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CAPITAL REQUIREMENTS, SCREENING AND INTERLINKED SHARECROPPING AND CREDIT CONTRACTS*

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This paper provides one more rationale for interlinking credit and tenancy contracts in the context of production loans. In an environment characterized by a heterogeneous labor pool and imperfect information, landlords will have an incentive to avail themselves of screening devices. By linking tenancy and credit contracts a screening device can be implemented. The equilibrium set of contracts is characterized by a variety of interest rates, some of which might be below the market interest rate; the interest rate-principal schedule is downward sloping, with higher ability tenants choosing larger principals at lower interest rates.

1. Introduction

It is often noted that agrarian developing countries (South Asia, in particular) are characterized by the following features:

- (i) Tenancy contracts appear to take pure forms of either sharecropping or fixed rentals. The superior linear contracts which include both share and fixed-fee components are not often observed [see Singh (1982, ch. 2)].
- (ii) Sharecropping contracts are often interlinked with credit contracts [see Bharadwaj (1974), Bardhan (1980) and Binswanger et al. (1982)].
- (iii) Credit contracts between landlords and tenants are often in the form of production loans and tied to the purchase of fertilizers, seeds, or other forms of capital [see Singh (1982, ch. 11)].
- (iv) Different tenants cum borrowers pay different interest rates on their loans [see Bardhan and Rudra (1978)].
- (v) Landlords provide tenants also with low interest rate loans, i.e., interest rates significantly below the perceived market rate [see Bardhan and Rudra (1978)].

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There is no clear theoretical explanation for the fact that linear¹ tenancy contracts are not commonly observed. One possible explanation may be that the interest component of a tenancy-cum-credit contract substitutes for the fixed-fee component of the linear tenancy contract. In any case, the environment which we consider here is rural and characterized by pure sharecropping² contracts which are interlinked with credit contracts. In the past, theoretical discussions of these phenomena viewed them only as a form of exploitation of less powerful agents (tenants) by more powerful ones (landlords), e.g., Bhaduri (1973, 1977). Recently, two other views of interlinking have been advanced:

- (i) It was demonstrated by Braverman and Srinivasan (1981) that in an imperfect credit market, a landlord may offer credit to his tenant, sometimes even at a subsidized rate of interest, without necessarily insisting that the sharecropper borrow only from him, thus precluding an involuntary (from the point of view of the tenant) linkage between credit and land transactions. However, any legally or socially imposed constraints on tenant's share (as for instance, a floor) may provide incentives for a credit-tenancy linkage that may otherwise be absent.
- (ii) In a world characterized by uncertainty and asymmetrical distribution of information between landlords and tenants, moral hazard problems arise. Interlinking of contracts is a response to this particular phenomenon of incomplete set of markets [see Bell and Zusman (1980), Braverman and Stiglitz (1982), Mitra (1983)]. In such an environment, it is possible that landlords will subsidize loans to tenants in order to induce more effort on their part.

Our purpose in this paper is to provide further insights into the rationality of market linking. We suggest an additional aspect of interlinked credit and tenancy contracts in the context of production loans.³ All recent models of market linkage have dealt with a homogeneous population of laborers. However, the case is that workers in general differ in attributes and characteristics relevant to the production process, but unobservable or very difficult to measure by the landlord. As a result, in an environment characterized by a heterogeneous labor pool and imperfect information, landlords will have an incentive to avail themselves of screening devices. *By linking tenancy and credit contracts a screening device can be implemented.*

¹Non-linear contracts may be too complex to implement.

²It has already been demonstrated [e.g., Stiglitz (1974)] that if tenants are risk averse, pure sharecropping contracts dominate fixed-rent contracts, since the latter, though preferable from the tenant's incentive point of view, shift all the risk to the tenants.

³Braverman and Srinivasan (1981) deal only with consumption loans, while the analysis of Braverman and Stiglitz (1982) deal with both consumption and production loans. Although our analysis is set in a production loans framework, it could be adapted to a consumption loan framework. In such a setting bullocks ought to be viewed as part of the assets of the tenants, and the consumption loans (principal and interest) would be tied to the bullocks' contribution by the tenant.

In analyzing this problem we use the methodology for investigating self-selection screening equilibria which was first developed by Spence (1974), and Rothschild and Stiglitz (1976).⁴ Using a monopolistically competitive market structure, we analyze the resulting allocation under the interlinked credit-cum-tenancy contracts and compare it to the allocation obtained under a policy of disallowing credit market linking. Under the former allocation, laborers above a certain type or level of ability self-select into each of the equilibrium contracts, according to their ability. In equilibrium each contract is designed to attract one and only one type of laborer above a certain minimum ability level. Tenants are compelled to accept the credit terms set by landlords for the purchase of capital in order to be allocated a plot of land. The sorting interest rate principal schedule is downward sloping, with high ability tenants being subsidized for larger purchases of capital. So the separating, self-selection equilibrium, if it exists, is characterized by a variety of interest rates, some of which may be below the market interest rate. We also show that while the linking of credit and land contracts might generate the efficient allocation, a policy of disallowing linking will undoubtedly generate an inefficient allocation. Hence we provide further support to the point raised elsewhere [e.g., Braverman and Srinivasan (1981), and Braverman and Stiglitz (1982)] that some partial agrarian reforms may do more harm than good. However, in general the ranking of the two regimes, the one with linking and the one without linking, will depend on the distribution of ability types.

2. The model

2.1. Tenants and landlords

We consider an environment characterized by a pool of laborers, identical in all aspects except for their ability, e_i . Ability is modelled as the quality of labor input, i.e., e_i may be interpreted as the number of efficiency units of labor supplied within an hour. We assume a finite number of ability types, $i=1$ to N . The distribution of labor by ability is given in terms of the function $g(e_i)$. An individual with ability e_i will be denoted by a type i worker, and for $i > j$, $e_i > e_j$. There are a finite number of identical plots of land owned by a collection of landlords. To keep the model simple and in order to emphasize the effects of linkage we assume the size of the plot as fixed and that the number of units of labor input is constant and normalized

⁴Hallagan (1978), and Newbery and Stiglitz (1979) use this methodology in explaining the coexistence of rent, wage and share contracts. As pointed out by Braverman and Guasch (1982) and Basu (1982) Hallagan's model is not consistent with a full equilibrium. For other applications of this methodology in the context of labor markets, see Salop and Salop (1976), and Guasch and Weiss (1980).

to be one.⁵ Hence, the number of efficiency units of labor that type i contributes is e_i .

Output, Q , from a given plot of land is a function, then, of the ability of the tenant cultivating it and of the units of capital b utilized on the plot of land, i.e., $Q = F(e, b)$, with F being strictly concave with positive partial derivatives and $F_{21} > 0$. Landlords would rather like to allocate their plots to the more able laborers but ability is not observable or known to them. Since laborers differ in their ability, it follows that their marginal product of capital will also be different. Landlords can exploit that fact to sort the workers by inducing the would-be tenants to contribute a certain number of units of capital. Thus ownership of capital serves as an entrance ticket for a tenancy position in a land-scarce economy⁶ and tenants have to borrow to finance such acquisition.

The laborer can either become a tenant or earn wage income, w , as a hired hand elsewhere. For simplicity we assume that all workers face the same opportunity wage, e.g., the skill differential is not expressed in public works. However, the main results still obtain in cases where opportunity wage increases with ability.⁷ As a tenant the worker is offered: (i) a sharecropping contract where α denotes the tenant's output share — α is exogenously given (determined by social norms) and common to all tenants;⁸ and (ii) a set of credit contracts, S^* , where each contract s includes a principal k at an interest rate r which is *tied* to the purchase of capital and is repaid at the end of the production process. The workers, then, have a choice between being hired workers elsewhere or choosing one tenancy-cum-credit contract. They

⁵We have chosen to assume a fixed plot size for several reasons. It allows us to emphasize the pure role of production loans as tie-in devices to screen applicants. Clearly, allowing the landlord to discriminate between tenants with respect to the plot size would enlarge the opportunity set of feasible allocations. It could be modeled at the expense of some additional analytical complexity. However, as a screening device, production loans would dominate plot size variability for two basic reasons. First, the inherent indivisibilities associated with land technology will make it costlier (higher transaction costs) to discriminate according to plot size variability rather than with production loans where those indivisibilities do not exist. Also changing plot sizes from year to year will imply higher transaction costs than changing the size of the production loans. Second, the case is that tenants will require production loans regardless. Since the landlord is interested in inducing purchases of capital, and production loans seem to be a 'cheaper' screening device, he might as well use them for that purpose. The introduction of plot size variability ought not to critically affect the results. The contracts, then, would tend to be designed such that a larger plot size would be most attractive to the most able tenants with larger production loans associated with them. Similar patterns as obtained here would be developed, but with the additional analytical complexity.

⁶See Bell (1977), and Bliss and Stern (1981) for evidence from Bihar, that ownership of bullocks is an entrance ticket to the tenancy market.

⁷Namely, the expected wage that they could get elsewhere either as self-employed, hired hands, or otherwise.

⁸Allowing landlords to choose a common output share in an optimal way will not change the results. The crucial assumption is that all contracts should have the same output share. It is noted in many LDC's that output shares seem regularly to be fixed around fifty percent. Such a social norm may be accepted by the landlords if they can use the credit instrument to screen and extract surplus out of more able tenants.

make the choice which maximizes their expected utility. For simplicity we shall assume away the incentive and uncertainty problems in order to focus on the screening problem.⁹ Hence, since labor units are assumed to be fixed, maximizing expected utility is equivalent to maximizing income.

Formally a type i worker will select the contract that $\max_{s_j \in \bar{S}} \alpha F(e_i, b_j) - (1+r_j)ab_j$ given that the maximum is not less than w . We have normalized the price of output to be one, and a is the market price of one unit of capital. Clearly, $b_i = k_i/a$. To simplify the notation we replace k_i by b_i on the contract structure; thus a contract will be expressed as $s = (b, r)$. We also assume that capital is observable by the landlord or that it can be monitored. Depending on the nature of the capital used in the production function a will be the purchase price or the rental price of one unit of capital.

Now consider the landlords' problem. We assume that landlords are identical and large in number, and behave non-cooperatively in selecting their contract offers. r_0 denotes the market interest rate or opportunity cost of capital, which is the return landlords would obtain with their idle funds. (It is also the rate laborers would face if they were not tied to borrow from the landlord.)¹⁰ Landlords are risk neutral and offer the optimal contract(s) to maximize expected profits, taking as given the contract offered by other landlords. Uncertainty may appear when different ability types are attracted to the same contract. Among those, the landlord will select one worker at random or on a first-come-first-serve basis, and the landlord's ex post profits will depend on the worker's ability.

2.2. Equilibrium

The equilibrium analyzed is the Nash non-cooperative equilibrium.

Definition. A non-cooperative Nash equilibrium is a set of contracts $\bar{S} = \{s_i = (b_i, r_i), i \in I\}$ such that

$$\text{for } i \in I, E\pi(s_i/\bar{S}) \geq E\pi(s/\bar{S}) \text{ for any } s \in \bar{S}. \quad (1)$$

Since there is a limited number of plots of land, not all types of workers in equilibrium will be able to become tenants. The lowest ability type who is attracted to a sharecropping-cum-credit contract will obtain in equilibrium a return equal to the wage income he could get as a hired laborer (a utility equivalent contract).¹¹ Because of competition among the landlords, in

⁹The incorporation of these two factors will complicate the technical analysis without changing the qualitative nature of the results obtained.

¹⁰One could argue that although r_0 is the market rate of interest, different tenants if in need to borrow from the market might be given different interest rates according to assets, reputation, or other types of collateral set forth. However, this is irrelevant in the linking regime since tenants are forced to borrow from the landlord in order to become sharecroppers.

¹¹See Braverman and Srinivasan (1981) and Mitra (1983) for sufficient conditions for existence of utility equivalent contract equilibria, and Braverman and Stiglitz (1982) for discussion of utility equivalent and non-equivalent contract equilibria.

equilibrium, the return from all contracts or all plots to the landlords should be the same. Otherwise the equilibrium would be broken by switching contracts/plots from the less profitable to the more profitable ones and slightly underbidding them.

We will say that an allocation is a *sorting equilibrium* if it satisfies (1) and each contract is the most preferred to one and only one ability type. A *pooling equilibrium* will be one in which there is at least a contract which is the most preferred for more than one ability type. As is the case in most models of imperfect information, a pooling equilibrium does not exist [e.g., see Rothschild and Stiglitz (1976), or Guasch and Weiss (1980)]. This is straightforward to show. The idea is that the more able group in the pool can always be sorted out by a new contract, since they have the highest marginal productivity of capital, breaking the pooling equilibrium.

Therefore, we are left to analyze the existence of a sorting equilibrium. But first, let us determine (i) the lowest ability type that will operate as a sharecropper in equilibrium, and (ii) the common return the landlords will get per plot in equilibrium.

Let L be the total number of plots of land owned by the landlords. Let n be the index such that $\sum_{i=n}^N g(e_i) \geq L$ and $\sum_{i=n+1}^N g(e_i) < L$; then, since in equilibrium no plot will remain idle, types n to N will operate as sharecroppers. We can determine now the common return z per plot of land to the landlords. In equilibrium, types n will earn their opportunity wage, thus the contract most preferred to them (b_n, r_n) will be such that

$$\alpha(F(e_n, b_n)) - (1 - r_n)ab_n = w. \quad (2)$$

The return to the landlord z will be

$$(1 - \alpha)F(e_n, b_n) + (r_n - r_0)ab_n = z. \quad (3)$$

Combining (2) and (3) we obtain

$$F(e_n, b_n) - (1 + r_0)ab_n = z + w, \quad (4)$$

stating that the net return on any plot equals the sum of the landlord's profits and the tenant's return. Then z can be obtained by maximizing the left-hand side of (4) with respect to b_n . Let b_n^* be the argument that maximizes $F(e_n, b_n) - (1 + r_0)ab_n$, then

$$z^* = F(e_n, b_n^*) - (1 + r_0)ab_n^* - w \quad (5)$$

will be the return per plot of land to the landlords. The interest rate associated with principal ab_n^* will be

$$r_n^* = (\alpha F(e_n, b_n) - w) / ab_n^* - 1.$$

Thus in equilibrium the contract (ab_n^*, r_n^*) is designed to attract type e_n laborers.

Two observations are warranted at this point. First, note that we have not assumed an opportunity cost to hold land (we are implicitly assuming it is zero). Suppose \hat{z} was the opportunity cost. If $z^* \geq \hat{z}$, n will be determined as above. If $z^* < \hat{z}$, then n would be determined by solving (5) for $n+1, n+2, \dots$ etc. until a $z^*(i) \geq \hat{z}$ is obtained. The minimum i that generates a $z^*(i) \geq \hat{z}$ will determine then the lowest ability types that will operate in equilibrium as sharecroppers. Secondly, notice that the contract (b_n^*, r_n^*) induces the efficient (first best) allocation by type n labor, since r_0 is the market opportunity cost of capital.

Since the only possible equilibrium is a sorting one, let us characterize the conditions that a set of contracts ought to satisfy to sort the workers. Since only types n to N will become tenants, we will denote the contracts $s_i = (b_i, r_i)$ for $i = n$ to N meaning that contract s_i is designed to attract labor types i . Clearly in full employment equilibrium types $i = 1$ to $n-1$ will become hired laborers elsewhere and earn a wage income w .

A set of contracts $S^* = \{(b_i, r_i)_{i=n \text{ to } N}\}$ is a sorting one if

$$\text{for } i \geq n, \alpha F(e_i, b_i) - (1 + r_i)ab_i \geq \alpha F(e_i, b_j) - (1 + r_j)ab_j \quad \text{for all } N \geq j \geq n, \quad (6)$$

$$\text{for } i = n, \alpha F(e_n, b_n) - (1 + r_n)ab_n = w, \quad (7)$$

$$\text{for } i \geq n, (1 - \alpha)F(e_i, b_i) + (r_i - r_0)ab_i = z^*. \quad (8)$$

Furthermore, this set of contracts will be an equilibrium if there is no pooling contract that can generate higher profits for the landlord given the set S^* of contracts.

Inequality (6) is the sorting or optimality condition stating that the i th contract is the most preferred by type i laborers. Eq. (7) states that each tenant holding land will earn at least as much as a hired laborer, with the lowest type earning just the same income as he would earn as hired laborer. Since types $i < n$ cannot do as well as type n , they will not be attracted to tenancy contracts. Eq. (8) states that the return to the landholders of any of the equilibrium contracts is the same and is the highest common return attainable by the landlords. Clearly, in equilibrium there will be as many effective i contracts (b_i, r_i) as the number of type $i \geq n$ laborers.

From the sorting condition (6) for any $i, j \geq n$, it follows that

$$\alpha(F(e_i, b_i) - F(e_i, b_j)) \geq a(1 + r_i)b_i - a(1 + r_j)b_j \geq \alpha(F(e_j, b_j) - F(e_i, b_j)). \quad (9)$$

Since $F_{21} \geq 0$, for $i > j$ it follows that in equilibrium $a(1+r_i)b_i > a(1+r_j)b_j$, the more able a tenant is the higher the debt he incurs.

In the appendix we show that a sorting set of contracts always exists, namely, there is always an equal profit set of contracts where each type of tenant i for $i \geq n$ selects optimally a different contract. Each contract generates the same profits and laborers of type $i < n$ are better off choosing to work as hired hands elsewhere earning wage income w . That set of contracts generates the highest profits among any other sorting set of contracts. It may or may not be an equilibrium. The reason why it may not be sustainable as an equilibrium is that the induced allocation might not be efficient. If faced with that sorting but inefficient allocation, it might be worthwhile for the landlords to offer a new contract, a partial pooling one (where more than one type of labor is attracted to it). The profitability of the new contract will depend on the relative distribution of the types attracted to the contract. The higher the percentage of high ability types relative to the less able ones the more likely it is that the partial pooling contract will be more profitable than the sorting one. If so, the sorting equilibrium will be broken. Of course the ability differential among the types of labor will also be a factor in determining the profitability of the pooling contract. Thus that sorting set of contracts, even if inefficient, can still be an equilibrium.

The non-existence of equilibrium in models of imperfect information is quite common and was first pointed out by Rothschild and Stiglitz (1976). There, as well as in our model, the existence of a sorting equilibrium depends on the distribution of types and on the 'closeness' among types (the cost of separating). Notice, however, that risk attitudes on the part of the buyers are inconsequential in our model, since, of course, there is no risk to bear. On the other hand, the risk attitudes of the sellers (landlords) can affect the existence of equilibrium. In Rothschild and Stiglitz (1976) the sellers were assumed to be risk neutral, assumptions that can be justified by noticing that each seller will transact a relatively large number of contracts. Here each seller (landlord) will contract only one plot (or a small number) of land; therefore one might want to assume a certain degree of risk aversion on their part. If the landlords are infinitely risk averse then the sorting set of contracts obtained above is an equilibrium; it never pays to pool. If they are risk neutral, as in our framework, it might pay to pool depending on the distribution of types.

3. Properties of the equilibrium allocation

As we have seen the only possible equilibrium is of the sorting type. It is characterized by the following properties:

- (i) In equilibrium not only more able laborers purchase more units of capital, but they incur a higher debt as well, namely for $i > j \geq n$, $b_i > b_j$ and $(1+r_i)b_i a > (1+r_j)b_j a$.

- (ii) The equilibrium interest rate–loan size schedule is downward sloping. As the principal increases the corresponding interest rate decreases. Moreover, some segment of the interest rate schedule may lie below the market interest rate. The derivation of this property is presented in the appendix.

The intuition behind these properties is that in equilibrium all landlords (contracts) should earn the same profits regardless of the type of tenant they attract. Landlords who attract high ability tenants obtain a larger output than those landlords who attract low ability tenants. But because of the equal profits equilibrium condition the interest rate that the latter landlords will offer has to be higher than that offered by the other landlords. However, if both types of landlords established the same capital requirements (principal) all tenants would obviously choose the lower interest rate contract and that would not sort. To induce sorting, the landlords offering lower interest rates have to attach them to higher capital requirements (principal). Then the high ability tenants would opt to choose the large principal, lower interest rate contract since they have higher marginal productivity of capital.

This type of allocation is in agreement with the Bardhan and Rudra (1978) observation that often in West Bengal landlords provide subsidized loans to their tenants.¹² The fact that larger loans are offered at lower interest rates provides more incentives for the more able to borrow more for larger purchases of capital.

4. Welfare analysis

In this section we analyze the welfare properties of the sorting equilibrium allocation in relation to the first best one.

Note that at the sorting equilibrium allocation at least one of the contracts, the (b_n, r_n) , generates an efficient allocation. Moreover, depending on the parameters of the model, it could be that the set of sorting contracts generates the efficient allocation, i.e., every contract leads to an efficient allocation. The first statement has already been shown. To show the second, let us construct the efficient allocation.

An efficient allocation entails inducing type i laborers to select the b_i that

$$\max F(e_i, b) - (1 + r_0)ab, \quad (10)$$

since the market cost of capital is r_0 . Solving (10) we obtain a function $b(e_i) \equiv b_i$, $b'(e_i) > 0$. Competition will induce a common return on all plots of land equal to z , which has been previously defined.

¹²The other results of our analysis, namely that interest rates vary inversely with the amount of the loan and tenant ability, are not necessarily borne out by the Bardhan–Rudra study since they did not distinguish tenant types and did not test the hypothesis between loan size and interest rates.

The return to the landlord would be

$$(1-\alpha)F(e_i, b(e_i)) + (r_i - r_0)ab(e_i) = z. \quad (11)$$

From (11) we can obtain the interest rate that should be associated with principal ab_i ,

$$r_i = (z + r_0ab_i - (1-\alpha)F(e_i, b_i))/ab_i \equiv r(e_i).$$

The set of contracts would be $(b(e_i), r(e_i))_{i=n \text{ to } N}$. This set of contracts will constitute an equilibrium if the contract $(b(e_i), r(e_i))$ is the most preferred by type i laborers, or equivalently if that set of contracts satisfies the sorting conditions (6). Notice that the interest rate schedule for the set of efficient contracts, if feasible to implement, will also be downward sloping. It will not always be the case that the set of contracts $(b(e_i), r(e_i))_{i=n \text{ to } N}$ will satisfy the sorting conditions (6). Thus an efficient allocation may not be implementable, because laborers may choose other contracts that might give them higher returns (and lower returns to the landlords); once that effect is taken into account, the set of efficient contracts will not be offered, leading to the inefficient set of contracts previously obtained.

Since each contract in the equilibrium set is designed for a specific type and to discourage lower ability types from applying, the units of capital b_i resulting from the sorting contract will be greater than or equal to those resulting from the efficient allocation. Otherwise the landlords would be better off by increasing the requirement of capital and adjusting the interest rate to retain the type i 's and to discourage applications from lower ability laborers.

It is easy to see graphically why the set of efficient contracts might not be implementable. Let b_n^*, b_{n+1}^*, \dots be the optimal capital requirements for types $n, n+1, \dots$. Let r_n^* be the interest rate offered along the b_n^* capital requirements. That contract gives type n a return of w . Let r_{n+1}^* be the interest rate associated with b_{n+1}^* such that when type $n+1$ selects that contract, the landlord obtains the same return z as that generated under contract (b_n^*, r_n^*) . If $r_{n+1}^* = r_{n+1}^1$ (in fig. 1) the efficient contract (b_{n+1}^*, r_{n+1}^1) is implementable since the n types do not prefer it to the (b_n^*, r_n^*) as long as I_{n+1}^1 intersects I_n below A . While if $r_{n+1}^* = r_{n+1}^2$ then the efficient contract (b_{n+1}^*, r_{n+1}^2) is not implementable since the n types would also prefer this contract to the (b_n^*, r_n^*) . This can be seen in fig. 1 where I_n and I_{n+1} are the indifference curves of types n and $n+1$, respectively.

Also, note that the low ability types impose a negative externality on the high ability ones. If the former would reveal themselves as such all types of labor (the tenants) would be made better off without anyone being worse off, since then the efficient allocation would be obtained.

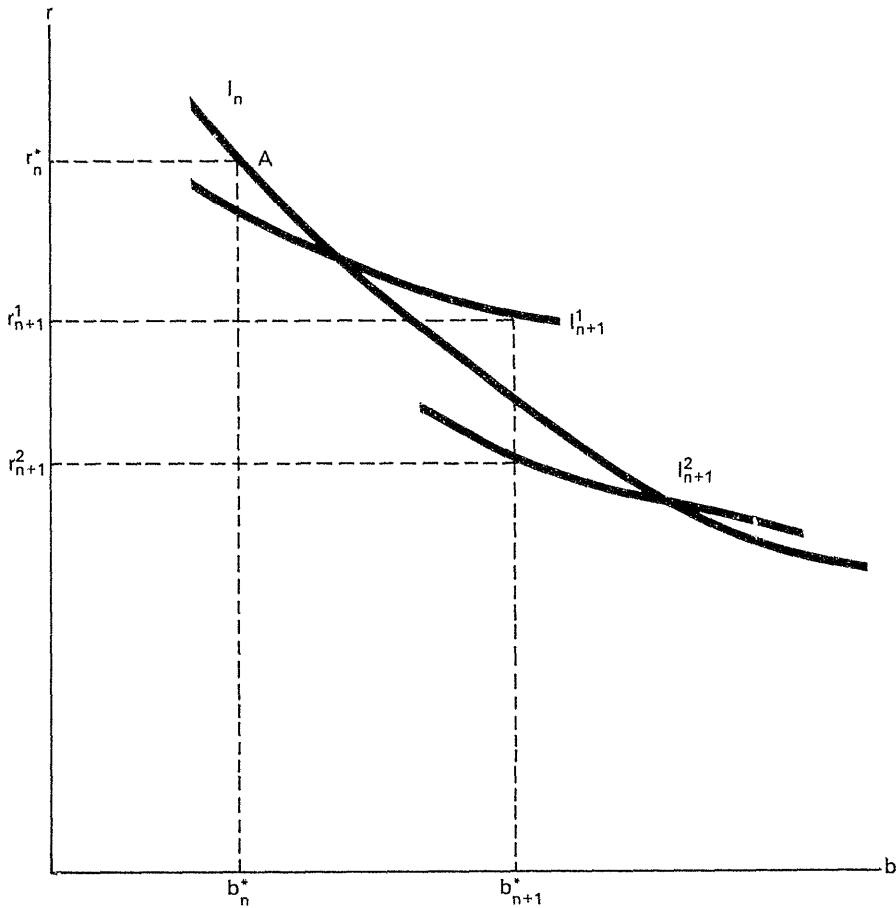


Fig. 1

5. Alternate policies

In this section we would like to investigate the effect on the land-tenancy allocation of a policy disallowing the landlords control of the credit market. In this situation capital would still serve as an entry ticket to the land-tenancy market. The only control the landlords have now is to require a minimum number of units of capital (e.g., bullocks) in order to be eligible to become a sharecropper. Laborers borrow from the market at the rate of r_0 .¹³ Since no plot will remain idle, that minimum number is the largest value of b that solves the equation $\alpha F(e_n, b) - (1 + r_0)ab = w$. Let that value be \hat{b}_n . Also

¹³We have assumed that tenants can borrow at the market rate of interest r_0 . This assumption can be too strong since different tenants might be able to obtain different interest rates. That would not affect the policy results since then the proper comparison would be between r_n and \hat{r}_n rather than r_n and r_0 , where \hat{r}_n is the interest rate type n can obtain at the market. The results would be along the same lines, especially since the most likely presumption is that $\hat{r}_i > r_0$ for all i .

let \bar{b}_i be the value of b that $\max_b \alpha F(e_i, b) - (1+r_0)ab$, then types $N \geq i > n$ will purchase $\hat{b}_i = \max(\bar{b}_n, \bar{b}_i)$.

Recall that under the sorting equilibrium set of contracts, b_n would be the $\text{Arg max } F(e_n, b) - (1+r_0)ab$ (it was the efficient allocation) and that $\alpha F(e_n, b_n) - (1+r_n)ab_n = w$. Therefore if $r_n > r_0$ then $\hat{b}_n > b_n$ while if $r_n < r_0$, then $\hat{b}_n < b_n$, which says that a regime of no-credit linking will induce an inefficient allocation for type n laborers, with overinvestment of capital if $r_n > r_0$ and underinvestment if $r_n < r_0$. In either case landlords who draw type n laborers will earn less profits than they would under a regime of credit linking.

Following are some observations comparing the efficiency of the two regimes: (i) under the credit linking regime an efficient allocation may be possible, while a no-linking regime always leads to an inefficient allocation; (ii) profits per plot are the same regardless of the ability of the tenant under the credit linking regime, while they depend on the tenant under the no-linking regime, with the lowest profit (if a type n tenant is drawn) being below that constant level and the highest profit being above — note that the landlords in the latter regime have no control over which type of tenant they draw. The landlords face a lottery which depends on the distribution of tenant types.

When comparing the welfare generated by the interlinking regime to one which disallows linking, one observation ought to be made. While interlinking provides the landlord with a screening device to identify tenants, a regime without interlinking necessitates landlords to choose tenants at random. Then under the no-linking regime the ex-post value of the landlord's profits, which is contingent upon the ability type being hired, will differ from the ex-ante expected profits which is based on the 'average' potential tenant. Hence while a monopolistically competitive equilibrium with interlinking will imply that landlord profits are equal ex-ante and ex-post, in the no-linking situation this will not be the case. The comparison of the ex-ante expected profits of landlords in both situations is contingent upon the distribution of ability types. Here, the opportunity cost of all potential tenants is the same, independent of their ability (their ability is manifested only in organizing production as tenants rather than as wage laborers). If there are relatively many high ability potential tenants and few low ability ones, landlords' ex-ante profits would be higher under the regime without linking. This is due to the fact that in the interlinking regime the equal level of profits is determined by the profits generated from the lowest ability tenant n , under the constraint that that tenant has to earn the alternative wage income w . However, in general, the comparison is ambiguous; it depends on the distribution of ability types. Similar conclusions hold regarding the welfare of the tenants.

6. Monopolistic structure

A final note about market structure. Although we have developed our model in the context of a monopolistically competitive market structure, a

similar study could be undertaken for a monopoly market structure. The results would be quite similar in spirit. The optimal set of contracts offered by the monopolist would still be of the sorting type. However, two basic differences would appear. First, it may be in the interest of the monopolist to leave some land idle, and secondly, profits per plot of land or contract would be a function of the type of workers in charge of it. Profits would increase with the ability of workers. The monopolist will contract discriminate the tenants to extract a larger surplus.

A credit-cum-tenancy contract would allow a monopolist landlord to extract a larger surplus out of his heterogeneous tenants. So in this respect we may provide support to Bhaduri's (1973, 1977) claim that interlinked credit and tenancy contracts are a way in which landlords exploit their tenants.

7. Conclusion

In an environment characterized by a heterogeneous labor force with some unobservable attributes and a number of landlords with a limited supply of land, we have presented an additional aspect of interlinking credit and tenancy markets. Offering laborers tie-in tenancy and credit contracts serves landlords as a self-selection screening device to identify and allocate tenants according to their ability. The only possible equilibrium under a monopolistically competitive market structure is a sorting one, where each type of labor above a given ability level self-selects by choosing a different contract. We have characterized that equilibrium showing that the interest rate-principal schedule is downward sloping. More able types borrow more to buy more capital but at a lower interest rate, i.e., landlords subsidize the purchase of capital by the more able laborers. The equilibrium may be efficient while the equilibrium allocation under a regime of no credit linking is always inefficient.

Appendix

A.1. Derivation of the sorting set of contracts

Let us show here that a sorting set of contracts always exists. Let $F^{ij} \equiv F(e_i, b_j)$ and $Q^i \equiv F^{ii} - (1+r_i)ab_i$. Then equilibrium condition (9) can be rewritten as

$$\alpha(F^{ii} - F^{ji}) \geq Q^i - Q^j \geq \alpha(F^{ij} - F^{jj}). \quad (\text{A.1})$$

First we will show that if a set of $\{b_i\}$ can be obtained such that $Q^i - Q^{i-1} = \alpha(F^{ii} - F^{i-1, i})$ for all i , then inequality (A.1) will be satisfied.

We have that

$$\begin{aligned}
 Q^i - Q^{j-1} &= \alpha[(F^{ii} - F^{i-1,i}) + (F^{i-1,i-1} - F^{i-2,i-1}) + \dots \\
 &\quad + (F^{jj} - F^{j-1,j})] \\
 &= \alpha[F^{ii} - (F^{i-1,i} - F^{i-1,i-1}) - (F^{i-2,i-1} - F^{i-2,i-2}) - \dots \\
 &\quad - F^{j-1,j}] \\
 &= \alpha \left[F^{ii} - F^{j-1,j} - \sum_{k=j}^{i-1} (F^{k,k+1} - F^{k,k}) \right].
 \end{aligned}$$

Notice that for $i \geq k \geq j-1$, $F^{i,k+1} - F^{ik} \geq F^{k,k+1} - F^{kk} \geq F^{j-1,k+1} - F^{j-1,k}$. To see this, look at, for fixed $b_{k+1} > b_k$, the function

$$g(x) \equiv F(x, b_{k+1}) - F(x, b_k),$$

which is increasing because $F_{12} > 0$, ($b_{k+1} > b_k \Rightarrow F(x, b_{k+1}) > F(x, b_k)$). Then it follows that

$$\begin{aligned}
 Q^i - Q^{j-1} &= \alpha \left[F^{ii} - F^{j-1,j} - \sum_{k=j}^{i-1} (F^{j-1,k+1} - F^{j-1,k}) \right] \\
 &= \alpha \left[F^{ii} - F^{j-1,j} - \sum_{k=j}^{i-1} F^{j-1,k+1} + \sum_{k=j-1}^{i-2} F^{j-1,k+1} \right] \\
 &= \alpha[F^{ii} - F^{j-1,j} - F^{j-1,i} + F^{j-1,j}] = \alpha[F^{ii} - F^{j-1,i}].
 \end{aligned}$$

Also,

$$\begin{aligned}
 Q^i - Q^{j-1} &\geq \alpha \left[F^{ii} - F^{j-1,j} - \sum_{k=j}^{i-1} (F^{i,k+1} - F^{i,k}) \right] \\
 &= \alpha \left[F^{ii} - F^{j-1,i} - \sum_{k=j}^{i-1} F^{i,k+1} + \sum_{k=j-1}^{i-2} F^{i,k+1} \right] \\
 &= \alpha[F^{ii} - F^{j-1,j} - F^{ii} + F^{ij}] = \alpha[F^{ij} - F^{j-1,j}] \\
 &\geq \alpha[F^{i,j-1} - F^{j-1,j-1}],
 \end{aligned}$$

since $F_{12} > 0$; therefore equilibrium condition (A.1) is satisfied.

Finally it is straightforward to show that b_i 's can be found so that

$$Q^i - Q^{i-1} = \alpha(F^{ii} - F^{i-1, i}) \quad \text{for all } i. \quad (\text{A.2})$$

Begin with $i-1=n$ and use the b_n^* obtained in the text as the starting point. Then using (A.2) and the equal profit constraint, solve for b_{n+1} and r_{n+1} . Iterate the procedure till b_N and r_N are obtained. Therefore, a sorting set of contracts always exists.

A.2. Derivation of the equilibrium interest rate-loan size schedule

Notice that the sorting set of contracts developed above satisfies the condition $Q^i - Q^{i-1} = \alpha[F^{ii} - F^{i-1, i}]$ or

$$(1-\alpha)F^{ii} - (F^{i-1, i-1} - \alpha F^{i-1, i}) = (1+r_i)ab_i - (1+r_{i-1})ab_{i-1}. \quad (\text{A.3})$$

We can rewrite the equal return per plot condition as

$$\begin{aligned} (1-\alpha)(F^{ii} - F^{i-1, i-1}) &= (1+r_0)a(b_i - b_{i-1}) \\ &\quad + (1+r_{i-1})ab_{i-1} - (1+r_i)ab_i. \end{aligned} \quad (\text{A.4})$$

Combining (A.3) and (A.4) we obtain

$$\begin{aligned} \alpha(F^{i-1, i} - F^{i-1, i-1}) &= 2((1+r_i)ab_i - (1+r_{i-1})ab_{i-1}) \\ &\quad - (1+r_0)a(b_i - b_{i-1}) \end{aligned} \quad (\text{A.5})$$

but by the sorting condition

$$\alpha(F^{i-1, i} - F^{i-1, i-1}) < (1+r_i)ab_i - (1+r_{i-1})ab_{i-1}. \quad (\text{A.6})$$

Combining (A.5) and (A.6) we obtain

$$r_0(b_i - b_{i-1}) > r_i b_i - r_{i-1} b_{i-1}.$$

Let $r_i = r_{i-1} + \delta$; then

$$r_0(b_i - b_{i-1}) > r_{i-1}(b_i - b_{i-1}) + \delta b_i.$$

Therefore if $r_{i-1} > r_0$, then $r_{i-1} > r_i$; thus the principal-interest rate schedule will be downward sloping. Since r_n depends on the exogenous parameters α and w , and the schedule serves the purpose of a sorting device, the same result should hold for all i , namely if $i > j \geq n$, $r_i < r_j$. Some segment of the schedule may lie below the market interest rate.

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