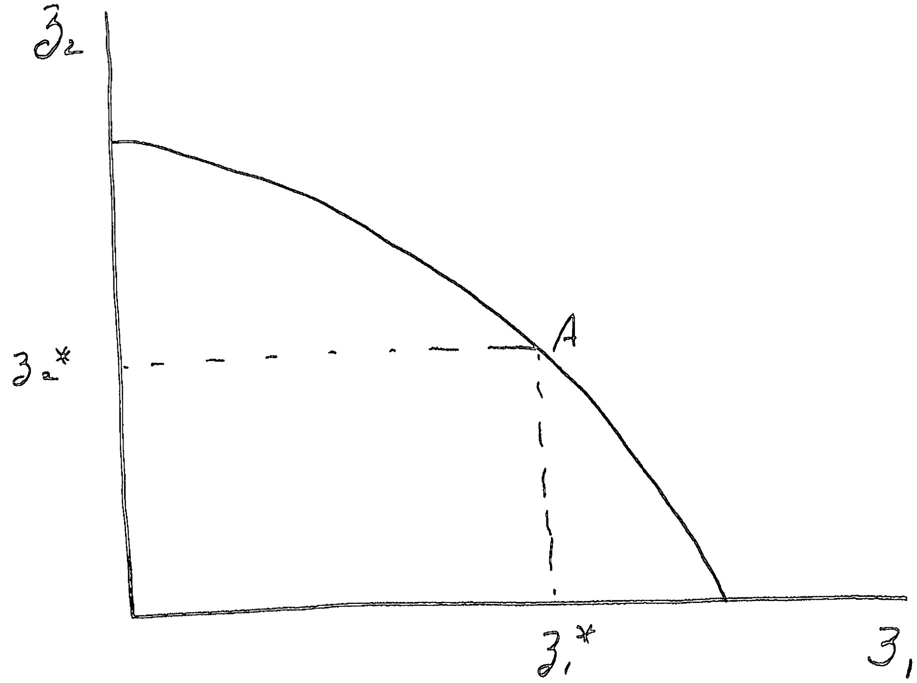

Figure 1: A State-Contingent Output Set.

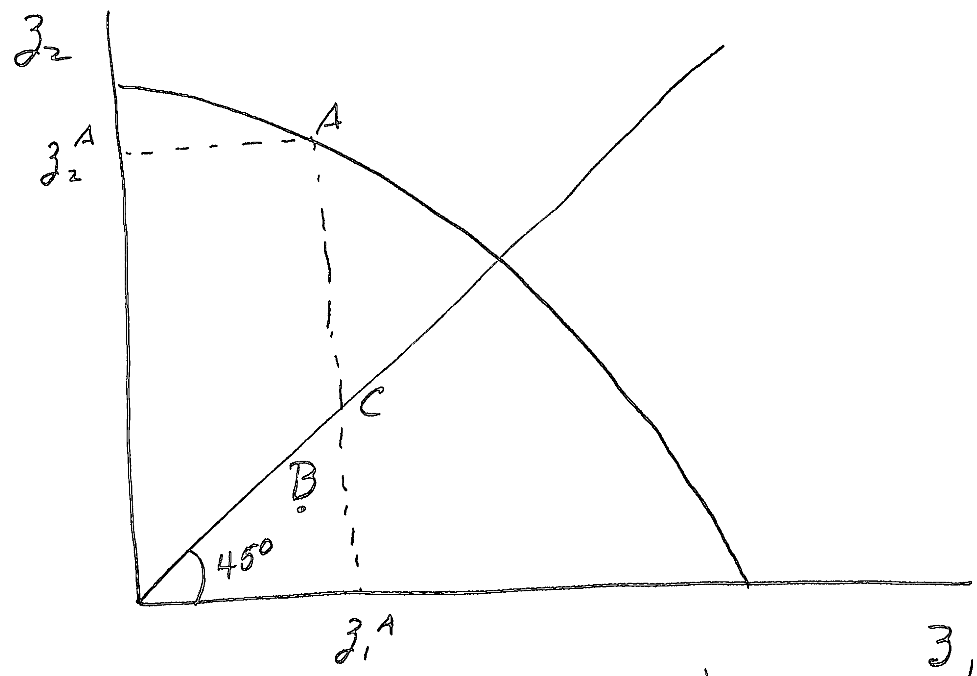

Figure 2: Contract Monotonicity

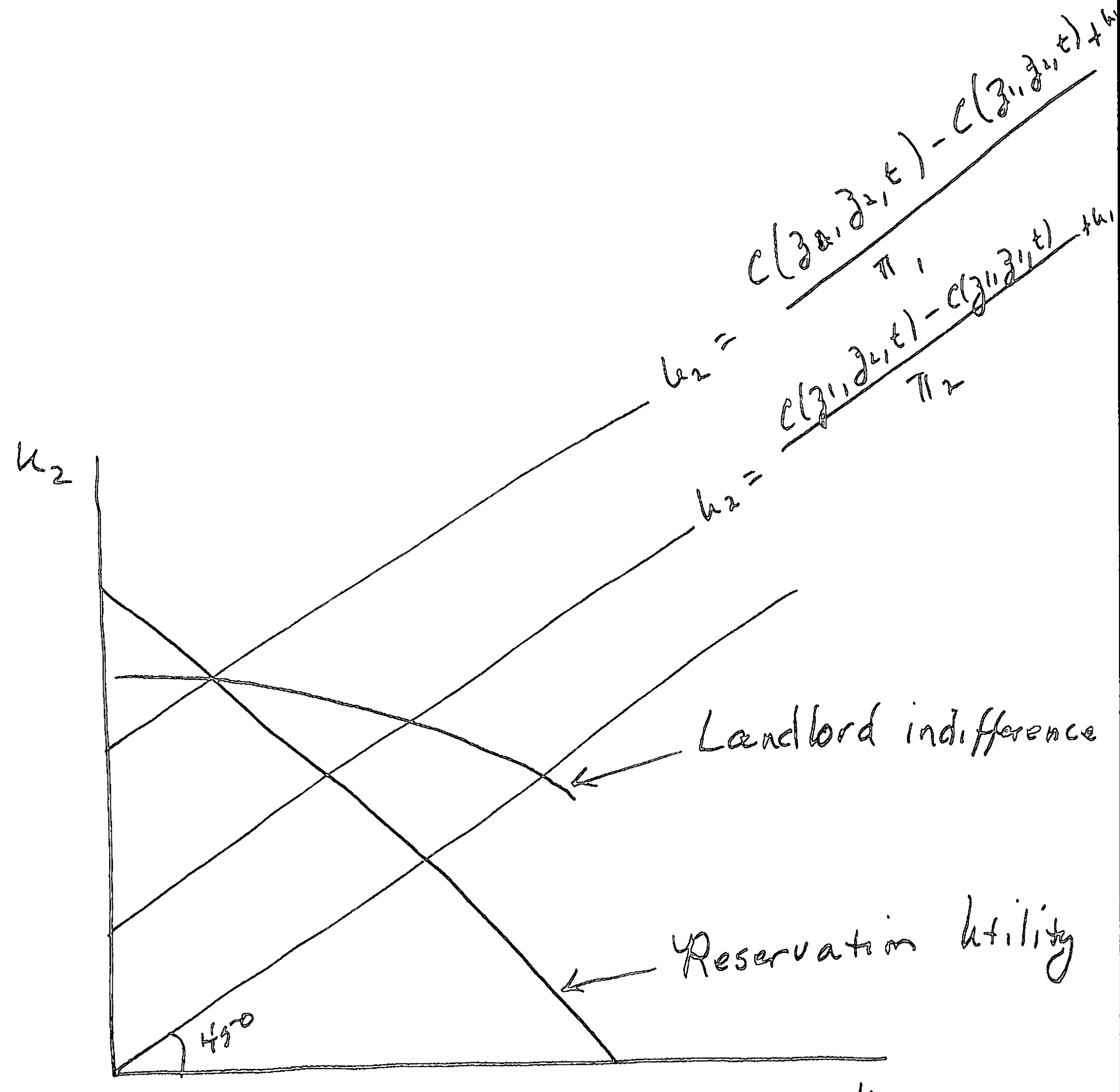

Figure 3: Solution to Agency Cost