Sharecropping, interlinkage and price variation*

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Abstract

This paper proposes a theory of sharecropping and interlinkage on the basis of seasonal variation of price and imperfectly competitive nature of rural product markets. First, a benchmark model is considered to show the optimality of sharecropping in the presence of price variation. This model is extended by allowing interlinked contracts to show that there are multiple equilibria and both forms of contracts—fixed rental and sharecropping—can be sustained in equilibrium. Finally, incorporating the possibility of competition in the product market, an equilibrium refinement is proposed and it is shown that the unique equilibrium that is robust to this refinement results in a contract that involves sharecropping as well as interlinkage. This theory also sheds light on several related issues like observed uniformity of share contracts, technological stagnation and the notion of power in a rural context.

Keywords: Sharecropping, interlinkage, price variation, rural product market, the ε-agent

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1 Introduction

Over the years, sharecropping has remained a widely prevalent, and perhaps the most controversial, tenurial system in agriculture. While writings on this institution can be traced back earlier, modern economic theories of sharecropping are centered around its criticism of Alfred Marshall (1920). The essence of the Marshallian critique is that sharecropping is an inefficient system. Under a sharecropping contract, the tenant-cultivator pays the landlord a stipulated proportion of the output. This leads to suboptimal application of inputs: even though there is gain in surplus from employing additional inputs, it does not pay the tenant to do so since he keeps only a fraction of the marginal product. In contrast, the tenant has the incentive to maximize the surplus under a fixed rental contract, where he keeps the entire output and pays only a fixed rent to the landlord. The landlord, who usually has the bargaining power, can then extract the entire additional surplus by appropriately determining the rent. Thus, apart from being inefficient, sharecropping is also apparently suboptimal for the landlord. The wide prevalence of this system has therefore remained a puzzle and several theories have been put forward to explain its existence. In particular, it has been argued that sharecropping can be explained by the trade-off between risk-sharing and incentive provision (Stiglitz, 1974; Newbery, 1977; Newbery & Stiglitz, 1979), informational asymmetry (Hallagan, 1978; Allen, 1982; Muthoo, 1998), moral hazard (Reid, 1976, 1977; Eswaran & Kotwal, 1985; Laffont & Matoussi, 1995; Ghatak & Pandey, 2000) or limited liability (Shetty, 1988; Basu, 1992; Sengupta, 1997; Ray & Singh, 2001).[1]

The present paper is motivated by a simple, yet basic observation that seems to have gone unnoticed in the literature. The core of the contention here is sharing of the agricultural product between the contracting parties. Now the worth of the product depends on its price. So a natural question is: Does the price behavior in agriculture play any role in explaining this institution? This issue is sidestepped in the existing theories of sharecropping as it is always implicitly assumed that price is competitively determined in agriculture and the contracting parties take it as given. While price in agriculture is often regarded to be competitive, it is also well-known that agricultural price does exhibit seasonal variation. Empirical observations further reveal a broad pattern in the variation, especially in case of foodgrains: the price is the lowest right after the harvest, then it rises and finally reaches its pick just before the next harvest.[2] In less-developed agrarian economies, a landlord can take advantage of this variation by resorting to a practice known as 'hoarding': he can store the output for a few months and sell it when the price is high. A tenant-farmer, on the other

[1] See also Cheung (1968, 1969), Bardhan and Srinivasan (1971), Bardhan (1984) and recent papers of Ray (1999) and Roy and Serfes (2001). The literature of sharecropping is enormous and we do not attempt to summarize it here. We refer to Singh (1989) for a comprehensive survey.

[2] For example, the Summary Report (2000, p. 8) of Bangladesh Agricultural Research Council states: "The overall findings of the market survey regarding the prices of rice over the twelve months indicate that there had been seasonal variation of prices of rice and other foodgrains. The average retail price of coarse rice in the selected three regions reached its peak (Tk.16.05/kg) in Chaitra (mid-March to mid-April) and went down to its minimum (Tk.11.12/kg) in Jaiyastha (mid-May to mid-June). This means pre-harvesting price of rice was the highest and the immediate post-harvesting price was the lowest with a 44.3 percent difference from the minimum to maximum prices."

hand, has to sell the output at low price immediately after the harvest.[3] We argue that this innate difference in behavior of the two parties can explain sharecropping even in the absence of factors like risk or informational asymmetry.[4] The underlying intuition is simple. A fixed rental contract leaves the entire output with the tenant. Since the tenant sells the output at low price, the revenue and consequently the rent to the landlord is low. In contrast, a sharecropping contract enables the landlord to take advantage of price fluctuations by allowing him to keep a proportion of the output. We develop this basic idea in a benchmark model to show the optimality of sharecropping. But then an immediate question arises: since there are gains from trade, why doesn't the landlord also buy the tenant's share of output? This naturally leads us to consider interlinked transactions, where the landlord interacts with the tenant in both land and product markets.[5] It is shown that when the landlord is allowed to offer interlinked contracts, there are multiple equilibria and both forms of contracts—fixed rental and sharecropping—can be sustained in equilibrium. We resolve this multiplicity by proposing an equilibrium refinement that takes into consideration the fact that although the landlord has monopoly power over the land he owns, this is not necessarily the case in the product market, where he could face competition from other entities (e.g., traders, intermediaries) who might be interested in trading with the tenant.[6] Then it is shown that the unique equilibrium that is robust to this refinement results in a sharecropping contract. Thus, we provide an explanation of sharecropping entirely on the basis of price variation and the imperfectly competitive nature of rural product markets. The broad implications of our theory can be summarized as follows.

1. We show that the equilibrium share of the tenant is completely determined by the extent of price variation and the nature of rural product markets. Since these features are likely to be similar in a particular region, to a certain extent, our theory can explain the well-observed empirical fact (see, e.g., Rudra & Bardhan, 1983, Bardhan, 1984) that for sharecropping contracts in a given region, the stipulated share does not vary too much across plots.

2. A general prediction of our theory is that sharecropping is more likely to be seen for

[3]There could be a host of possible reasons behind this, e.g., (i) unlike a landlord, a tenant-farmer does not have enough buffer wealth to pay for essential commodities for immediate consumption or (ii) the lack of necessary storage facilities for a tenant. The fact that a tenant-farmer cannot usually take advantage of price fluctuations has been quite explicitly recognized in Bhaduri (1973). In Bhaduri's model, however, sharecropping is exogenously given.

[4]The broad theme that fluctuations in market can influence tenures in agriculture finds support in a related context in the classic study of Chayanov (1966, p. 21):"...[T]he *rent* going to the feudal lord on the strength of his feudal tenure is dependent not only on the amount of payment in kind but also on the market situation for selling the products received. Fluctuations in the market situation can, in spite of a constant amount of payment in kind, favorably or unfavorably influence the rent and, thus, the price of the tenure." (emphasis in the original)

[5]The theoretical literature on interlinkage has mainly focused on credit contracts, considering (i) land-credit linkage (e.g., Bhaduri, 1973; Braverman & Stiglitz, 1982; Mitra, 1982; Basu, 1983; Bardhan, 1984; Gangopadhyay & Sengupta, 1986; Ray & Sengupta, 1989; Banerji, 1995; Basu et al., 2000) and (ii) product-credit linkage (e.g., Gangopadhyay & Sengupta, 1986; Bell & Srinivasan, 1989). See also Chapter 14 of Basu (1998) and Chapter 9 of Bardhan and Udry (1999).

[6]See, e.g., Subbarao (1978), Rudra (1982) for empirical evidence. We discuss this issue in more detail in Section 3.2.

crops that show a higher degree of price fluctuation. This can explain why, in contrast to the prediction of risk-sharing theory, sharecropping contracts are often observed for crops like rice that are more likely to exhibit seasonal fluctuations of price but where the risk factor is relatively low (see, e.g., Rao, 1971).

3. Our theory contributes to the issue of technological stagnation in agriculture (e.g., Johnson, 1950; Bhaduri, 1973; Basu, 1989; Naqvi, 1989) by identifying situations where neither the landlord, nor the tenant has any incentive to make productive investments.

4. Our analysis also sheds some light on the question of 'power' in a rural context and presents an interesting dual to the analysis of Basu (1986) on triadic interactions.

The rest of the paper is organized as follows. We present the benchmark model in Section 2. The model with interlinked contracts is presented in Section 3. We conclude in Section 4. Some proofs are relegated to the Appendix.

2 The benchmark model

Consider a landlord who owns a piece of land that can grow only one crop. The landlord seeks to employ a tenant to carry out production in the land.[7]

• *The Production Process:* There is only one input of production: labor (ℓ). The production function is given by $f(\ell)$, where $f(0) = 0$. It is assumed that f is twice continuously differentiable, strictly increasing and strictly concave, i.e., $f' > 0$ and $f'' < 0$. Moreover, $\lim_{\ell \to 0+} f'(\ell) = \infty$ and $\lim_{\ell \to \infty} f'(\ell) = 0$. The cost of ℓ units of labor is given by $c(\ell)$, where $c(0) = 0$. It is assumed that c is twice continuously differentiable, strictly increasing and convex, i.e., $c' > 0$ and $c'' \geq 0$.

• *The Set of Contracts:* The set of contracts available to the landlord is the set of all linear contracts[8] (α, β), where $\alpha \in [0, 1]$ is the share of the output of the tenant and $\beta \in \Re$ is the fixed lump-sum cash transfer from the tenant to the landlord.[9] We say that (α, β) is a

[7] It is assumed that the landlord under consideration is an *absentee* landlord, so self-cultivation by the landlord is ruled out. To focus on the role of price variation, we also rule out all other factors that might contribute to sharecropping, i.e., both parties are assumed to be risk-neutral and there is no uncertainty or informational asymmetry.

[8] This is consistent with the theoretical literature, which has considered only linear contracts on the ground that contracts observed in practice are usually linear. In this regard, the comments of Stiglitz (1989, p. 23) are worth mentioning: "In general, nonlinear contracts will do better...Yet most contracts seem to be of remarkably simple form...The best we can say at this juncture is that perhaps the gains from nonlinearities are not very great...and that, if it becomes conventional to employ linear contracts, suspicions will be raised about those who deviate from the norm."

[9] It is well-known that in equilibrium, β will be determined so that the participation constraint of the tenant binds. However, the interpretation of β is often left unclear in the existing literature. We consider β to be the *lump-sum cash* transfer from the tenant to the landlord. So, for example, the contract $(\alpha = 0.6, \beta = 100)$ has the following interpretation: the tenant keeps 60% of the output, leaves the remaining 40% with the landlord and makes the lump-sum cash transfer of 100 (e.g., 100 rupees) to the landlord. Consequently, throughout the

sharecropping contract if the landlord and the tenant share the output, i.e., if $0 < \alpha < 1$.[10] If $\alpha = 1$ and $\beta > 0$, the resulting contract is a *fixed rental contract*, where the tenant keeps the entire output and pays the fixed rent β to the landlord.[11]

• *Price Variation:* The variation in price is modeled by considering two stylized seasons: 0 and 1. In both seasons, the market price of the product is competitively determined. Season 0 can be viewed as the period right after the harvest when the price is p_0, while season 1 corresponds to a future period sometime after the harvest when the price is p_1, where $0 < p_0 < p_1$. The basic difference in the behavior of the two parties is the following. The landlord stores his share of output in season 0 and sells it in season 1 at price p_1, while the tenant sells his share of output in season 0 at price p_0.[12]

• *The Strategic Environment:* The strategic interaction between the landlord and the tenant is modeled as a three-stage game in extensive form, G. In the first stage, the landlord offers a contract (α, β) to the tenant. In the second stage, the tenant either accepts or rejects the contract. If the tenant rejects the contract, then the game terminates and both parties get their respective reservation payoffs.[13] If the tenant accepts, the game moves on to the third stage where the tenant chooses the amount of labor for carrying out production and output is realized. Finally, the tenant pays the landlord in accordance with the contract. If the tenant works under the contract (α, β) and output is Q, (i) he keeps αQ and leaves the rest $(1 - \alpha)Q$ with the landlord and (ii) makes the lump-sum cash transfer β to the landlord. We employ the backward induction method to determine subgame-perfect equilibrium of

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paper, all payoffs are measured in terms of monetary units (e.g., rupees) and *not* in terms of units of the output. Although the qualitative conclusions are not altered if the fixed payment is a transfer in kind, we consider β to be a cash transfer for the following reasons: (1) For a linear contract (α, β), if $\beta > 0$ is a payment in kind instead of cash, the contracting parties can interpret the terms of contract in different ways that creates unnecessary confusion as follows: should the output be shared between the two parties *before* or *after* the amount β is deducted from the output? (2) When β is a cash transfer, the contracts are flexible to different practical possibilities. For example, suppose the landlord determines $\beta = 100$ (i.e., the tenant has to make a lump-sum transfer of Rs. 100 to the landlord), but the tenant needs an initial capital of Rs. 50 to start production. The contract can be implemented in the following way: the landlord pays the tenant Rs. 50 *before* the production and collects from him a rent of Rs. 150 *after* the production.

[10] As Singh (1989, p. 37) points out, "...[A] landlord offering a share contract may plausibly incorporate a fixed payment to and from the tenant." In other words, a sharecropping contract $(0 < \alpha < 1)$ could be accompanied by either $\beta < 0$ or $\beta > 0$. When $0 < \alpha < 1$ and $\beta = 0$, it is a *pure* sharecropping contract.

[11] If $\alpha = 0$ and $\beta < 0$, the contract is a *fixed wage contract*, where the tenant gives the entire output to the landlord and gets a fixed wage $-\beta$ from him. Observe that in that case, the tenant has no incentive to produce any positive output, so offering such a contract is not optimal for the landlord. In practice, a fixed wage contract is meaningful if the landlord cultivates his own land by hiring labor. For an absentee landlord it is therefore reasonable to consider only tenancy contracts (i.e., fixed rental and sharecropping contracts), as in Basu (1992, p. 204): "A landowner is considered who cannot be present on his land to directly supervise hired labour. So his problem is to devise a suitable tenancy contract (share, fixed or a mixture) and lease out the land."

[12] See footnote 3 for possible reasons behind this. Our emphasis in this paper lays on explaining tenurial contracts on the basis of price variation and we do not attempt to endogenize the process of variation itself. See, e.g., Sarkar (1993) for a theory of price formation in agriculture.

[13] It is well-known that in equilibrium, the tenant gets exactly his reservation payoff. Throughout the paper, it is implicitly assumed that the landlord's equilibrium payoff is not less than his reservation payoff, so that it is optimal for him to offer a contract.

this game.[14]

2.1 Equilibrium analysis of G

If the amount of labor is ℓ, the output is $f(\ell)$. When the tenant operates under the contract (α, β) and employs ℓ units of labor, he keeps $\alpha f(\ell)$ which he sells in season 0 at price p_0, thus earning a revenue of $p_0 \alpha f(\ell)$. The cost of ℓ units of labor is $c(\ell)$. Moreover, the tenant has to make the lump-sum cash transfer β to the landlord. So the tenant will choose ℓ to maximize his payoff, given by

$$\Phi(\ell) = p_0 \alpha f(\ell) - c(\ell) - \beta.$$

Since $f'' < 0$ and $c'' \geq 0$, $\Phi(\ell)$ is strictly concave in ℓ for $\alpha > 0$ and the unique optimal solution, $\ell(\alpha)$, is determined from the following first-order condition.

$$p_0 \alpha f'(\ell) = c'(\ell). \tag{1}$$

Obviously, $\ell(0) = 0$. When the tenant optimally chooses ℓ, his payoff is given by

$$\Phi\left(\ell(\alpha)\right) = p_0 \alpha f\left(\ell(\alpha)\right) - c\left(\ell(\alpha)\right) - \beta.$$

Let $\widetilde{\Phi}$ be the reservation payoff of the tenant. The tenant will accept a contract (α, β) only if $\Phi\left(\ell(\alpha)\right) \geq \widetilde{\Phi}$, i.e.,

$$\beta \leq p_0 \alpha f\left(\ell(\alpha)\right) - c\left(\ell(\alpha)\right) - \widetilde{\Phi}. \tag{2}$$

Now consider the landlord. When the tenant operates under the contract (α, β) and acts optimally, the output that the landlord gets to keep is $(1-\alpha) f\left(\ell(\alpha)\right)$. The landlord stores this output in season 0 and sells it in season 1 at price p_1, earning a revenue of $p_1(1-\alpha) f\left(\ell(\alpha)\right)$. Moreover, he gets the fixed payment β from the tenant. So the payoff of the landlord is

$$\Pi\left(\alpha, \beta\right) = p_1(1-\alpha) f\left(\ell(\alpha)\right) + \beta. \tag{3}$$

Clearly, for any α, the landlord will choose β so that the participation constraint of the tenant in (2) binds. Thus β is completely determined by α, given by

$$\beta(\alpha) = p_0 \alpha f\left(\ell(\alpha)\right) - c\left(\ell(\alpha)\right) - \widetilde{\Phi}. \tag{4}$$

From (3) and (4), the payoff of the landlord is completely determined by α and it is given by

$$\Pi\left(\alpha\right) = \left[p_1(1-\alpha) + p_0 \alpha\right] f\left(\ell(\alpha)\right) - c\left(\ell(\alpha)\right) - \widetilde{\Phi}. \tag{5}$$

The problem of the landlord is now to choose $\alpha \in [0,1]$ to maximize $\Pi(\alpha)$. Since $\Pi\left(\alpha\right)$ is bounded for $\alpha \in [0,1]$, the maximum of this function exists in this interval. Since $f(\ell(0)) = f(0) = 0$, the maximum is not attained at $\alpha = 0$. For $\alpha > 0$, we have

$$\frac{\mathrm{d}\Pi\left(\alpha\right)}{\mathrm{d}\alpha} = \left[p_1(1-\alpha) + p_0\alpha\right] f'(\ell(\alpha)) \frac{\partial \ell(\alpha)}{\partial \alpha} - \left(p_1 - p_0\right) f(\ell(\alpha)) - c'(\ell(\alpha)) \frac{\partial \ell(\alpha)}{\partial \alpha}.$$

[14] Although for this section, the analysis can be reduced to a single-person decision problem of the landlord, we maintain the game-theoretic approach throughout the paper, as it will be convenient to analyze the situation in Section 3.3, where the landlord faces potential competition in the product market. Throughout the paper, the solution concept we use is the notion of *subgame-perfect equilibrium* and denote it simply by *equilibrium*.

From the optimization condition of the tenant in (1), it follows that $p_0 \alpha f'(\ell(\alpha)) = c'(\ell(\alpha))$. Using this equality in the expression above, we get

$$\frac{\mathrm{d}\Pi(\alpha)}{\mathrm{d}\alpha} = p_1(1-\alpha) f'(\ell(\alpha)) \frac{\partial \ell(\alpha)}{\partial \alpha} - (p_1 - p_0) f(\ell(\alpha)). \tag{6}$$

Differentiating both sides of the equation $p_0 \alpha f'(\ell(\alpha)) = c'(\ell(\alpha))$ with respect to α, we have $\partial \ell(\alpha)/\partial \alpha = p_0 f'(\ell(\alpha))/ [c''(\ell(\alpha)) - p_0 \alpha f''(\ell(\alpha))] > 0$ for $\alpha > 0$, since $f' > 0$, $f'' < 0$ and $c'' \geq 0$. Since $f(\ell(0)) = 0$, we then conclude from (6) that

$$\lim_{\alpha \to 0+} \frac{\mathrm{d}\Pi(\alpha)}{\mathrm{d}\alpha} > 0 \text{ and } \frac{\mathrm{d}\Pi(\alpha)}{\mathrm{d}\alpha}(\alpha = 1) = -(p_1 - p_0) f(\ell(1)) < 0.$$

Thus $\Pi(\alpha)$ is increasing in α in the neighborhood of 0, while it is decreasing in α in the neighborhood of 1. This proves that any maximum of $\Pi(\alpha)$ is attained at α satisfying $0 < \alpha < 1$, which establishes the following proposition.

Proposition 1. *In any equilibrium of G, the landlord offers a sharecropping contract, i.e., $0 < \alpha < 1$ in any equilibrium.*

The intuition behind this result can be seen in particular clarity if we consider the payoff of the landlord in (5). The weight of the production function there is $\alpha p_0 + (1-\alpha)p_1$, a convex combination of the two levels of prices p_0 and p_1. This captures the trade-off faced by the landlord. On the one hand, the landlord has to provide the tenant with sufficient incentives, which can be achieved by a high share of output for the tenant (a high value of α), but on the other hand, if the landlord's own share is low, his gain from future high price is also low. This trade-off is settled by a sharecropping contract, where $0 < \alpha < 1$.[15]

To conclude this section, we observe that although the benchmark model rationalizes sharecropping, it is incomplete in two aspects. First, the model does not allow for arbitrage by the landlord (i.e., buying the tenant's share of output at low price and selling it at high price), although the landlord has potential gains from it. Second, it is implicitly assumed that the landlord can store *any* amount of output, while a more realistic scenario would be the one where he is constrained by some storage capacity. We take up these issues in the next section.

3 The model with interlinked contracts

In this section, we extend the benchmark model by incorporating the following. First, we assume that the landlord has a finite storage capacity $K > 0$.[16] Second, we allow the landlord to engage in arbitrage, i.e., the landlord can buy the tenant's share of output and sell it later at a higher price. This naturally gives rise to interlinked transactions, because now the

[15] For example, when $f(\ell) = \sqrt{\ell}$ and $c(\ell) = w\ell$, the unique equilibrium results in $\alpha = p_1/(2p_1 - p_0)$.

[16] It is reasonable to assume that the storage capacity is not too large, i.e., K is smaller than the *total* output produced in equilibrium, although this assumption will not be used in our main results (see, however, footnote 32). The assumptions on the production process and price variation introduced in the benchmark model are maintained throughout the paper.

landlord operates with the tenant in both land and product markets. As before, we restrict our attention to linear contracts. So formally, a typical contract offered by the landlord is now a triplet given by (α, β, ρ), where $\alpha \in [0,1]$ is the share of output of the tenant, $\beta \in \Re$ is the lump-sum cash transfer from the tenant to the landlord and $\rho > 0$ is the per-unit price at which the tenant can sell his share of output to the landlord if he decides to do so. Observe that the tenant will sell his output to the landlord only if $\rho \geq p_0$. On the other hand, an arbitrage is profitable for the landlord as long as $\rho \leq p_1$. So we can restrict $\rho \in [p_0, p_1]$.[17] The strategic interaction between the landlord and the tenant can be modeled as a three-stage game in extensive form, which we call G_1. In the first stage, the landlord offers a contract (α, β, ρ) to the tenant. In the second stage, the tenant either rejects the contract, in which case the game terminates with both parties getting their respective reservation payoffs, or he can accept the contract, in which case the game moves on to the third stage where the tenant decides on the amount of labor for carrying out the production and output is realized. If the output is Q, (i) the tenant keeps αQ and leaves the rest $(1-\alpha)Q$ with the landlord and (ii) he makes the lump-sum cash transfer β to the landlord. The tenant can sell his share of output αQ in season 0 at price p_0, or he can sell it to the landlord at price ρ, as specified in the contract. We employ the backward induction method to determine subgame-perfect equilibrium of the game G_1.

3.1 Equilibrium analysis of G_1

Observe that for $\rho \geq p_0$, in equilibrium, the tenant sells his share of output to the landlord at price ρ. So when the tenant operates under the contract (α, β, ρ), he chooses ℓ to maximize his payoff

$$\Phi(\ell) = \rho\alpha f(\ell) - c(\ell) - \beta.$$

Let us define the new variable $\theta := \rho\alpha$. Then θ is the *effective unit price* of the output for the tenant when he operates under the contract (α, β, ρ). It will be convenient to carry out the analysis in terms of θ. The payoff of the tenant can be written in terms of θ as follows.

$$\Phi(\ell) = \theta f(\ell) - c(\ell) - \beta.$$

Since $f'' < 0$ and $c'' \geq 0$, $\Phi(\ell)$ is strictly concave in ℓ for $\theta > 0$ and the unique optimal solution, $\ell(\theta)$, is determined from the first-order condition, given by

$$\theta f'(\ell) = c'(\ell). \tag{7}$$

Obviously, $\ell(0) = 0$. So the payoff of the tenant when he optimally chooses the amount of labor is given by

$$\Phi\left(\ell(\theta)\right) = \theta f\left(\ell(\theta)\right) - c(\ell(\theta)) - \beta.$$

[17] Note that for any α, β: (i) an interlinked contract (α, β, ρ), where $\rho < p_0$, is equivalent to the non-interlinked contract (α, β), since the tenant will not sell his share of output to the landlord if $\rho < p_0$ and (ii) for the landlord, the interlinked contract (α, β, p_0) is at least as good as the non-interlinked contract (α, β). So it is sufficient to consider interlinked contracts (α, β, ρ) where $\rho \geq p_0$. Our results will not change if we allow for $\rho > p_1$. The only technical requirement is that ρ has to lie in a closed interval.

Denoting by $\widetilde{\Phi}$ the reservation payoff of the tenant, he will accept a contract (α, β, ρ) only if $\Phi(\ell(\theta)) \geq \widetilde{\Phi}$, i.e.,

$$\beta \leq \theta f(\ell(\theta)) - c(\ell(\theta)) - \widetilde{\Phi}. \tag{8}$$

Now consider the landlord. We first state the following lemma, which will be used to determine the payoff of the landlord.

Lemma 1. *Suppose the storage capacity of the landlord is K. Let $R(Q_L)$ denote the revenue of the landlord when he has output Q_L at his disposal. Then $R(Q_L) = p_0 Q_L + (p_1 - p_0)K$.*

Proof. See the Appendix. ■

Observe that the payoff of the landlord has the following components.

(a) The landlord has his share of output $(1-\alpha)f(\ell(\theta))$. Moreover, the tenant sells his share $\alpha f(\ell(\theta))$ to the landlord. So the total output at the disposal of the landlord is $f(\ell(\theta))$. From Lemma 1, taking $Q_L = f(\ell(\theta))$, we conclude that the revenue of the landlord from this output is

$$R(f(\ell(\theta))) = p_0 f(\ell(\theta)) + (p_1 - p_0)K. \tag{9}$$

(b) The tenant sells his share of output $\alpha f(\ell(\theta))$ to the landlord at price ρ. So the landlord pays $\rho\alpha f(\ell(\theta)) = \theta f(\ell(\theta))$ to the tenant.

(c) The landlord gets the fixed payment β from the tenant. In equilibrium, the landlord chooses β so that the participation constraint of the tenant in (8) binds. So β is completely determined by θ, given by

$$\beta(\theta) = \theta f(\ell(\theta)) - c(\ell(\theta)) - \widetilde{\Phi}. \tag{10}$$

From (a), (b) and (c), the payoff of the landlord is given by

$$\Pi(\alpha, \rho) = R(f(\ell(\theta))) - \theta f(\ell(\theta)) + \beta(\theta).$$

Then from (9) and (10), we conclude that

$$\Pi(\alpha, \rho) = [p_0 f(\ell(\theta)) + (p_1 - p_0)K] - \theta f(\ell(\theta)) + \left[\theta f(\ell(\theta)) - c(\ell(\theta)) - \widetilde{\Phi}\right]. \tag{11}$$

From (11), it follows that the payoff of the landlord is completely determined by the variable θ and it is given by

$$\Pi(\theta) = p_0 f(\ell(\theta)) - c(\ell(\theta)) + (p_1 - p_0)K - \widetilde{\Phi}. \tag{12}$$

So the landlord's problem reduces to choosing θ to maximize $\Pi(\theta)$. Since $\alpha \in [0,1]$, $\rho \in [p_0, p_1]$ and $\theta = \rho\alpha$, hence $\theta \in [0, p_1]$. As $\Pi(\theta)$ is bounded for $\theta \in [0, p_1]$, the maximum of this function exists in this interval. Since $\ell(0) = 0$, the maximum is not attained at $\theta = 0$. For $\theta > 0$, we have the following from (12), where the second equality follows from the tenant's optimization condition in (7) by noting that $\theta f'(\ell(\theta)) = c'(\ell(\theta))$.

$$\frac{\mathrm{d}\Pi(\theta)}{\mathrm{d}\theta} = p_0 f'(\ell(\theta))\frac{\partial \ell(\theta)}{\partial \theta} - c'(\ell(\theta))\frac{\partial \ell(\theta)}{\partial \theta} = f'(\ell(\theta))(p_0 - \theta)\frac{\partial \ell(\theta)}{\partial \theta}. \tag{13}$$

Differentiating both sides of the equation $\theta f'(\ell(\theta)) = c'(\ell(\theta))$ with respect to θ, we have $\partial\ell(\theta)/\partial\theta = f'(\ell(\theta))/\left[c''(\ell(\theta)) - \theta f''(\ell(\theta))\right] > 0$ for $\theta > 0$, since $f' > 0$, $f'' < 0$ and $c'' \geq 0$. Then from (13), it follows that

$$\frac{\mathrm{d}\Pi\left(\theta\right)}{\mathrm{d}\theta} \geq 0 \Leftrightarrow \theta \leq p_0 \text{ with equality iff } \theta = p_0.$$

So the maximum of $\Pi\left(\theta\right)$ is attained at $\theta = p_0$. Since $\theta = \rho\alpha$, we then conclude the following.

Proposition 2. *The game G_1 has multiple equilibria. Any (α, β, ρ) is an equilibrium where $\rho \in [p_0, p_1]$, $\rho\alpha = p_0$ and β is chosen so that the participation constraint of the tenant binds. In any equilibrium, the tenant sells his share of output to the landlord.*

The underlying intuition behind Proposition 2 is simple. Since the tenant sells his share of output to the landlord, the latter has the full output at his disposal. In that case, he does not particularly care about the respective shares and his only consideration is providing optimal incentive to the tenant. Since the effective unit price of the output for the tenant is $\theta = \rho\alpha$ and optimal incentive demands $\theta = p_0$, multiple utility-equivalent combinations of α and ρ can serve the purpose. From the condition $\rho\alpha = p_0$, note that (i) $\alpha = 1$ when $\rho = p_0$ and (ii) $0 < \alpha < 1$ when $\rho > p_0$. So both fixed rental $(\alpha = 1)$ and sharecropping $(0 < \alpha < 1)$ contracts can be sustained in equilibrium. Since for a fixed rental contract, the price at which the landlord buys the tenant's share of output is not different from the market price (i.e., $\rho = p_0$), in actual sense, there is no interlinkage.[18] Thus, interlinkage is necessarily accompanied by a sharecropping contract. Also observe that when the landlord buys the tenant's share of output (say αQ) at a price $\rho > p_0$, in effect, he provides a total subsidy of $(\rho - p_0)\alpha Q$ to the tenant. This is equivalent to a cost-sharing arrangement and could be particularly useful when costs are not observable (see, e.g., Bardhan & Singh, 1987). Hence the conclusion of Proposition 2 that ρ exceeds p_0 for a sharecropping contract is consistent with the empirically observed fact that sharecropping contracts are often accompanied by some form of cost-sharing (see, e.g., Rudra & Bardhan, 1983; Bardhan, 1984).

3.2 Motivation for a refinement criterion: some features of rural product markets

Now the question is, how to resolve the multiplicity of equilibria? Observe that in our analysis so far, it has been implicitly assumed that in his interaction with the tenant, the landlord acts as a monopolist in both land and product markets. While the landlord can exercise monopoly power over the land he owns, there is considerable empirical evidence (e.g., Subbarao, 1978; Rudra, 1982) that suggests that this is not necessarily the case in the rural product market, which closely resembles what one might call a case of *imperfect competition*, somewhat in the line suggested by Stiglitz (1989, p. 25):

[18] As Gangopadhyay (1994, p. 130) points out, "...[H]ow do we identify interlinkage? Consider two markets dealing in two commodities A and B...Suppose there are some agents who are common to both markets. If it is observed that (even one of) such common agents transact at prices *different* from those operating in one of the markets only, we will say that there is interlinking of markets by the common agent(s)." (emphasis added)

> "There is competition; inequality of wealth itself does not imply that landlords can exercise their power unbridled. On the other hand, markets in which there are a large number of participants...need not be highly competitive...transaction costs and, in particular, information costs imply that some markets are far better described by models of imperfect competition than perfect competition."

We resolve the multiplicity of equilibria by proposing a refinement that takes into consideration the fact that the landlord might face potential competition in the product market. Then we show that the unique equilibrium that is robust to this refinement criterion results in a sharecropping contract. Before entering into a formal analysis, it would be helpful to examine in some detail the nature of rural product markets from Rudra (1982, pp. 44-45):[19]

> "...Our investigations in more than 200 villages in West Bengal and Bihar indicate the following ranking among different categories of traders in terms of prices paid by them as purchasers of grains.
>
> 1. village retail shops.
> 2. big farmers acting as traders.
> 3. village wholesalers.
> 4. travelling traders (or itinerant merchants) and other village level traders.
> 5. *hats* (that is, non-permanent markets centres functioning on a number of days per month or per week), market wholesalers, and rice mills.
>
> The lowest prices are paid by the village retail shops and the highest prices are paid by the rice mills, market wholesalers, and *hats*."

In what follows, we would posit a situation that is broadly reflective of the essential findings of Rudra (1982).[20] Consider a small farmer who works as a tenant for a landlord. Out of the marketing channels given above, the price is the highest at *hats* (category 5), which serve as the dominant outlet for the landlord. Due to transportation and other costs, the tenant-farmer does not have access to this channel. If no intermediate channel is available, the tenant has to sell his product in village retail shops (category 1) that pay the lowest price.[21]

[19] For the sake of concreteness, we motivate our theoretical analysis by using the findings of Chapter 3 of Rudra (1982), based on a survey conducted in a sample of villages of two states of India: West Bengal and Bihar. This survey brings out two features of rural product markets: (i) existence of multiple trading channels and (ii) price variation among different channels. It should be emphasized that although the specifics might vary, these basic features can be widely observed in other states of India as well as many other countries. For example, see Subbarao (1978) for similar evidence from the state of Andhra Pradesh, and Poduval and Sen (1958) for an overview of agricultural markets in different parts of India.

[20] We present a simplified situation that captures the imperfectly competitive nature of a rural product market. An actual product market in villages is of course more complex. See Chapter 3 and especially Tables 1-7 (pp. 52-61) of Rudra (1982) for more details.

[21] With respect to our model, one can interpret p_0 as the average price paid by the village retail shops in season 0 and p_1 as the average price prevailing in *hats* in season 1. It is interesting to observe here that even in the absence of seasonal variation, our analysis will go through entirely on the basis of spatial variation with the following interpretation: p_0 is the price paid in village shops in season 0, p_1 is the price paid in *hats* also in season 0 and K is the maximum amount that can be transported by the landlord from the village to the *hats*. The presence of seasonal variation of course strengthens our argument.

Now suppose that the landlord offers to buy the tenant's output. As a buyer, the landlord belongs to category 2 above and pays a price no lower than that paid by the retail shops. It is crucial to observe here that in trading with the tenant, the landlord does not enjoy complete monopoly power. There are a host of other agents (belonging to categories 3 and 4), who might find it profitable to trade with the tenant and offer him a better price.[22] Now suppose that such an agent appears with some small but positive probability. Then the question is, out of all contracts obtained in Proposition 2, what are the ones that the landlord will choose once he anticipates such a possibility? Put differently, out of the multiple equilibria, what are the ones that are robust to the possibility of competition in the product market? We show that there is a unique equilibrium that satisfies this refinement criterion and it results in a sharecropping contract. Let us now present the formal analysis in the next section.

3.3 The perturbed game $G_1(\varepsilon)$

The possibility of competition in the product market is modeled by the perturbed game $G_1(\varepsilon)$. The game $G_1(\varepsilon)$ is a game in extensive form that has four stages. In the first stage, the landlord offers a contract (α, β, ρ) to the tenant. In the second stage, the tenant either rejects the contract, in which case the game terminates with both parties getting their respective reservation payoffs, or he can accept the contract, in which case the game moves on to the third stage where the tenant carries out production and output is realized. If the output is Q, (i) the tenant keeps αQ and leaves the rest $(1-\alpha)Q$ with the landlord and (ii) makes the lump-sum cash transfer β to the landlord. At the end of this stage, a third agent, who we call *the ε-agent*,[23] emerges with probability $\varepsilon > 0$. The ε-agent, knowing the contract offered by the landlord, decides whether or not to buy the tenant's share of output αQ and what price $\tilde{\rho} > 0$ to offer. In the fourth and final stage, the tenant decides whether to sell his share of output to the landlord at price ρ or to the ε-agent at price $\tilde{\rho}$. At the end, payoffs are realized and the game terminates. As before, we employ the backward induction method to find subgame-perfect equilibrium of the game $G_1(\varepsilon)$. We can now formally describe our refinement criterion.

Definition: An equilibrium $(\alpha^*, \beta^*, \rho^*)$ of the game G_1 is *robust to the emergence of the ε-agent* if there is a sequence $\{(\alpha(\varepsilon), \beta(\varepsilon), \rho(\varepsilon))\}$ such that the following hold. (1) For every $\varepsilon > 0$, $(\alpha(\varepsilon), \beta(\varepsilon), \rho(\varepsilon))$ is an equilibrium of the game $G_1(\varepsilon)$ and (2) $(\alpha(\varepsilon), \beta(\varepsilon), \rho(\varepsilon)) \rightarrow (\alpha^*, \beta^*, \rho^*)$ as $\varepsilon \rightarrow 0+$.

In what follows, it will be shown that there is a unique equilibrium $(\alpha^*, \beta^*, \rho^*)$ of the

[22] One could perceive of several reasons behind this. For example, (i) a trader who is a seller at *hats*, could find it worthwhile to buy the tenant's output at higher price if buying in bulks from retail shops turns out to be difficult after a certain extent, or (ii) for an agent who is a *travelling trader*, cost of transportation is likely to be a major concern and he won't mind paying a higher price if he can collect a large amount of the produce from the same locality. Observe here that these potential buyers are obviously not homogenous, so the price at which it is profitable to trade with the tenant will also vary from agent to agent. This heterogeneity is modeled by considering the *valuation* of a potential buyer as a random variable in Section 3.3.1.

[23] We use the abstract term *ε-agent* to keep the identity of this agent non-specific. The ε-agent is someone who finds it profitable to trade with the tenant. For example, he could be a wholesaler, a small trader or a travelling trader (see footnote 22).

game G_1 that is robust to the emergence of the ε-agent, where $0 < \alpha^* < 1$.

3.3.1 Equilibrium analysis of $G_1(\varepsilon)$

The valuation of the ε-agent: The *valuation* of the ε-agent, denoted by v, is the maximum price that makes it profitable for him to trade with the tenant. Observe that this valuation will depend on who actually emerges as the ε-agent (for example, the maximum price that a wholesaler is willing to pay will potentially differ from what a trader is willing to pay; see footnote 22). So the valuation v of the ε-agent is not a constant, rather it is a random variable drawn from a distribution. We assume that v is uniformly distributed in the interval $[p_0, p_1]$.[24] Observe that any $v \in [p_0, p_1]$ can be written as $v = p_0 + c$. One can interpret c as the unit opportunity cost of the ε-agent, i.e., c is the unit cost of transaction that the ε-agent has to incur when he does not buy the output from the tenant, but uses the alternative trading channel available to him.[25]

Let us now determine the subgame-perfect equilibrium of the game $G_1(\varepsilon)$ by backward induction. Suppose the landlord has offered the contract (α, β, ρ) and the ε-agent of valuation v has emerged after production has been carried out. Let $\tilde{\rho}$ denote the price offered by the ε-agent to the tenant. Observe that (i) since v is the maximum price that makes it profitable for the ε-agent to trade with the tenant, clearly the ε-agent will not offer a price $\tilde{\rho} > v$ and (ii) since the tenant can sell his output to the landlord at a price ρ, he will not trade with the ε-agent if $\tilde{\rho} < \rho$. Then we conclude that when the landlord offers the contract (α, β, ρ), a necessary condition of a trade between the tenant and the ε-agent is $v \geq \rho$. Since v has a continuous distribution over the interval $[p_0, p_1]$, $\Pr(v \geq p_1) = 0$, so there can be no trade between the tenant and the ε-agent when $\rho = p_1$. Let us then consider $\rho < p_1$ and suppose that the ε-agent of valuation v has emerged, where $v \geq \rho$. Observe that if the ε-agent offers a price $\tilde{\rho} < \rho$, the tenant will trade with the landlord. We cannot have $\tilde{\rho} < \rho$ in equilibrium, because the ε-agent can improve his payoff by setting his price marginally above ρ that will induce the tenant to trade with him. Next observe that if $\tilde{\rho} > \rho$, the tenant will trade with the ε-agent. However, any $\tilde{\rho} > \rho$ also cannot be an equilibrium, as the ε-agent can improve his payoff by reducing $\tilde{\rho}$ marginally. When $\tilde{\rho} = \rho$, the tenant is indifferent between trading with the landlord and the ε-agent, but in equilibrium, he will trade with the latter. Trading with the landlord in case $\tilde{\rho} = \rho$ cannot be sustained as an equilibrium, because in that case, the ε-agent can improve his payoff by raising his price $\tilde{\rho}$ marginally above ρ to induce the tenant to trade with him. So we conclude that if the ε-agent emerges and $v \geq \rho$, in the unique equilibrium, he offers the price $\tilde{\rho} = \rho$ and the tenant trades with him. We then have

[24] Viewing p_0 as the minimum price (e.g., average price paid by the village retail shops in season 0) and p_1 as the maximum price (e.g., average price prevailing in *hats* in season 1), the interval $[p_0, p_1]$ seems a reasonable support for v. The assumption of uniform distribution has been made for clarity of presentation and our conclusions will continue to hold qualitatively for a broad class of distributions.

[25] For example, if the ε-agent is a travelling trader and his alternative trading channel involves a transportation cost of c for every unit that he buys, he would be willing to pay a price of at most $p_0 + c$ to the tenant and consequently his valuation would be $v = p_0 + c$. It has been implicitly assumed that the valuation of the landlord is $v_L = p_0$ (i.e., the landlord has zero transaction cost). Our results will continue to hold meaningfully even if the landlord has some positive transaction cost (so that his valuation is $v_L = p_0' > p_0$) as long as the interval $[p_0', p_1]$ is not too small, i.e., p_0' is not too close to p_1, which seems reasonable.

the following lemma.

Lemma 2. *In any equilibrium of the game $G_1(\varepsilon)$, the following holds when the landlord offers the contract (α, β, ρ). If the ε-agent of valuation v emerges and $v \geq \rho$, he offers the price $\tilde{\rho} = \rho$ and the tenant sells his share of output to the ε-agent. Otherwise, the tenant sells his share of output to the landlord.*

Lemma 2 shows that whenever the landlord offers the contract (α, β, ρ), the tenant gets the price ρ for his share of output in equilibrium, regardless of whether he trades with the landlord or the ε-agent. This implies that for the perturbed game $G_1(\varepsilon)$, the tenant's problem remains the same as in the game G_1 in Section 3.1 (page 12). As before, in equilibrium, the landlord will choose the fixed payment β so that the participation constraint of the tenant binds. So β is completely determined by $\theta = \rho\alpha$ and it is given by the following.[26]

$$\beta(\theta) = \theta f\left(\ell(\theta)\right) - c(\ell(\theta)) - \widetilde{\Phi}. \tag{14}$$

Now observe that when the landlord offers the contract (α, β, ρ), the tenant trades with the ε-agent provided *both* of the following hold: (1) the ε-agent emerges, which occurs with probability ε and (2) he has a valuation of $v \geq \rho$. Since v is uniformly distributed in $[p_0, p_1]$, we have $\Pr(v \geq \rho) = (p_1 - \rho)/(p_1 - p_0)$. Let us denote

$$\tau(\varepsilon, \rho) := \varepsilon \Pr(v \geq \rho) = \varepsilon(p_1 - \rho)/(p_1 - p_0). \tag{15}$$

Then we conclude that the tenant trades with the ε-agent with probability $\tau(\varepsilon, \rho)$ and with the landlord with probability $[1 - \tau(\varepsilon, \rho)]$. Let (i) Π_0 denote the landlord's payoff when the tenant trades with the ε-agent and (ii) Π_1 denote the payoff when the tenant trades with the landlord. Then the expected payoff of the landlord is given by

$$\Pi^{\varepsilon}(\alpha, \rho) = \tau(\varepsilon, \rho)\Pi_0 + \left[1 - \tau(\varepsilon, \rho)\right]\Pi_1. \tag{16}$$

When the tenant trades with the landlord, the landlord's payoff is the same as in the game G_1 in Section 3.1 and from equation (12) (page 13), it is given by

$$\Pi_1 = \Pi(\theta) = p_0 f(\ell(\theta)) - c(\ell(\theta)) + (p_1 - p_0)K - \widetilde{\Phi}. \tag{17}$$

Now consider the event where the tenant sells his share of output to the ε-agent. Then the payoff of the landlord has following components.

(a) The landlord has only his share of output $(1-\alpha)f(\ell(\theta))$ at his disposal. Taking $Q_L = (1-\alpha)f(\ell(\theta))$ in Lemma 1 (page 12), the revenue of the landlord from this output is

$$R\left((1-\alpha)f(\ell(\theta))\right) = p_0(1-\alpha)f(\ell(\theta)) + (p_1 - p_0)K.$$

Noting that $\theta = \rho\alpha$, the expression above can be written as

$$R\left((1-\alpha)f(\ell(\theta))\right) = p_0 f(\ell(\theta)) + \theta(1 - p_0/\rho)f(\ell(\theta)) - \theta f(\ell(\theta)) + (p_1 - p_0)K. \tag{18}$$

[26] Recall that $\ell(\theta)$ denotes the optimal amount of labor chosen by the tenant as a function of θ and $\widetilde{\Phi}$ is the reservation payoff of the tenant.

(b) The landlord gets the fixed payment β from the tenant and from (14), it is given by the following.

$$\beta(\theta) = \theta f\left(\ell(\theta)\right) - c(\ell(\theta)) - \widetilde{\Phi}. \tag{19}$$

From (a) and (b), the payoff of the landlord when the tenant trades with the ε-agent is $\Pi_0 = R\left((1-\alpha)f(\ell(\theta))\right) + \beta(\theta)$. Then from (18) and (19), we have

$$\Pi_0 = \left[p_0 f(\ell(\theta)) - c(\ell(\theta)) + (p_1 - p_0)K - \widetilde{\Phi}\right] + \theta(1 - p_0/\rho)f(\ell(\theta)). \tag{20}$$

From (17) and (20), we conclude that $\Pi_0 = \Pi(\theta) + \theta(1-p_0/\rho)f(\ell(\theta))$. Then from (16) and (17), we can write the expected payoff of the landlord as a function of θ and ρ as follows.

$$\Pi^{\varepsilon}(\theta, \rho) = \Pi(\theta) + \tau(\varepsilon, \rho)\theta(1 - p_0/\rho)f(\ell(\theta)). \tag{21}$$

Recall from (15) that $\tau(\varepsilon, \rho) = \varepsilon(p_1 - \rho)/(p_1 - p_0)$. Let us denote

$$h(\rho) := (p_1 - \rho)(1 - p_0/\rho)/(p_1 - p_0). \tag{22}$$

Then from (21), we have

$$\Pi^{\varepsilon}(\theta, \rho) = \Pi(\theta) + \varepsilon h(\rho)\theta f(\ell(\theta)). \tag{23}$$

So the problem of the landlord now reduces to choosing θ and ρ (since $\theta = \rho\alpha$, this is equivalent to choosing α and ρ) to maximize the payoff given above. First observe from (23) that that for any θ, the optimal value of ρ is the one that maximizes $h(\rho)$. From (22), it follows that $h'(\rho) = (p_0p_1 - \rho^2)/\rho^2(p_1 - p_0)$ and $h''(\rho) = -2p_0p_1/\rho^3(p_1 - p_0)$. So we conclude that for $\rho \in [p_0, p_1]$, the unique maximum of $h(\rho)$ is attained at $\rho = \sqrt{p_0p_1} \equiv \rho^*$.[27] Since $\theta = \rho\alpha$ and $\alpha \in [0, 1]$, from (23), the problem of the landlord now reduces to choosing $\theta \in [0, \rho^*]$ to maximize

$$\Pi^{\varepsilon}(\theta, \rho^*) = \Pi(\theta) + \varepsilon h(\rho^*)\theta f(\ell(\theta)). \tag{24}$$

From our discussion so far, we then conclude the following.

Lemma 3. *For $\varepsilon > 0$, $(\alpha(\varepsilon), \beta(\varepsilon), \rho(\varepsilon))$ is an equilibrium of the game $G_1(\varepsilon)$ if and only if all three of the following conditions hold:* (1) $\rho(\varepsilon) = \rho^* = \sqrt{p_0p_1}$, (2) $\alpha(\varepsilon) = \theta(\varepsilon)/\rho^*$ *for some $\theta(\varepsilon)$ such that for $\theta \in [0, \rho^*]$, the function $\Pi^{\varepsilon}(\theta, \rho^*)$ is maximized at $\theta = \theta(\varepsilon)$ and* (3) *$\beta(\varepsilon)$ is determined by $\alpha(\varepsilon)$ and $\rho(\varepsilon)$ so that the participation constraint of the tenant binds when he acts optimally under the contract $(\alpha(\varepsilon), \beta(\varepsilon), \rho(\varepsilon))$.*

Now observe from (24) that when $\varepsilon = 0$, $\Pi^{\varepsilon}(\theta, \rho^*) = \Pi(\theta)$. For $\varepsilon = 0$, we have the same problem as in the game G_1 in Section 3.1 and it has been shown there (page 14) that the unique maximum of $\Pi(\theta)$ is attained at $\theta = p_0$. The following lemma follows from this fact by using certain standard continuity arguments.

[27] Observe that ρ^* is completely determined by the function $h(.)$, which depends only on the distribution of v. In particular, ρ^* does not depend on either the production function $f(.)$ or the cost function $c(.)$.

Lemma 4. *Consider any sequence* $\{\theta(\varepsilon)\}$ *such that for* $\theta \in [0, \rho^*]$, *the function* $\Pi^{\varepsilon}(\theta, \rho^*)$ *is maximized at* $\theta = \theta(\varepsilon)$ *for* $\varepsilon > 0$. *For any such sequence,* $\theta(\varepsilon) \to p_0$ *as* $\varepsilon \to 0+$.

Proof. See the Appendix. ■

Let us now consider any sequence $\{(\alpha(\varepsilon), \beta(\varepsilon), \rho(\varepsilon))\}$ such that $(\alpha(\varepsilon), \beta(\varepsilon), \rho(\varepsilon))$ is an equilibrium of the game $G_1(\varepsilon)$ for every $\varepsilon > 0$. Then from Lemmas 3 and 4, by continuity arguments, it follows that (1) for every $\varepsilon > 0$, $\rho(\varepsilon) = \rho^* \equiv \sqrt{p_0 p_1}$, (2) $\alpha(\varepsilon) \to \alpha^* \equiv p_0/\rho^* = \sqrt{p_0/p_1}$ as $\varepsilon \to 0+$ and (3) $\beta(\varepsilon) \to \beta^*$ as $\varepsilon \to 0+$, where β^* is determined from α^* and ρ^* so that the participation constraint of the tenant binds when he acts optimally under the contract $(\alpha^*, \beta^*, \rho^*)$. This establishes the following proposition.

Proposition 3. *There exists a unique equilibrium* $(\alpha^*, \beta^*, \rho^*)$ *of the game* G_1 *that is robust to emergence of the* ε*-agent, where the landlord offers a sharecropping contract, i.e.,* $0 < \alpha^* < 1$. *Specifically,* $\alpha^* = \sqrt{p_0/p_1}$, $\rho^* = \sqrt{p_0 p_1}$ *and* β^* *is determined so that the participation constraint of the tenant binds.*

Proposition 3 shows that the unique equilibrium that is robust to the emergence of the ε-agent results in (i) sharecropping $(0 < \alpha^* < 1)$ and (ii) interlinkage $(p_0 < \rho^* < p_1)$. To see the intuition behind this result, first observe that to take advantage of the seasonal variation of price, the landlord needs to have some output at his disposal. He can of course buy some output right after the harvest and sell it later at higher price. However, his profit is higher if he has his own share of output, as he pays nothing for this share. In the absence of any competition in the product market, the tenant sells his share of output to the landlord. Then the landlord has the *total* produced output at his disposal and in that case, he does not particularly care about his own share. However, under the possibility of competition in the product market, a fixed rental contract $(\alpha = 1)$ has an obvious drawback: such a contract leaves the entire output with the tenant, so in the event the tenant trades with a third party, the landlord is left with no output of his own. Once the landlord anticipates this, naturally he would like to keep his share of output $(1 - \alpha)$ as high as possible. Recall that the tenant's incentive depends on $\theta = \rho\alpha$, so provision of incentives demands that the landlord's gain from a higher value of his own share of output (low α) has to be accompanied by a loss from a higher price at which he buys the tenant's share of output (high ρ). This is where potential competition actually turns out be advantageous for the landlord, as in the event some third agent finds it profitable to trade with the tenant, the landlord can have the gain from a higher share (low α) without incurring the loss of paying a higher price to the tenant. But then is it optimal for the landlord to keep his share very high (i.e., $1 - \alpha$ close to one or α close to zero)? The answer is no, because to provide sufficient incentives to the tenant, a very small value of α has to compensated by a very large value of ρ. However, as ρ (the price offered by the landlord) becomes larger, it becomes less likely that a third agent will be able to offer the tenant a better price. So the landlord's gain from competition will be denied if ρ is very high. Consequently, the optimal value of the share cannot be too large or too small, i.e., it will be positive, but less than one $(0 < \alpha^* < 1)$, while the optimal value of ρ will be settled somewhere between the minimum and maximum levels of prices $(p_0 < \rho^* < p_1)$. Thus the equilibrium robust to the possibility of competition results in the landlord offering a contract that involves both sharecropping and interlinkage. The rather precise values ($\alpha^* = \sqrt{p_0/p_1}$,

$\rho^* = \sqrt{p_0 p_1}$) in Proposition 3 of course depend on the assumption of uniform distribution, but the basic intuition that we have described will continue to hold under more general settings.

4 Concluding remarks

In conclusion, we discuss the broad implications of our theory as follows.

(1) The equilibrium share in our model is completely determined by the extent of seasonal variation of price and the nature of the rural product market under question.[28] It is reasonable to expect that in a particular region, the characteristics of product markets (e.g., the number of retail shops, presence of various levels of traders, distance to the wholesale market) and the extent of price variation will be similar. Therefore, to a certain extent, our theory can explain the well-observed empirical fact (see, e.g., Rudra, 1982; Rudra & Bardhan, 1983) that for sharecropping contracts in a specific region, the stipulated share stays more or less uniform across plots. Moreover, our theory suggests that if the extent of price variation becomes more or less stable and there is no intervention (e.g., by the government) in the product markets for a long period of time, the share is likely to stabilize around certain specific values.

(2) Since the characteristics of agricultural markets and seasonal variation of price can be observed and suitably quantified, our theory can be tested empirically. So from an empirical point of view, the theory we propose is immune from the criticism that has been sometimes leveled against the risk-sharing theory of sharecropping.[29] In particular, our theory can provide a possible explanation of the dominance of sharecropping contracts in certain cases where the empirical support for the risk-sharing theory is inconclusive (e.g., Rao, 1971; Shaban, 1987). For example, in his study of West Godavari district of the state of Andhra Pradesh in India, Rao (1971, pp. 584-585) finds that:

> "...[W]ithin the same district, share-lease and cash-lease arrangements coexist, the latter being negligible in the rice zone and predominant in the tobacco zone...Also, the rice crop, for which the share-lease system is extensive, is a major marketed or cash-crop of the region, so that the share-lease system cannot readily be explained in terms of the subsistence nature of the crop."

A general prediction of our theory is that sharecropping contracts are more likely to be seen for crops that show a higher degree of price fluctuation. Since foodgrains like rice are more likely to exhibit seasonal fluctuations of price compared to non-food crops like tobacco, the empirical findings of Rao described above are consistent with our prediction.

[28] From Proposition 3, the equilibrium share is given by $\alpha^* = p_0/\rho^*$, where ρ^* is completely determined by the distribution of the valuation v of the ε-agent (see footnote 27). So α^* is completely determined by the minimum price (p_0) and the distribution of v. In particular, α^* does not depend on either the production function $f(.)$ or the cost function $c(.)$.

[29] For example, Allen and Lueck (1995, p. 448) state: "...[P]redictions from risk-sharing models are difficult, if not impossible to test with existing data. Since individual risk preferences are not measurable, the predictions using preference parameters are *never* testable." (emphasis in the original)

(3) Our theory contributes to the issue of technological stagnation, which is a serious problem in less developed agrarian economies:

> "...[T]he really important problem of traditional agriculture is to explain why some of the critical resources (for example land in efficiency units) remain given, and the fact that the way production is organized does not generate economic forces and incentives to augment them through productive investment over time." (Bhaduri, 1999, p. 89)

Several theories have been put forward to explain technological stagnation in agriculture,[30] but as Basu (1989, p. 254) has pointed out:

> "A more complete theory of stagnation has to explain *simultaneously* why it will not be worthwhile for *any* agent (that is, the landlord *or* the tenant) to innovate." (emphases in the original)

Basu (1989) (see also Naqvi, 1989) has provided such a theory based on adverse selection. Our model provides an alternative explanation of technological stagnation by identifying situations where neither the landlord, nor the tenant has any incentive to engage in productive investments. In what follows, we shall describe the basic argument without getting into a formal analysis. First consider the tenant. There are two reasons why the tenant might not invest: (i) it is costly for him and (ii) as in Basu (1989), he might quit the land in future for better opportunities elsewhere, so he will not reap the benefits of an investment. Now consider the landlord. From (12), denoting by ℓ^* the equilibrium amount of labor, the payoff of the landlord in our model is given by

$$\Pi = [p_0 f(\ell^*) - c(\ell^*)] + (p_1 - p_0)K - \widetilde{\Phi}. \tag{25}$$

Assuming that the cost function $c(.)$ and reservation payoff $\widetilde{\Phi}$ of the tenant are given, the landlord can increase his payoff in the following alternative ways: (1) by investing in the land (e.g., soil improvement, irrigation) which can be viewed as a shift of the production function from $f(.)$ to $\lambda f(.)$ for $\lambda > 1$; this in turn will lead to an increase in the equilibrium amount of labor and raise the net surplus $[p_0 f(\ell^*) - c(\ell^*)]$, or (2) by investing in the storage capacity (e.g., building a larger warehouse, buying a better cart for carrying the produce to the town market), which is equivalent to increasing K to λK for $\lambda > 1$. Following Bhaduri (1981), we can say that the first type of investment is *productive*, while the second type is *unproductive*. Observe that compared to the first type, the gains of the landlord from the second type of investment are more immediate and less uncertain. Comparing the marginal gains of these investments, one can then identify situations where the landlord has no incentive to carry out productive investment. While we approach the problem from a different point of view, in spirit, this rationale behind stagnation is the same as in Bhaduri (1973, 1981, 1999).[31]

[30] E.g., Johnson (1950), Bhaduri (1973), Basu (1989), Naqvi (1989). See Singh (1994) for an excellent survey of the literature.

[31] That is, the income of the landlord has two components. In Bhaduri (1973), two sources of this income are (i) land and (ii) usury, while in our model, they are (i) land and (ii) hoarding. Thus, one source of the income can be strengthened by productive investment in land. However, such an investment either weakens the other source (usury in Bhaduri's model) or an alternative unproductive investment in the other source yields higher gains. In both cases, we have a situation where the landlord does not find it optimal to engage in productive investment.

(4) Our theory also sheds some light on the question of *power* in a rural context and complements the analysis of Basu (1986) on triadic interactions (see also Naqvi $\&$ Wemhöner, 1995 and the references therein). To see the main idea of Basu, consider the following triadic interaction, involving a landlord, a laborer hired by the landlord and a village merchant:

> "...[S]uppose when the labourer quits the landlord's job, he tells the labourer he will never again employ the labourer and he tells the village merchant that he will not buy merchandise from his shop if the merchant sells goods to this labourer."(Basu, 1994b, p. 12)

In the situation described above, the landlord is *powerful*, as he can credibly use the threat of not trading with the merchant to compel the merchant to not trade with the laborer. This in turn makes quitting the landlord's job costlier for the laborer and he might continue to work for the landlord under less acceptable terms. In our model, we also have a situation of triadic interaction involving three similar agents: the landlord, the tenant and the ε-agent. As we have argued before, in this case, the landlord would want the ε-agent to trade with the tenant as that enables him to keep a higher share of output for himself without incurring the loss of buying the tenant's output at higher price. We have seen that the landlord determines the terms of the contract to achieve this (in expected terms). This presents an interesting dual to Basu's analysis and shows that power can manifest itself in different ways: the landlord who can use a credible threat to ensure that the third party does not trade with the second party can also design a contract to generate a completely different outcome where the third party actually trades with the second party. In both cases, the power of the landlord originates from the fact that he controls the basic source of the second party's income: land. It is therefore not surprising that in villages, land is considered a valued asset and a landowner often wields more influence than a trader.

To conclude, in this paper we have shown that price variation and imperfectly competitive nature of rural product markets can help us to have a better understanding of tenurial contracts as well as several other important issues of agrarian economies. Given that landowners have advantage in both land and product markets, an important question is: what should be the role of the government in this regard? The government can intervene in the product market (e.g., through existing policies like minimum-support price) or in the land market (e.g., through tenancy reforms, as carried out in the state of West Bengal in India, see Banerjee et al., 2002). Do these interventions complement each other? In particular, will a price policy be effective without a corresponding policy in tenancy reforms? These questions are left for future research.

Appendix

Proof of Lemma 1. We consider two possible cases. First, when $Q_L \geq K$, the landlord can store the amount K in season 0 and sell it in season 1 at price p_1, thus earning a revenue of $p_1 K$. The remaining amount $Q_L - K$ cannot be stored and has to be sold in season 0 at price p_0, which gives a revenue of $p_0(Q_L - K)$. So the total revenue is $p_1 K + p_0(Q_L - K) = p_0 Q_L + (p_1 - p_0)K$. Next, when $Q_L \leq K$, the landlord can store the entire amount Q_L in season 0 and sell it in season 1 at price p_1, thus earning a revenue of $p_1 Q_L$. Moreover he can buy $K - Q_L$ in season 0 at price p_0 and sell this amount in season 1 at price p_1, thus earning a revenue of $(p_1 - p_0)(K - Q_L)$. Hence his total revenue is $p_1 Q_L + (p_1 - p_0)(K - Q_L) = p_0 Q_L + (p_1 - p_0)K$. This completes the proof.[32] ■

Proof of Lemma 4. Let us denote $g(\theta) := h(\rho^*)\theta f(\ell(\theta))$. Then from (24),

$$\Pi^{\varepsilon}(\theta, \rho^*) = \Pi(\theta) + \varepsilon g(\theta). \tag{26}$$

Consider any sequence $\{\theta(\varepsilon)\}$ such that for $\theta \in [0, \rho^*]$, $\Pi^{\varepsilon}(\theta, \rho^*)$ is maximized at $\theta = \theta(\varepsilon)$ for $\varepsilon \geq 0$. Observe that when $\varepsilon = 0$, $\Pi^{\varepsilon}(\theta, \rho^*) = \Pi(\theta)$. While analyzing the game G_1 (page 14), we have shown that the unique maximum of $\Pi(\theta)$ is attained at $\theta = p_0$. Hence for any sequence $\{\theta(\varepsilon)\}$, we have $\theta(0) = p_0$. To prove the lemma, we need to show that for every $\delta > 0$, $|p_0 - \theta(\varepsilon)| < \delta$ for $\varepsilon < \delta$. To see this, let us define the set $A(\delta) := \{\theta \in [0, \rho^*] \text{ such that } |p_0 - \theta| \geq \delta\}$. Consider δ small enough so that the set $A(\delta)$ is non-empty. Since the unique maximum of $\Pi(\theta)$ is attained at p_0, for any $\theta \in A(\delta)$, we have $\Pi(p_0) > \Pi(\theta)$. Since $\Pi(\theta)$ is bounded, $\exists$ a constant $K_1 > 0$ such that for any $\theta \in A(\delta)$, $\Pi(p_0) - \Pi(\theta) > K_1$. Then from (26), it follows that for any $\theta \in A(\delta)$,

$$\Pi^{\varepsilon}(p_0, \rho^*) - \Pi^{\varepsilon}(\theta, \rho^*) = [\Pi(p_0) - \Pi(\theta)] + \varepsilon[g(p_0) - g(\theta)] > K_1 - \varepsilon|g(p_0) - g(\theta)|. \tag{27}$$

Since $g(\theta)$ is bounded, $\exists$ a constant K_2 such that $|g(p_0) - g(\theta)| < K_2$. Then from (27), we have $\Pi^{\varepsilon}(p_0, \rho^*) - \Pi^{\varepsilon}(\theta, \rho^*) > K_1 - \varepsilon K_2 > 0$ when $\varepsilon < \min\{K_1/K_2, \delta\}$. Hence for any $\delta > 0$, when $\varepsilon < \delta$, $\Pi^{\varepsilon}(p_0, \rho^*) > \Pi^{\varepsilon}(\theta, \rho^*)$ for all $\theta \in A(\delta)$. So for any $\delta > 0$, when $\varepsilon < \delta$, any maximum of $\Pi^{\varepsilon}(\theta, \rho^*)$ for $\theta \in [0, \rho^*]$ is attained at $\theta(\varepsilon)$ satisfying $|p_0 - \theta(\varepsilon)| < \delta$. ■

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[32] It has been assumed here that at the minimum price p_0, (1) the landlord can sell any excess amount $Q_L - K$ or (2) fill up any storage deficit by buying $K - Q_L$. It can be argued that in case of foodgrains, there is always enough demand in villages, so selling the excess amount at the lowest price right after the harvest might not be a problem. However, it might be more difficult to buy a large amount at the lowest price. Such a case will actually tilt the argument in favor of sharecropping. To see this, let Q be the total produced output and assume that $K < Q$ (see footnote 16). If the landlord's share is $1 - \alpha$, the output at his disposal is $Q_L = (1 - \alpha)Q$. In that case, if buying in large amount turns out be difficult, the landlord would like to have Q_L larger than K, i.e., $Q_L = (1 - \alpha)Q \geq K$, so that $\alpha \leq 1 - K/Q$.

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