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SHARECROPPING, LAND EXPLOITATION AND LAND-IMPROVING INVESTMENTS*

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This paper analyses the tenancy problem in a dynamic setup and addresses two long-standing issues: inefficiency and lack of investment. It considers the problems that the tenant, with a shorter-term interest in the farm than the landlord, might overexploit the land to maximize immediate returns even at the cost of future damages, and under-supply long-run productivity improving investments in land. I show that the efficient (first-best) levels of input use and investment can be achieved (both in the steady state and in transition) by a suitable share contract which, by dampening incentives to maximize current returns, addresses the land exploitation problem, and by an appropriate cost allocation rule which can address the investment problem.
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1. Introduction

While in reality agricultural tenancy almost always involves a complex dynamic relationship between the landlord and the tenant, the existing literature has focused mainly on the static aspects.[1] Further, since the analysis of investment problems naturally demands a dynamic framework, the investment incentives have not been studied very carefully in the existing literature.[2] This paper analyses the tenancy problem in a dynamic setup, capturing some important aspects of agricultural realities and addressing two long-standing issues: inefficiency and lack of investment. It makes a case in favour of sharecropping by showing both why it exists in reality, and why its existence may be desirable from a long-run point of view. I show that a *share contract* is optimal to deal with the land exploitation problem when a landlord is concerned about the potential damage to land quality through exhaustive use by the tenant. Further, this share contract, combined with an *allocation rule* that matches the costs and benefits of investments appropriately, is optimal to deal with the problem of productivity-improving investments. What makes my approach distinct is that I consider the dynamics of land quality explicitly and provide a rationale for sharecropping that does not rely on risk aversion, adverse selection or limited liability.

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1 For a nice survey of this literature, see Singh (1989) and Otsuka *et al.* (1992).

2 Two important exceptions are Bose (1993) and Banerjee and Ghatak (2004) which I discuss towards the end of this section.

I consider a setup where production depends on inputs that affect only current output, and on the quality of land that affects current as well as future output. The quality of land evolves over time, improving with productive investments and deteriorating because of natural depreciation and exploitation. The owner of the land has a permanent interest in the farm and enters into periodical tenurial contracts with separate tenants in each period. The tenants take the important decisions regarding labour effort and investment. The landlord's objective is to maximize the present discounted value of profit from the farm operation.

The paper analyses this contracting problem and investigates the type of tenurial arrangement that emerges as a solution. I show that a share contract, with an appropriately defined allocation rule, can achieve the efficient (first-best) levels of effort and investment both in the steady state and in transition. The possibility of a share contract arises when the landlord values the land for future use, and the land is susceptible to erosion as a consequence of intensive cultivation.

In terms of the time frame, the interests of the landlord and the tenant are typically conflicting. The tenant has a shorter-term interest in the farm than the landlord. Keeping this conflicting time frame in mind, when we cast the problem of designing a tenancy contract in a dynamic framework, it becomes clear that current actions of the tenant generate future externalities which the tenant, with a shorter time-horizon, fails to internalize. An important theme of this paper is that the landlord can make the tenant do so by designing the tenancy contract appropriately.

For instance, the tenant may indulge in farming practices that increase output immediately, but at the expense of soil erosion or some other form of land quality deterioration. This is a negative externality. Having only a shorter time frame, the tenant does not take this negative externality into account. Now observe that, since in a fixed-rental system the tenant pays the landlord a fixed amount and keeps the entire residual crop, he has the maximum incentive to overexploit the land and reap the immediate returns even at the cost of future damages. The landlord needs to force him not to do so by dampening his output incentives appropriately. Thus a share contract, with its associated effect of dampening incentives, is a rational response in this scenario, creating incentives for the proper utilization of land.

Also, since he does not get to enjoy the full long-run benefits, the tenant is typically reluctant to make any long-run productivity-improving investments in land. This is a positive externality. I show that this problem can be taken care of by designing an allocation rule for investment expenditure that essentially suggests to make the tenant responsible for only that part of the investment expenditure the benefits of which he enjoys during his tenure on the farm. This idea of allocation rule—borrowed from the accounting literature (Dechow, 1994; Rogerson, 1997)—is very much in line with the suggestions made by the agricultural economists and cooperative extension services in the United States in terms of the inclusion of a "compensation for unexhausted improvements clause" in the lease.[3]

There is ample empirical evidence in support of the hypothesis suggested here. Analysing the 1988 Agricultural Economics and Land Ownership Survey (AELOS) data for the USA, Canjels concludes:

[3] See section 4 for details.

> I have provided three pieces of evidence to suggest that cash renters tend to exploit the land and that sharecropping is used to limit the exploitation. First, landlords who are less able to monitor the correct usage of the land because they live far away are more likely to choose a share contract. Second, more erodible land is more likely to be sharecropped. Finally, owner operators use less inputs[4] than cash renters. (Canjels, 1996, p. 155)

Also, there are certain crops such as corn, potatoes, soybeans, sugarcane and oilseeds that use the land very intensively, whereas crops like hay, alfalfa or barley do not use it intensively at all. In line with the hypothesis of this paper, studies by Allen and Lueck (1992, 1993), using data from the American Midwest, and by Datta *et al.* (1986), using data from India, found that the former type of crop is more likely to be sharecropped and the latter to be rented under fixed-rental contracts. Finally, perennial crops such as vines, citrus fruits and olive trees are soil-exhausting and sensitive to maintenance. For instance, current production can be boosted by pruning vines short or putting manure near the roots, at the cost of long-run productivity. Once again, in line with the prediction of the model, analyses of the historical data of early Renaissance Tuscany (Ackerberg and Botticini, 2000, 2002) and of nineteenth-century rural Sicily (Bandiera, 2003) show that the probability of observing a sharecropping contract is higher when the tenant grows such perennial crops.[5]

There are theoretical and empirical works taking into account the concern for land mismanagement in the choice of tenancy contracts. Murrell (1983), Datta *et al.* (1986) and to some extent Alston *et al.* (1984) have considered the cost of land mismanagement as one of the many components determining the total transaction cost of any contract, and conclude that alternative forms of contract arise under alternative circumstances to minimize this transaction cost. Allen and Lueck (1992, 1993) consider land exploitation and output division costs as two important determinants of transaction cost. The fixed-rental contract has a high land exploitation cost but no output division cost, whereas almost the opposite is true for a share contract. The trade-off between these two costs determines the contract choice. While this literature is in the static transaction cost framework, I pose the contracting problem in a standard principal–agent setup with an explicit dynamic analysis of the evolution of land quality.

This type of dynamic analysis is conspicuous by its absence in the share tenancy literature. To the best of my knowledge, only Bose (1993) and Banerjee and Ghatak (2004) have carried out similar dynamic analyses. Both of these have dealt with the problem of investment incentives in a dynamic framework; but they have gone in different directions. Bose (1993) shows that, in an underdeveloped country where the contracts may not be binding, the stylized image of a perpetually indebted tenant who obtains credit at favourable rates from his landlord can correspond to a Pareto-efficient outcome. Banerjee and Ghatak (2004) highlight a potentially positive effect of eviction threats on investment incentives and isolate conditions when eviction threats can increase investment efforts.

Of course there are important dynamic models of tenancy, such as Bardhan (1984, chapter 8), Dutta *et al.* (1989) and Banerjee *et al.* (2002). But the dynamic analyses in these models are in the nature of repeated principal–agent interaction, focusing on the

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4 Here “inputs” refers to fertilizer, herbicides and pesticides and petroleum products. Thus, this third point implies that owner–operators till the land less intensively than cash renters (tenants under fixed-rent contract).

5 Section 5.2 makes these empirical linkages more precise.

non-renewal of contracts or eviction threats as incentive devices. In contrast, I address the agency problem in a dynamic context where a state variable (land quality in my model) evolves over time, affecting current as well as future opportunities.

The paper is organized as follows. The basic model is introduced in Section 2. Section 3 analyses the solution to the first-best where the tenant's labour effort is directly observable. Section 4 takes up the contracting problem. Section 5 considers the transition dynamics and steady-state analysis. Finally, Section 6 concludes. Some of the more technical proofs and derivations are relegated to the Appendix.

2. The model

Quality or productivity of land plays a very important role in determining farm output. By quality of land I mean the moisture and nutrient contents, acidity, erodibility, etc., of the soil, and several other features of the farmland such as the condition of the irrigation ditches, soil-saving dams, terraces and grassed waterways. Quality of land in any period t is denoted by Q_t. It should be mentioned at the outset that Q_t can be thought of as a proxy for any durable resource that affects current as well as future output.

Output in any period t is determined by the amount of labour effort exerted, L_t, and the quality of the land. Here L_t stands for all the inputs that affect only current production.

The production function in any period t is given by

$$Y_t = \varepsilon_t F(L_t, Q_t), \tag{1}$$

where F is continuous, strictly increasing and strictly concave in (L, Q) on $\mathcal{R}^2_+$, and twice differentiable on $\mathcal{R}^2_{++}$. I also assume that the Inada condition holds for labour; that is, $\lim_{L\to 0} F_L(L, Q) = \infty$.

Here ε_t is a stochastic variable representing uncertainties in production arising from weather, pests or any other exogenous factor. It takes values from $[\underline{\varepsilon}, \bar{\varepsilon}]$, and $E(\varepsilon_t) = 1$. Because of the presence of uncertainty, there is moral hazard in the farmer's choice of labour effort. Only output is observable—labour effort is neither observable nor verifiable.

Quality of land changes over time by investment and erosion. Let us consider these in turn.

Quality of land can be improved by making land-improving investments. Let the quality of land at the beginning of period t be denoted by q_t. The period t farmer receives the land of quality q_t and spends an amount x_t in the form of land-improving investment expenditure at the beginning of period t. Thus, x_t includes expenses for spreading limestone or rock phosphate, the introduction of a new irrigation system or soil conservation programme, and so on.[6]

This expenditure improves the quality of land in period t by $h(x_t)$. So

$$Q_t = q_t + h(x_t), \tag{2}$$

where h is continuous, strictly increasing and strictly concave on $\mathcal{R}_+$, and twice differentiable on $\mathcal{R}_{++}$. I also assume that $\lim_{x\to 0} h'(x) = \infty$.

[6] I consider investment in the usual physical sense. In particular, this differs from Bose (1993) or Banerjee and Ghatak (2004), where investment takes the form of efforts towards care, maintenance and land improvement. Investments being physical in nature, x_t is observable.

As is usual in agriculture, every period can be divided into two seasons: a slack season and a busy season. We may think that the farmer makes the investments on land in the lean season and then works with the land of improved quality in the busy season.

The quality of land is susceptible to deterioration from two factors. First, soil is eroded by natural factors like rain, wind or snow. Second—and from the point of view of this paper more importantly—land quality deteriorates if the land is used exhaustively for current production. For instance, land can be ploughed in a manner that increases current output, but leads to wind erosion, nutrient depletion or loss of moisture (Allen and Lueck, 1992). Current production can be enhanced by overusing chemicals and commercial fertilizers at the expense of the future fertility of the soil.

These factors motivate the following law of motion for beginning-of-period land quality:

$$q_{t+1} = G(L_t, Q_t), \tag{3}$$

where G is continuous, decreasing in L, increasing in Q and concave in (L, Q) on $\mathcal{R}^2_+$, and twice differentiable on $\mathcal{R}^2_{++}$. Since land quality can depreciate because of natural factors, it is reasonable to assume that $0 \leq G_Q(L, Q) < 1$ at $(L, Q) \gg 0$.

The initial (period 0) beginning-of-period quality of land is given as q_0.

The farmer bears a cost or disutility of effort given by

$$c_t = c(L_t), \tag{4}$$

where c is continuous, strictly increasing and strictly convex on $\mathcal{R}_+$, and twice differentiable on $\mathcal{R}_{++}$.

The owner of the farm is infinitely lived, that is, he lives for $t = 0, 1, 2, \ldots$. This essentially captures the idea that the landlord has a permanent interest in the farm.[7] The landlord's discount factor is ρ, $0 < \rho < 1$.

There is a pool of potential tenants from which in each period the landlord chooses one to work his farm; that is, the tenant's tenure is one period.[8,9]

[7] The landlord may either bequeath the farm to his next generation or sell it in the market, in which case its price reflects the present discounted value of future profits from the farm. Either way, the landlord has a long-term interest in the future productivity of the farm.

[8] In semiarid tropical India, 70%–98% of the area is leased out on an annual basis. (Jodha, 1984). In the American Midwest, where sharecropping is quite widespread, most of the lease agreements are annual contracts (Allen and Lueck, 1992). Of course, the contracts are renewed, and on an average repeated for 10–15 years (Canjels, 1996). In that case we can define one period as the average tenure of a tenant. The assumption of one-period tenure is not essential. What is needed is that the tenant has a shorter-term interest in the farm than the landlord.

[9] There exists an extensive literature emphasizing the importance of short-term leases as an incentive device: see Johnson (1950), Singh (1983), Bardhan (1984, ch. 8), Dutta *et al.* (1989), Banerjee *et al.* (2002). I must clarify that in this model I have taken the short-term contract as given. One important justification is the tenancy laws that offer security of tenure. For instance, Jodha (1984, p. 104) comments: "Tenancy laws usually confer the ownership right to the actual tiller of leased-in land after he cultivates it for a specific period. Apprehension created by these laws was quite widespread and was not confined to large farmers. This was particularly confirmed by the short-period of lease of most of the transactions. To guard against the loss of land through long-term lease of land, landowners either tried to change tenants every year or tried to lease out the land to the same tenant on an annual basis." Another serious disadvantage of a long-term contract is the landlord's helplessness in case of unsatisfactory performance by the tenant (Wallace and Beneke, 1956, p. 63).

Each potential tenant is identical and has a reservation income of $\bar{K}$ per period.

In order to emphasize the concern for land quality, I underplay the concern for risk aversion, and assume that both landlord and tenants are risk-neutral.

3. First-best effort and investment

As a hypothetical ideal standard, I consider in this section the situation where the tenant's effort, L_t, is directly observable and verifiable. So I assume, for the time being, that the landlord can specify $\{L_t, x_t\}_{t=0}^{\infty}$, and pay fixed values of wages $\{w_t\}_{t=0}^{\infty}$ so that in each period the tenant's participation constraint is satisfied.

Since they are risk-neutral, with the above specification the landlord's expected utility in period t can be taken to be his expected income $F(L_t, Q_t) - w_t$, and the tth tenant's expected utility can be taken to be $w_t - c(L_t) - x_t$.

So the landlord's problem is:

$$\left.\begin{array}{lll} \underset{\{L_t,\, x_t,\, w_t\}_{t=0}^{\infty}}{\text{Max}} & & \sum_{t=0}^{\infty} \rho^t [F(L_t, q_t + h(x_t)) - w_t] \\ \text{subject to} & \text{(i)} & w_t - c(L_t) - x_t \geq \bar{K}, \; t = 0, 1, \ldots, \\ & \text{(ii)} & q_{t+1} = G(L_t, q_t + h(x_t)), \; t = 0, 1, \ldots, \\ & & L_t, x_t, w_t \geq 0, \\ & & q_0 \text{ is given.} \end{array}\right\}$$

Here (i) is the tenants' participation constraints, and (ii) is the constraint imposed by the evolution of land quality.

Clearly, the participation constraints hold with equality; that is, $w_t = c(L_t) + x_t + \bar{K}$, $t = 0, 1, \ldots$. Substituting this into the objective function, the problem becomes:

$$\left.\begin{array}{ll} \underset{\{L_t,\, x_t\}_{t=0}^{\infty}}{\text{Max}} & \sum_{t=0}^{\infty} \rho^t [F(L_t, q_t + h(x_t)) - c(L_t) - x_t - \bar{K}] \\ \text{subject to} & q_{t+1} = G(L_t, q_t + h(x_t)), \; t = 0, 1, \ldots, \\ & L_t, x_t \geq 0, \\ & q_0 \text{ is given.} \end{array}\right\} \quad \text{(P)}$$

3.1 First-order conditions for the first-best

Recognizing that in a dynamic optimization problem the first-order conditions are essentially localized in nature, I take the following approach to derive the first-order conditions of problem (P).

Suppose q_t and q_{t+2} are on the optimal path. The problem now is to find the value of q_{t+1} by choosing $(x_t, x_{t+1}, L_t, L_{t+1})$ so as to go from q_t to q_{t+2} optimally. This optimal choice is determined by solving the following problem:

$$\left.\begin{array}{ll} \underset{\{x_t,\, x_{t+1},\, L_t,\, L_{t+1} \geq 0\}}{\text{Max}} & [F(L_t, q_t + h(x_t)) - c(L_t) - x_t - \bar{K}] \\ & +\rho[F(L_{t+1}, G(L_t, q_t + h(x_t)) + h(x_{t+1})) - c(L_{t+1}) - x_{t+1} - \bar{K}] \\ \text{subject to} & G(L_{t+1}, G(L_t, q_t + h(x_t)) + h(x_{t+1})) - q_{t+2} = 0. \end{array}\right\} \quad \text{(P}'\text{)}$$

It is shown in Appendix Section A1 that the necessary and sufficient conditions for problem (P′) are given by

$$\frac{1}{h'(x_t)} = F_Q(L_t, Q_t) + \rho G_Q(L_t, Q_t)\frac{1}{h'(x_{t+1})}, \tag{5}$$

$$F_L(L_t, Q_t) + \frac{\rho}{h'(x_{t+1})} G_L(L_t, Q_t) = c'(L_t). \tag{6}$$

Notice that equation (5) is a recursive relation in $1/(h'(x_t))$. It is shown in Section A2 of the Appendix that this recursive relation converges, and we can derive

$$h'(x_t)\sigma_t = 1, \tag{7}$$

where I use the notation $\sigma_t = F_Q(L_t, Q_t) + \rho G_Q(L_t, Q_t)F_Q(L_{t+1}, Q_{t+1}) + \rho^2 G_Q(L_t, Q_t)G_Q(L_{t+1}, Q_{t+1}) F_Q(L_{t+2}, Q_{t+2}) + \ldots.$

Using (7), it follows from (6) that

$$F_L(L_t, Q_t) + \rho G_L(L_t, Q_t)\sigma_{t+1} = c'(L_t). \tag{8}$$

So, finally, the first-order conditions for the first-best problem (P) are given by equations (7) and (8) and the law of motion for land quality, equation (3).

These first-order conditions have simple interpretations. Consider (7) first. Note that σ_t measures the present discounted value of marginal increments in future output as a result of a marginal increase in land quality in period t, i.e. Q_t, and that $h'(x_t)$ is the increase in Q_t arising from an increase in investment expenditure, x_t. So the left-hand side of (7) is the marginal benefit from investment expenditure, whereas the right-hand side is the marginal cost. Condition (7) says that x_t should be chosen optimally to equate the marginal benefit and the marginal cost of investment.

Condition (8) has a similar interpretation. An increase in L_t increases current output by $F_L(L_t, Q_t)$, but decreases period $(t + 1)$ land quality by $G_L(L_t, Q_t)$, which in turn decreases the present discounted value of the future stream of outputs given by σ_{t+1}. Thus, the left-hand side measures the net marginal benefit from an increase in labour effort in period t, and the right-hand side measures the marginal cost. At an optimal choice, these two are equal.

4. Contracting

From now on I assume that the tenant's labour effort is not observable or verifiable by the landlord. However, land-improving investments, being physical in nature, are observable.[10]

[10] I should clarify that x_t is observed *ex-post*, but not the contingencies under which the investment decisions are taken. Presumably the cultivator has a better understanding of the improvements required depending on the contingencies (e.g., flood, heavy rain), and the landowner should not simply dictate to him. This clarification is important, because if the landlord can dictate the amount of investment expenditure to be undertaken, the incentive problem for investment will not arise in the first place.

Also, as usual, output is observable. Hence a tenurial contract must be conditioned only on the observables Y_t and x_t.

Since the tenant's tenure is just one period, whereas the benefits from land-improving investments are long-term in nature, the tenant cannot enjoy the full benefits from the investments. Thus, if the tenant has to bear the full cost of the investment, he will typically underinvest.

This problem is not confined to the agrarian context alone. A similar concern arises regarding investment decisions of a manager in an industrial setup. The accounting literature suggests basing the managerial compensation on *accounting income* to take care of this problem:

> One technique that firms use to help combat this potential distortion is to base managerial compensation on accounting measures of income created by allocating investment expenditures to the future periods that benefit from the investment. The intuitive justification for this procedure is that matching costs to benefits creates a more "accurate" measure of income on a period-by-period basis and thus reduces distortions caused by the fact that managers may not compare cash flows across time correctly. (Rogerson, 1997, p. 771)[11]

This idea of "allocating investment expenditures to the future periods that benefit from the investment" is not totally foreign to agricultural farming. For a long time the agricultural economists and Cooperative Extension Services in the USA have advised the inclusion of a compensation clause in the lease that should provide returns to the tenant for unexhausted investment if he has to move before their full returns have been realized:

> Some farm inputs are not used up in a single year; hence, part of their value frequently remains when the time comes for the tenant to move. If no provision is included in the lease for repaying the tenant for any unused portion, he understandably will hesitate to invest his money in these types of inputs when he rents on a year-to-year lease. Provisions of this type are called compensation for unexhausted improvements clauses. (Beneke, 1955, p. 48)

> Short leases also discourage a tenant from making improvements as the lease may be terminated before the costs can be recovered. These problems can be at least partially solved by longer-term leases and agreements to reimburse the tenant for the uncovered cost. Improvements at the tenant's expense such as application of limestone and erection of soil conservation structures can be covered under an agreement of this type. (Kay and Edwards, 1994, p. 373)

Wallace and Beneke (1956, pp. 64–67) have illustrated the detailed procedure required to work out a "compensation for unexhausted improvements clause" developed by I. W. Arthur, extension economist at Iowa State College, USA. These days a typical lease form suggested by the Cooperative Extension Services includes such a clause that says:

[11] Rogerson (1997) has referred to Dechow (1994); see also the other references from accounting and finance literature in Rogerson (1997).

> the tenant will be compensated for his share of the depreciated cost of his contribution when he leaves the farm based on the value of the tenant's contribution and depreciation rate shown in the following table. (Section V-C-2, "Crop-Share or Crop-Share-Cash Farm Lease", North Central Regional Publication No. 77: Kay and Edwards, 1994, p. 383)[12]

In view of the above discussion, and following Rogerson (1997), I define an accounting measure of income and consider a tenurial contract based on this income.

Let η_t denote the investment cost allocated to period t per unit of investment. That is, if investment expenditure is x_t, then the landlord allocates a cost of $\eta_t x_t$ to period t for the tenant to bear.

Recall that the *gross income* of the farm in period t is $Y_t = \varepsilon_t F(L_t, Q_t)$. With the above allocation rule, the *accounting income* of the farm in period t is defined as

$$y_t = Y_t - \eta_t x_t \qquad \text{for all } t. \tag{9}$$

Finally, a tenancy contract received by the period t tenant is defined as a function of accounting income:

$$w_t(y_t) = \alpha_t y_t + \beta_t \qquad \text{for all } t.^{13} \tag{10}$$

Thus, a contract is specified by the parameters $(\eta_t, \alpha_t, \beta_t)$. Taking into account the tenant's response to the contract, the landlord chooses $(\eta_t, \alpha_t, \beta_t)$ optimally.

4.1 Tenant's choice

Since the tenants are risk-neutral, the expected utility of the period t tenant, given the contract w_t, is $\alpha_t F(L_t, q_t + h(x_t)) - \alpha_t \eta_t x_t + \beta_t - c(L_t)$.

Thus, given the contract w_t, the period-t tenant's choice problem is:

$$\max_{\{L_t,\, x_t \geq 0\}} \quad \alpha_t F(L_t, q_t + h(x_t)) - \alpha_t \eta_t x_t + \beta_t - c(L_t).$$

The necessary and sufficient conditions for this problem are:

$$h'(x_t) F_Q(L_t, Q_t) = \eta_t, \tag{11}$$

$$\alpha_t F_L(L_t, Q_t) = c'(L_t). \tag{12}$$

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12 See also Kadlec (1985, p. 293); Kay (1986, p. 289); Luening *et al.* (1991, p. 509). Similar practice is prevalent in England, Scotland and Wales: ". . . where a tenancy comes to an end the tenant may be able to claim against the landlord for improvements made during the tenancy and for tenant right. The amount of the compensation which might be payable under this heading will probably reflect the increase in value of the farm as an agricultural holding attributable to the improvement." (Buckett, 1988, p. 136)

13 I consider only linear contracts because of their simplicity and wide empirical validity. It will be interesting to see whether the efficient outcome can be induced even with such simple contracts.

4.2 Achieving the first-best through contracting

Let the solution to the first-best be denoted by upper-bar; that is, let $\{\bar{L}_t, \bar{x}_t\}_{t=0}^{\infty}$ solve the landlord's first-best problem (P), and let $\bar{q}_0 = q_0$, $\bar{Q}_t = \bar{q}_t + h(\bar{x}_t)$, and $\bar{q}_{t+1} = G(\bar{L}_t, \bar{Q}_t)$, for $t \geq 0$.

This solution must satisfy the first-order conditions given by (7) and (8). So we have

$$h'(\bar{x}_t)\bar{\sigma}_t = 1, \tag{13}$$

$$F_L(\bar{L}_t, \bar{Q}_t) + \rho G_L(\bar{L}_t, \bar{Q}_t)\bar{\sigma}_{t+1} = c'(\bar{L}_t), \tag{14}$$

where I use the notation $\bar{\sigma}_t = F_Q(\bar{L}_t, \bar{Q}_t) + \rho G_Q(\bar{L}_t, \bar{Q}_t)F_Q(\bar{L}_{t+1}, \bar{Q}_{t+1}) + \rho^2 G_Q(\bar{L}_t, \bar{Q}_t)G_Q(\bar{L}_{t+1}, \bar{Q}_{t+1})F_Q(\bar{L}_{t+2}, \bar{Q}_{t+2}) + \ldots$

Comparing the conditions of the individual period t tenant's problem (equations (11) and (12)) with the conditions of the first-best (equations (13) and (14)), it becomes clear that the individual tenant fails to internalize future externalities (positive ($\rho\bar{\sigma}_{t+1}$) in case of investments, and negative ($\rho G_L(\bar{L}_t, \bar{Q}_t)\bar{\sigma}_{t+1}$) in case of effort) generated by his current actions. The following proposition shows that the landlord can make him do so by designing the structure of the contract appropriately.

Proposition 1: *In any period t, the landlord can induce the first-best outcome by offering the following contract to the tth period tenant* ($t = 0, 1, \ldots$):

$$\eta_t = \frac{F_Q(\bar{L}_t, \bar{Q}_t)}{\bar{\sigma}_t},$$

$$\alpha_t = 1 + \frac{\rho G_L(\bar{L}_t, \bar{Q}_t)\bar{\sigma}_{t+1}}{F_L(\bar{L}_t, \bar{Q}_t)},$$

$$\beta_t = \bar{K} - \alpha_t F(\bar{L}_t, \bar{Q}_t) + \alpha_t \eta_t \bar{x}_t + c(\bar{L}_t).$$[14]

η_t can be rewritten as

$$\eta_t = \frac{h'(\bar{x}_t)F_Q(\bar{L}_t, \bar{Q}_t)}{h'(\bar{x}_t)[F_Q(\bar{L}_t, \bar{Q}_t) + \rho G_Q(\bar{L}_t, \bar{Q}_t)F_Q(\bar{L}_{t+1}, \bar{Q}_{t+1}) + \ldots]}.$$

Note that the investment expenditure, x_t, results in a direct benefit to the period t tenant by the amount $h'(x_t)F_Q(L_t, Q_t)$, whereas the present discounted value of the total future benefits to the farm is $h'(x_t)[F_Q(L_t, Q_t) + \rho G_Q(L_t, Q_t)F_Q(L_{t+1}, Q_{t+1}) + \ldots]$. So the expression on the right-hand side measures the proportion of the benefits from investment expenditure that the period t tenant enjoys. Recall that η_t is the proportion of investment expenditure that is allocated for the period t tenant to bear. Thus, the allocation rule is such that it takes care of the investment problem by matching costs to benefits appropriately.

Since $G_L(\bar{L}_t, \bar{Q}_t) < 0$, it follows that the crop share received by the tenant, α_t, is less than 1; that is, we have a *share contract* as the solution. The current tenant tends to over-exploit the land, which reduces its future productivity. Having only a short-term interest in the farm, the tenant does not take this negative externality into account. The landlord

[14] β_t is calculated so that the tenant's participation constraint is satisfied, that is, $\alpha_t F(\bar{L}_t, \bar{Q}_t) - \alpha_t \eta_t \bar{x}_t + \beta_t - c(\bar{L}_t) = \bar{K}$.

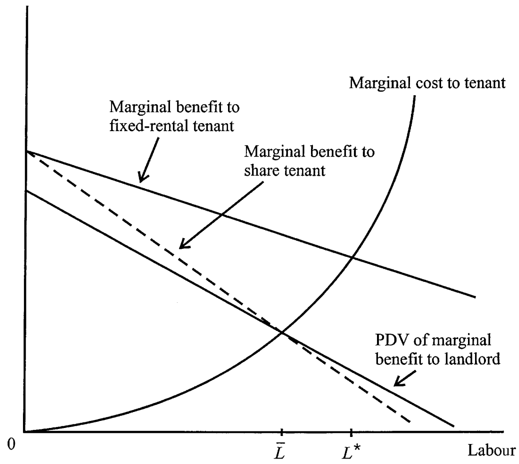

FIGURE 1.

can correct this situation by appropriately dampening the tenant's incentives. This gives rise to the share contract. Figure 1 illustrates this intuition.

Thus, I derive the interesting conclusion that, when the landlord is concerned about the potential depletion of land quality by overuse and there is scope for improving the quality of land by making appropriate investments, the first-best choices of effort and investment levels can be achieved by a share contract with an appropriately defined allocation rule.[15]

5. Transition dynamics and steady state

As the contracting problem is posed in a dynamic setup, it is natural to ask how the system behaves over time. Since, by Proposition 1, the outcome of the contracting problem coincides with the first-best outcome, it suffices to analyse the transition dynamics of the first-best problem.

Under some reasonable regularity restrictions, it can be shown that, given current land quality q (the state variable), next period's optimal land quality is given by the function $g(q)$, and the optimal choices of effort (L) and investment expenditure (x) are given by the functions $L(q)$ and $x(q)$, respectively. Thus, given the initial (period 0) beginning-of-period land quality q_0, the optimal path from q_0 is given by $(q_0, g(q_0), g^2(q_0), \ldots)$. The following proposition summarizes the transition dynamics of the first-best problem by showing that this optimal path is monotonic and converges to its steady-state value.[16]

Proposition 2: *If $F(L, Q)$ and $G(L, Q)$ exhibit constant returns to scale, then the optimal path is monotonic and converges to q^*, where q^* is the steady state value of land quality.*

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[15] Of course, the assumption that the tenant is risk-neutral makes the task of achieving the first-best much easier. In general, if the tenant is risk-averse (and the landlord is risk-neutral), it is well known that the contract will fail to achieve the first-best in order to provide for the optimal risk-sharing. But it is easy to see that allowing for risk aversion in the current framework will in fact strengthen the rational for sharecropping.

[16] The detailed analysis of the transition dynamics of the first-best problem is developed in a separate appendix and is available from the author upon request.

Now we proceed to see what shape the contract takes in the steady state and to demonstrate that the steady-state first-best outcome is induced through a share contract.

The steady-state value of land quality is defined as $q_t = q^*$, for all t. It follows that the steady-state optimal solutions of effort (L_t) and investment expenditure (x_t) are determined as $L_t = L(q^*) \equiv L^*$ and $x_t = x(q^*) \equiv x^*$ for all t.

Finally, we have $Q_t = q^* + h(x^*) \equiv Q^*$, for all t.

From (7), (8) and the evolution of land quality, it follows that the steady-state values for the first-best can be solved from the following three equations:

$$h'(x^*)F_Q(L^*, Q^*)\left(\frac{1}{1-\rho G_Q(L^*, Q^*)}\right) = 1\,, \tag{15}$$

$$F_L(L^*, Q^*) + \rho G_L(L^*, Q^*)F_Q(L^*, Q^*)\left(\frac{1}{1-\rho G_Q(L^*, Q^*)}\right) = c'(L^*), \tag{16}$$

$$G(L^*, q^* + h(x^*)) - q^* = 0. \tag{17}$$

5.1 Nature of the contract in the long run

Using the monotonicity of the optimal path, it is easy to see that the period t contract (η_t, α_t, β_t) converges to the steady-state contract (η, α, β) defined in Proposition 3. Comparing the necessary and sufficient conditions of the tth tenant's problem (equations (11) and (12)) with (15) and (16), it follows that the steady-state first-best outcome is induced by this contract.

Proposition 3: *The contract converges to the following steady-state contract, and the steady-state first-best outcome is induced*:

$$\eta = 1 - \rho G_Q(L^*, Q^*),$$

$$\alpha = 1 + \frac{\rho G_L(L^*, Q^*)F_Q(L^*, Q^*)}{F_L(L^*, Q^*)[1-\rho G_Q(L^*, Q^*)]}\,,$$

$$\beta = \bar{K} - \alpha F(L^*, Q^*) + \alpha\eta x^* + c(L^*).$$

Again, the steady-state crop share received by the tenants, α, is less than 1 since $G_L(L^*, Q^*) < 0$. Thus, as in the transition, in the steady state also the efficient levels of effort and investment are sustained by a *share contract*.

5.2 Some observations on the tenant's cropshare and empirical implications

Before I conclude, I must make some simple observations regarding the tenant's crop share in this framework that have some interesting empirical implications.[17]

[17] These observations apply to the nature of the contracts both in the steady state and in transition.

First, in this model $\alpha = 1$ if $\rho = 0$. That is, if the landlord does not value the future—or, more generally, if the landlord's time frame coincides with that of the tenant—the optimal contract is a fixed-rental one. This result is quite intuitive. As the landlord values the future, he cares more about the land quality, and so he should ensure that the current tenant does not overexploit the land. One empirical implication of this observation is as follows. If the farmland is soon to be used for non-agricultural activities (property development, factory building), then concern for land exploitation becomes less important and the time frames of the landlord and the tenant coincide. Thus, a fixed-rental contract is more likely to be observed for farmlands near urban populations. Allen and Lueck (1992) find precise empirical support for this observation.

Next, observe that $\alpha = 1$ if $G_L(\cdot, \cdot) = 0$. The magnitude of $G_L(\cdot, \cdot)$ measures the erodibility of land when used for crop production. For instance, certain crops (e.g. hay, alfalfa or barley) require less intensive tillage, and $G_L(\cdot, \cdot)$ might be considered to be equal to zero for these crops; whereas the row crops (e.g. corn, potatoes, soybeans and sugarbeet) need extensive tilling and so the (absolute) value of $G_L(\cdot, \cdot)$ will be high for such crops. Thus, we expect sharecropping to be more common for row crops and the fixed-rental system for the other type of crop. As mentioned in the Introduction, this result is very much in line with the empirical findings obtained by Canjels (1996), Allen and Lueck (1992, 1993) and Datta *et al.* (1986). Similarly, for perennial crops such as vines, citrus fruits and olive trees, efforts and farming practices to boost current output may result in substantial reduction in longer-term yields, and so the (absolute) value of $G_L(\cdot, \cdot)$ should be high for such crops. Studies by Ackerberg and Botticini (2000, 2002) and Bandiera (2003) confirm that, when such perennial crops are planted on a plot of land, there is less likelihood of observing fixed-rent contracts (versus share contracts), as fixed-rent contracts might induce overproduction which could damage these assets and thus future production.

Controlling for land quality has been an important issue in empirical works on sharecropping (e.g. Shaban, 1987). A stylized fact is that owner-operated plots are generally of better quality than sharecropped plots—which in turn are better than plots under a fixed-rent tenancy. The present model can throw some light on this stylized fact.[18] Suppose, for simplicity, that land is of two types—high quality and low quality—and that quality is a multiplicative parameter in the production function, $F(\cdot, \cdot)$. Since the high-quality land is more sensitive to maintenance and proper tillage, the (absolute) value of $G_L(\cdot, \cdot)$ will be higher for the high-quality land. Finally, as $G_Q(\cdot, \cdot)$ reflects the depreciation of land quality resulting from natural factors, it is reasonable to assume that its value does not vary over the two types of land. From the expressions of α in Propositions 1 and 3, it now follows that the tenant's cropshare will be lower for land of higher quality.[19] That is, sharecropping is more likely to occur for better-quality plots, whereas fixed-rental system is more likely for plots of poorer quality. This implication of the model is consistent with the stylized fact mentioned above.

[18] I am grateful to a referee for this suggestion.

[19] Since quality—high or low—appears as a multiplicative parameter in the production function, $F(\cdot, \cdot)$, and the expressions of α involve $F_L(\cdot, \cdot)$ in the denominator and $F_Q(\cdot, \cdot)$ in the numerator (for α_t in Proposition 1, refer to the expression of $\bar{\sigma}_{t+1}$ involving $F_Q(\cdot, \cdot)$), the impacts of quality on crop share arising from the production function cancel out. What remains is the effect arising from the differential values of $G_L(\cdot, \cdot)$.

6. Conclusion

The long-run erosion of land quality as a consequence of overuse is a matter of some global concern. At a more micro level, the lack of productivity-improving investment and the exploitation of land by tenants are of direct concern to landlords, and empirical studies (e.g. Canjels, 1996) have suggested that landlords might resort to sharecropping in an effort to limit land exploitation. In this paper I have attempted to develop a theory of sharecropping as an institution meant to limit the exploitation of land and achieve efficiency in investment.

Recognition of the concern about land exploitation as an influence on the choice of tenurial contract is relatively recent. The literature that voices this concern has incorporated it into a transaction cost framework, and the analysis is static in nature. However, the present paper has taken the stand that a problem involving land quality that evolves over time owing to land-improving investments, natural depreciation or exploitation is essentially *dynamic* in nature, and should be analysed as such. Dynamic analysis of this kind is somewhat absent in the literature and is of some interest on its own.

In this context, I have established the result that, both in the steady state and in transition, the landlord can induce efficiency in input use and investment by offering a share contract coupled with a cost reimbursement rule for investment. As mentioned in footnote 15, the efficiency property is a result of the assumption of risk neutrality of the tenant. In general, if the tenant is risk-averse the efficient outcome will not hold. But, as expected, it will strengthen the rational for sharecropping. Thus, this paper makes a strong case for sharecropping by showing both why it occurs, and why its occurrence may be desirable from the long-term investment perspective.

Finally, I conclude on a note of broader applicability of the framework developed in this paper, which opens up some interesting avenues of future research. While I have developed my model to deal with the contractual arrangements in agricultural farming, this framework could profitably be used in the context of contracting problems in any dynamic setup where current opportunities depend on current actions and on some state variable that affects current as well as future opportunities. Some examples are investments, learning by doing, exhaustible or renewable resource extraction (forestry and fishery in particular), industrial R&D and reputations in franchising.[20] There exists a huge literature on these topics, including setups involving uncertainty and strategic opportunity; but, surprisingly, the theory is rarely extended to deal with contractual problems.[21] Hence this would seem to be a profitable area for further research.

Appendix

A1 Necessary and sufficient conditions for problem (P′)

Let γ_t be the Lagrange multiplier associated with the constraint. The conditions on the limiting values of $F_L(L, Q)$ and $h'(x)$ ensure interior solutions. The first-order conditions are:

[20] Interestingly, sharing arrangements are well established in the fishing industry (Platteau and Nugent, 1992) and the franchising of fast food restaurants (Lafontaine, 1993).

[21] In the agency literature, dynamic analysis has usually focused on a repeated principal–agent relationship. What I am referring to is a different dynamic process, e.g. capital accumulation, resource evolution, and so on, which is considered standard in all areas of economics.

$$x_t: \quad F_Q(L_t, Q_t)h'(x_t) - 1 + \rho F_Q(L_{t+1}, Q_{t+1})G_Q(L_t, Q_t)h'(x_t) + \gamma_t G_Q(L_{t+1}, Q_{t+1})G_Q(L_t, Q_t)h'(x_t) = 0, \tag{A1}$$

$$x_{t+1}: \quad \rho F_Q(L_{t+1}, Q_{t+1})h'(x_{t+1}) - \rho + \gamma_t G_Q(L_{t+1}, Q_{t+1})h'(x_{t+1}) = 0, \tag{A2}$$

$$L_t: \quad F_L(L_t, Q_t) - c'(L_t) + \rho F_Q(L_{t+1}, Q_{t+1})G_L(L_t, Q_t) + \gamma_t G_Q(L_{t+1}, Q_{t+1})G_L(L_t, Q_t) = 0, \tag{A3}$$

$$L_{t+1}: \quad \rho[F_L(L_{t+1}, Q_{t+1}) - c'(L_{t+1})] + \gamma_t G_L(L_{t+1}, Q_{t+1}) = 0. \tag{A4}$$

Note that (A2) implies

$$\rho F_Q(L_{t+1}, Q_{t+1}) + \gamma_t G_Q(L_{t+1}, Q_{t+1}) = \frac{\rho}{h'(x_{t+1})}. \tag{A5}$$

I can rewrite (A1) as

$$F_Q(L_t, Q_t)h'(x_t) - 1 + [\rho F_Q(L_{t+1}, Q_{t+1}) + \gamma_t G_Q(L_{t+1}, Q_{t+1})]G_Q(L_t, Q_t)h'(x_t) = 0.$$

Now using (A5) above, I derive equation (5) in the text.

Rearranging (A3) similarly and using (A5), I get equation (6) of the text.

Finally, using the above relations, I can reduce condition (A4) to condition (A3) taken one period forward. That is, condition (A4) does not give any new condition different from (A3). Thus, I conclude that the necessary and sufficient conditions for problem (P′) are given by conditions (5) and (6) in the text. ■

A2 Some convergence results

Here I show that the recursive relation in equation (5) converges so that I can derive conditions (7) and (8) in the text.

Repeating the recursive relation once, I get

$$\frac{1}{h'(x_t)} = F_Q(L_t, Q_t) + \rho G_Q(L_t, Q_t)F_Q(L_{t+1}, Q_{t+1}) + \rho^2 G_Q(L_t, Q_t)G_Q(L_{t+1}, Q_{t+1})\frac{1}{h'(x_{t+2})}.$$

Now fix the time period t, and, as above, repeat the recursive relation T times. For $T \geq 1$, I have

$$\begin{aligned} F_Q(L_t, Q_t) + \rho G_Q(L_t, Q_t)F_Q(L_{t+1}, Q_{t+1}) + \ldots + \rho^{T-1}F_Q(L_{t+T-1}, Q_{t+T-1})\left(\prod_{s=t}^{t+T-2} G_Q(L_s, Q_s)\right) \\ = \frac{1}{h'(x_t)} - \rho^T\left(\prod_{s=t}^{t+T-1} G_Q(L_s, Q_s)\right)\frac{1}{h'(x_{t+T})}. \end{aligned} \tag{*}$$

Define

$$\begin{aligned} S(T) \equiv F_Q(L_t, Q_t) + \rho G_Q(L_t, Q_t)F_Q(L_{t+1}, Q_{t+1}) + \ldots \\ + \rho^{T-1}F_Q(L_{t+T-1}, Q_{t+T-1})\left(\prod_{s=t}^{t+T-2} G_Q(L_s, Q_s)\right). \end{aligned}$$

$S(T)$ is monotone non-decreasing in T and bounded above by $1/[h'(x_t)]$. So it converges. I use the notation $\sigma_t = \lim_{T\to\infty} S(T)$; that is,

$$\sigma_t = F_Q(L_t, Q_t) + \rho G_Q(L_t, Q_t)F_Q(L_{t+1}, Q_{t+1}) + \rho^2 G_Q(L_t, Q_t)G_Q(L_{t+1}, Q_{t+1})F_Q(L_{t+2}, Q_{t+2}) + \ldots.$$

Since t is fixed, the value of $1/[h'(x_t)]$ is fixed. And I have from above that $S(T)$ converges. Then from (*) it follows that

$$\rho^T \left(\prod_{s=t}^{t+T-1} G_Q(L_s, Q_s) \right) \frac{1}{h'(x_{t+T})}$$

converges. Note that I have $0 < \rho < 1$, $0 \le G_Q(L_s, Q_s) < 1$, for all s, and $h'(x_s) > 0$, for all s. Thus, I can conclude that

$$\lim_{T\to\infty} \rho^T \left(\prod_{s=t}^{t+T-1} G_Q(L_s, Q_s) \right) \frac{1}{h'(x_{t+T})} = 0.$$

Now condition (7) follows from (*). ■

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