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Renegotiation-proof tenurial contracts as screening mechanisms

Abhinay Muthoo *

Department of Economics, University of Essex, Colchester CO4 3SQ, England, UK

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Abstract

This paper is motivated by the hypothesis that the nature of the tenurial contract is sensitive to the tenant's privately known level of farming skill. In particular, tenants with 'low' skill levels work for wage contracts, those with 'high' skill levels work for rent contracts, and tenants whose skill levels lie in between these extremes work for share contracts. We study a principal-agent type model both with and without the assumption that the parties can commit not to renegotiate the terms of the initially (binding) accepted contract. If the parties can make such a commitment, then our results do support this hypothesis. On the other hand, if the parties cannot make such a commitment, then, with some positive probability, tenants of all skill levels work for the *same* (wage or share) contract. However, with the complement (positive) probability, the hypothesis is vindicated in the no commitment case as well. © 1998 Elsevier Science B.V. All rights reserved.

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* Corresponding author. Tel.: +44-1206-872736; fax: +44-1206-872724; e-mail: muthoo@essex.ac.uk.

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1. Introduction

Most tenurial arrangements in rural economies are characterised by simple, linear, contracts. They can be classified into one of the following types of contracts: wage contracts, rent contracts and share contracts. The basic features of such contracts are as follows. In a wage contract, the tenant–farmer receives a fixed (pre-specified) payment, while the owner–landlord gets to keep the rest of the generated output. At the other extreme are rent contracts. In such a contract, it is the owner–landlord who receives a fixed (pre-specified) payment, while the tenant–farmer gets to keep the rest of the output. In between these two extremes lie share contracts; in this type of contract the generated output is shared between the two actors in a pre-specified manner.

A main objective of this paper is to investigate a potential explanation for the nature of tenurial contracts. In particular, our theory endogenously determines the type of the tenurial contract that will emerge in equilibrium. The basic underlying idea is that a tenant–farmer's skill, or ability, to engage in farming is her *private* information. This assumption allows us to explore the hypothesis that the nature of the tenurial contract is sensitive to a tenant's level of farming skill. In particular, tenurial contracts are a means (or can be a means) to screen a tenant's skill level: tenants with 'low' skills work for wage contracts, those with 'high' skills work for rent contracts, and tenants with 'moderate' skills work for share contracts. [1] We shall investigate this hypothesis in a principal-agent type model, both with and without the assumption that the parties are committed not to renegotiate the terms of the initially (binding) accepted contract. [2]

In the literature, there exist several different explanations for the nature of tenurial contracts. One such explanation (provided by Newbery and Stiglitz, 1977) supports the emergence of share contracting. [3] In order not to confound our explanation with the Newbery–Stiglitz 'risk-sharing' type explanation, we shall consider an environment in which there is no uncertainty, and all actors are risk-neutral. These assumptions also ensure that a 'limited liability' type explanation, which motivates Basu (1992), [4] has no role in our theory. Another explanation is provided by Eswaran and Kotwal (1985), who construct a model in which

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[1] This hypothesis is discussed in Basu (1984) (pp. 132–134), and seems to be supported by the empirical findings of Brown and Atkinson (1981).

[2] The hypothesis has been investigated in Halligan (1978), Newbery and Stiglitz (1979) and Allen (1982) in the context of different kinds of models. However, neither Halligan (1978) nor Allen (1982) seem to support this hypothesis.

[3] Basu (1984) (Chap. 10) contains an excellent exposition of the pros and cons of sharecropping, where he also evaluates the work by Cheung (1969), among other authors. Singh (1989) contains a more comprehensive survey of the sharecropping literature.

[4] Allen (1985) is also motivated by a similar idea.

the landlord's managerial and the tenant's supervisory skills influence output. Their model determines the nature of the tenurial contract as a function of these two (commonly known) parameters.

Section 2 describes our model. If, at the time at which the tenurial contract is determined, the tenant's skill level were common knowledge among the two parties, then the first best contract would constitute a rent contract with some appropriate rent. This is because, in our model, productive efficiency is only achieved by rent contracts. The distribution among the two parties of this maximal generated surplus is then conducted via some appropriate rent. However, with asymmetric information about the tenant's skill level, the first best is not implementable, because a 'high' skill tenant will pretend to be a 'low' skill tenant in order to pay the lower 'low' skill first best rent.

In Section 3, we derive the optimal tenurial contracts given this asymmetry of information and on the assumption that the parties are committed to the initially (binding) accepted contract. Our main results here support the hypothesis that the tenurial contract is sensitive to the tenant's privately known skill level. We show that tenants with 'low' skill levels work for wage contracts and, with the exception of tenants with the highest possible skill level, tenants with any other (higher) skill level work for share contracts. The highest skill tenants are the only types who work for rent contracts.

A problem with this 'full commitment' solution is that it is open to (mutually beneficial) contract renegotiation before the contract is actually implemented. In this solution, the tenant's skill level is revealed by her acceptance of the contract designed for a tenant with her skill level, since the solution constitutes a 'separating' equilibrium. Thus, after a tenant with 'low' skill accepts her wage or share contract, it immediately becomes common knowledge among the two parties that by tearing up this contract, and instead implementing a rent contract with an appropriate rent, they could both become relatively better-off. With full commitment to the initially (binding) accepted contract, this fact is irrelevant. However, if the parties cannot commit not to renegotiate the terms of an accepted contract, then they will conduct such renegotiations. But this, then, implies that the optimal full commitment contracts are no longer viable. A 'high' skill tenant would anticipate such renegotiation, and thus she would not accept the contract that is designed for her, but she would instead accept the contract designed for a 'low' skill tenant. This is because she knows that she would subsequently be treated as a 'low' skill tenant and thus, she would then receive a rent contract with the lower 'low' skill rent.

In Section 4, we therefore derive the optimal contracts without the commitment assumption. The results obtained here support the hypothesis stated above, but only with some probability strictly less than one. Indeed, with some strictly positive probability, tenants of all skill levels work for the *same* (wage or share) contract. Our theory, therefore, can explain both (i) the co-existence of wage, share and rent contracts, and (ii) the existence of just one form of tenurial arrangement (which can be either sharecropping or wage contracts, but not rent contracts).

We conclude in Section 5 with some final remarks. Before proceeding with a description of our model, we should mention that although our model is formally stated as a two-player game between a single landlord and a single tenant, it can easily be re-interpreted as a model with a single landlord facing a large number of tenants.

2. The model

There are two players, a tenant-farmer (T) and a owner–landlord (L). Player L owns a plot of land, and needs to employ T in order to generate output. The production function f relates total output y to the effort e put in by T and to T's skill level s. That is:

$$y = f(e,s) \geq 0$$

where [5] $e \geq 0$ and $s \in [0,1]$. The cost to the tenant of putting in an effort e is denoted by $c(e)$. It will be maintained throughout that f is strictly increasing and strictly concave in both e and s: that is, $f_e > 0$, $f_s > 0$ $f_{ee} < 0$, $f_{ss} < 0$ and $f_{ee} f_{ss} - (f_{es})^2 > 0$. Furthermore, we shall also assume that $f_{es} > 0$. [6] Moreover, it will be maintained throughout that c is strictly increasing and strictly convex in e: that is, $c_e > 0$ and $c_{ee} > 0$. Furthermore, we shall also assume that $c(0) = c_e(0) = 0$. In order to simplify some of the computations, we shall assume that all third derivatives of both f and c are zero.

Both effort and the skill level are non-verifiable by any third party. Thus, the payment (or reward) to the tenant from the landlord cannot be made contingent on either the effort e or the skill level s. The payment from L to T can be made contingent only upon the level of output y, which is verifiable by a third party.

It will be assumed that payment schemes, or contracts, are linear in output. More specifically, a contract is a pair (α, β), where $\alpha \in \mathscr{R}$ and $0 \leq \beta \leq 1$, with the following interpretation. If the output generated is y, then the tenant receives a payment equal to $\alpha + \beta y$ from the landlord. Thus, assuming risk-neutrality, the

[5] Notice that output is not subject to any random element. Of course, we do not believe that this is descriptively plausible: indeed, in rural agriculture, uncertainty about the level of the output is pervasive. However, this assumption ensures that the results contained in this paper are not influenced by such uncertainty. Moreover, given that we shall also assume that both parties are risk-neutral, risk-sharing/insurance arguments have no place in our analysis.

[6] This is a plausible (and standard) assumption. However, in Section 5 we shall discuss the extent to which our results are affected if, instead, $f_{es} \leq 0$.

utilities to the two players, if they agree on a contract (α, β) and the tenant (with skill level s) chooses an effort e, are as follows.

$$U_T(\alpha, \beta, s, e) = \alpha + \beta f(e, s) - c(e) \tag{1}$$

$$U_L(\alpha, \beta, s, e) = -\alpha + (1 - \beta) f(e, s). \tag{2}$$

A rent contract has $\alpha < 0$ and $\beta = 1$, while a wage contract has $\alpha > 0$ and $\beta = 0$. On the other hand, a pure share contract has $\alpha = 0$ and $0 < \beta < 1$, while a mixed share contract has $\alpha \neq 0$ and $0 < \beta < 1$.

Suppose that the tenant with skill level s and the landlord agree on some contract (α, β). Then, the tenant will choose to put in that amount of effort which maximises her utility (Eq. (1)). Given our assumptions on f and c, for any $0 \leq \beta, s \leq 1$, the utility maximising effort level $E^*(\beta, s)$ is the unique solution to [7]

$$\beta f_e(e, s) = c_e(e). \tag{3}$$

It is straightforward to verify that $E^*\beta > 0$ and $E_s^* > 0$. We now define

$$V_T(\alpha, \beta, s) \equiv U_T(\alpha, \beta, s, E^*(\beta, s)) \tag{4}$$

$$V_L(\alpha, \beta, s) \equiv U_L(\alpha, \beta, s, E^*(\beta, s)). \tag{5}$$

Notice that $V_L(\alpha, \beta, s) + V_T(\alpha, \beta, s) = z(\beta, s)$, where

$$z(\beta, s) = f(E^*(\beta, s), s) - c(E^*(\beta, s)) \tag{6}$$

denotes the 'surplus' that will exist between the two parties. It can be verified that $z_\beta > 0$ and $z_s > 0$. Hence, productive efficiency requires that $\beta = 1$.

If the two parties fail to agree on some contract, then they will obtain their respective reservation utilities. Let η and r denote the reservation utilities of the landlord and the tenant, respectively. [8] We shall maintain throughout that 'gains to trade' always exist: that is, $z(0, s) = f(0, s) > \eta + r$. The latter assumption ensures that even a wage contract (which would imply that $E^*(0, s) = 0$) is mutually beneficial.

If the skill level s is common knowledge among the two parties, then a Pareto-efficient contract will constitute a rent contract. Furthermore, on the assumption that the landlord has all the 'bargaining power', [9] the rent that will be paid by the tenant to the landlord in such a contract will be such that $V_T(\alpha, 1, s) = r$.

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[7] The second-order conditions are trivially satisfied since, by assumption, the utility function is strictly concave in e.

[8] Notice that we have implicitly assumed that the tenant's reservation utility does not depend on her skill level. In Section 5, we shall discuss the extent to which our results are affected if, instead, the tenant's reservation utility is strictly increasing in her skill level.

[9] This assumption will be adopted in this paper, and will be made precise in Section 2.1.

Hence, the *first best* contract (α_s^*, β_s^*) between the landlord and the tenant with (commonly known) skill level s is as follows.

$$-\alpha_s^* = z(1,s) - r \tag{7}$$

$$\beta_s^* = 1. \tag{8}$$

We now introduce the main critical assumption of the model: the skill level s of the tenant is her private information. In order to keep the main arguments simple and intuitive, we shall assume that T's skill level can only take two values: high skill $(s = h)$ or low skill $(s = l)$, where $0 \leq l < h \leq 1$. Let the commonly known probability that $s = h$ be denoted by π, where $0 < \pi < 1$.

2.1. Two game forms

In Sections 3 and 4, we characterise the equilibrium contracts in two different games. The first game, studied in Section 3, involves the following three stages.

- Stage 1. The landlord offers a pair (or, menu) of contracts, denoted by (α_l, β_l) and (α_h, β_h).
- Stage 2. The tenant decides whether to reject both contracts on offer or to accept exactly one of them. If the tenant rejects both proposed contracts, then the game ends with the players receiving their respective reservation utilities. But, if the tenant accepts a contract, then the game proceeds to Stage 3.
- Stage 3. The tenant, having accepted some contract (α, β), chooses the amount of effort e that she will put into the land. Depending on her skill level s, some level of output $f(e,s)$ will be produced. And finally, a payment $\alpha + \beta f(e,s)$ will be made by the landlord to the tenant.

This game represents a standard principal-agent type model. From the revelation principle, it follows that the landlord will offer a type-contingent menu of contracts (α_l, β_l) and (α_h, β_h), where the former contract is designed for the low skill tenant and the latter for the high skill tenant. [10]

A basic, but rather crucial, assumption that underlies this game is a particular kind of commitment assumption. Namely, that after the tenant accepts a contract, it will be implemented without any further discussion whatsoever. In particular, even if ex-post [11] it becomes common knowledge among the two parties that there

[10] The optimal contracts can be given two interpretations. A 'normative' interpretation and a 'positive' interpretation. The former interpretation comes from viewing the solution as an exercise in mechanism design, and the focus is thus on the efficiency properties of the equilibrium contracts. One is interested in characterizing the second best; the first best will not be implementable, given the asymmetry in information. The revelation principle simplifies this problem by allowing us to focus on the set of incentive-compatible type-contingent menu of contracts. The second interpretation is based on the view that it is descriptively plausible to assume that the landlord has all the 'bargaining power', and hence can make 'take-it-or-leave-it' offers. In this interpretation, both the distribution and the efficiency properties of the equilibrium contracts are meaningful.

[11] That is, after the contract has been accepted at Stage 2, but before the tenant puts in any effort.

exists further mutually beneficial 'gains from trade', the parties are committed to the contract accepted at Stage 2. For example, suppose that the tenant accepts a share contract. And furthermore, suppose that her acceptance of this contract reveals her type (because a tenant with the other skill type would, in equilibrium, have accepted the other contract on offer in the menu). It will therefore become common knowledge among the two parties that there exists some unexploited, mutually beneficial, 'gains from trade': that is, by instead implementing a rent contract with an appropriate rent, they could both become better-off relative to the outcome associated with the share contract that has been accepted at Stage 2. However, in the game described above, it is implicitly assumed that such mutually beneficial renegotiation of the terms of the initially accepted contract are not allowed to take place. Hence, the parties' commitment to the initial contract, accepted at Stage 2, is absolute. The consequences for the nature of the equilibrium contracts of such a commitment assumption can be significant, as we shall see in this paper.

Indeed, in Section 4, we therefore study another game, which extends the above game by allowing the parties the option to engage in contract renegotiation. Basically, we add another stage to the above game: Stage 2.5. If at Stage 2 the tenant rejects both contracts on offer, then (as before) the game ends with the players receiving their respective reservation utilities. However, if the tenant accepts a contract, then the game proceeds to Stage 2.5.

- Stage 2.5. Having accepted some contract (α,β) at Stage 2, at Stage 2.5 the two parties engage in the following contract renegotiation game. In each 'period' t (where $t=0,1,2,3,\dots$), the landlord either ceases the renegotiations or proposes a contract (α^t,β^t). If a contract is proposed, then the tenant decides either to reject this contract or to accept it. In the latter case, all previously accepted contracts become void, and the latest accepted contract becomes binding on both parties. The contract renegotiation game ends in some period t if and only if the landlord chooses to cease renegotiations in that period. The contract that will then be implemented (at Stage 3) will be the last contract accepted by the tenant. If, on the other hand, contract renegotiations never terminate, [12] then, we assume, that the contract accepted at Stage 2 will be implemented at Stage 3. [13]

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[12] That is, the landlord chooses never to cease the renegotiations.

[13] We emphasize that this contract renegotiation phase is there to enable the landlord and the tenant to consummate any further unexploited 'gains to trade'. Since the initial contract accepted at Stage 2 is binding, either party can always costlessly enforce it on the other party. However, they may find it mutually beneficial to renegotiate the terms of that contract. As we will see in Section 4, in equilibrium the initially accepted contract is never renegotiated. This equilibrium property is probably consistent with the real-world. However, the fact that contracts can be renegotiated (out-of-equilibrium) may have a potent affect on the nature of the initially agreed contract (notwithstanding the fact that along-the-equilibrium-path such renegotiation does not occur).

Notice that we have described a ‘static’ model, in that the parties are determining the contract for one season. Implicitly, therefore, we are ignoring the potential effects that this season’s contract may have on future contractual relationships between these two parties, or indeed between the tenant and other landlords for whom the tenant might work for in the future. These ‘dynamic’ considerations might, in turn, affect the current contract. We leave it for future research to precisely explore the robustness of our results to such considerations. In Section 5, however, we shall briefly discuss the issues involved, and suggest in what way our results may be affected.

Finally, before proceeding with the analysis of the model, we briefly comment on our implicit assumption on the absence of discounting. Although the contract renegotiation game is an infinite horizon game, it should not be given a literal interpretation. We take the view that, during the contract renegotiation phase, the two parties will arrive at some agreement on a new contract or agree to implement the initially accepted contract; and that the outcome of the contract renegotiation process will be agreed upon at some point during a short discussion between the two parties. Although a finite-horizon contract renegotiation game would be more descriptive in that it captures the fact that renegotiations will end in finite time, it has the implausible feature that the parties are assumed to know from the beginning of the game the exact number of offers that will be made. The infinite-horizon model is a much better model of the renegotiation process, as it embodies the plausible feature that after any offer is accepted or rejected, the landlord can choose to make one more offer. [14] Furthermore, the no discounting assumption is meant to emphasise that discounting plays no significant role in determining the outcome of the contract renegotiation game. It does not mean that the parties do not, in general, discount future utilities. [15] Of course, when studying a ‘dynamic’ model, then utilities obtained in future seasons should be discounted.

3. Optimal full-commitment contracts

This section characterises the subgame perfect equilibrium outcome of the game described by Stages 1, 2 and 3. That is, we characterise the optimal menu of contracts on the assumption that the parties are fully committed to the contract

[14] See Rubinstein (1991) for a critical discussion of the finite versus infinite horizon modelling assumption. He argues, for example, that the infinite horizon model better captures the players’ strategic reasoning.

[15] Once again, see Rubinstein (1991) on this issue as well.

accepted at Stage 2. The landlord will offer a type-contingent menu of contracts (α_l, β_l) and (α_h, β_h) that satisfy the following individual rationality constraints. [16]

$$V_T^*(h) \geq r \tag{9}$$

$$V_T^*(l) \geq r \tag{10}$$

where we define $V_T^*(s) \equiv V_T(\alpha_s, \beta_s, s)$. Moreover, by the revelation principle, the following incentive-compatibility constraints need to be satisfied.

$$V_T^*(h) \geq V_T(\alpha_l, \beta_l, h) \tag{11}$$

$$V_T^*(l) \geq V_T(\alpha_h, \beta_h, l). \tag{12}$$

Given the assumption that the parties are fully committed to the contract that is accepted at Stage 2, the landlord's expected utility can be written as follows.

$$[\pi z(\beta_h, h) + (1-\pi) z(\beta_l, l)] - [\pi V_T^*(h) + (1-\pi) V_T^*(l)]. \tag{13}$$

Therefore, the optimisation problem that determines the optimal (full commitment) type-contingent menu of contracts is as follows.

$$\max_{\alpha_h, \beta_h, \alpha_l, \beta_l} (13) \tag{14}$$

subject to Eqs. (9)–(12).

Since Lemmas 1–3, stated below, follow from standard arguments, [17] their proofs are omitted. However, we note that such arguments rest on exploiting the following 'single-crossing' properties. Let $I_T(\alpha, \beta, s)$ denote the indifference curve (in the (α, β) space) of the tenant with skill level s through some point (α, β). [18] At the point (α, β), the slope of $I_T(\alpha, \beta, l)$ is strictly greater than the slope of $I_T(\alpha, \beta, h)$. Now let $I_L(\alpha, \beta, s)$ denote the indifference curve of the landlord through the point (α, β) when the tenant's skill level is s $(s = l, h)$. At the point (α, β), if $\beta < 1$ (resp., $\beta = 1$) then the slope of $I_L(\alpha, \beta, s)$ is strictly greater than (resp., equal to) the slope of $I_T(\alpha, \beta, s)$.

Lemma 1. *If a type-contingent menu of contracts $\{(\alpha_h, \beta_h), (\alpha_l, \beta_l)\}$ satisfies the two incentive-compatibility constraints, Eqs. (11) and (12), then $\alpha_h \leq \alpha_l$ and $\beta_h \geq \beta_l$.*

Lemma 2. *If $\{(\alpha_h, \beta_h), (\alpha_l, \beta_l)\}$ denotes an optimal type-contingent menu of contracts, then the low-type's individual rationality constraint (Eq. (10)) must bind.*

[16] It is straightforward to show that the landlord's expected payoff from employing both types of the tenant will be greater than his maximal expected payoff from employing at most one type. This is a straightforward consequence of our assumption that there always exist mutually beneficial 'gains from trade': i.e., for $s = l, h$, $f(0, s) > \eta + r$.

[17] Cf., for example, Kreps (1990) (Section 18.1) or Laffont and Tirole (1994), Chap. 1).

[18] It is straightforward to verify that this indifference curve is downward sloping and strictly concave.

Lemma 3. *If $\{(\alpha_h,\beta_h), (\alpha_l,\beta_l)\}$ denotes an optimal type-contingent menu of contracts, then the high-type's incentive-compatibility constraint (Eq. (11)) must bind.*

Our first main result, Proposition 1 below, establishes that at the optimum a rent contract will be designed for the high-type tenant.

Proposition 1. *If $\{(\alpha_h,\beta_h), (\alpha_l,\beta_l)\}$ denotes an optimal type-contingent menu of contracts, then $\beta_h = 1$.*

Proof. By contradiction. Thus, consider an optimal type-contingent menu of contracts such that $\beta_h < 1$. In Fig. 1, point A denotes the low-type contract, which lies on the low skill indifference curve $I_T(r,0,l)$, since the low-skill individual rationality constraint binds at the optimum (cf. Lemma 2). From Lemma 3, we know that the high-type contract must lie on the high skill indifference curve that goes through the low-type contract. In particular, by Lemma 1, it must lie between points A and D, but not at point D (for otherwise $\beta_h = 1$). Suppose that the high-type contract is at point B. Now consider an alternative menu of contracts, which differs only in the high-type contract: the high-type contract is now at point C. It is trivial to verify that all four constraints are still satisfied. By appealing to

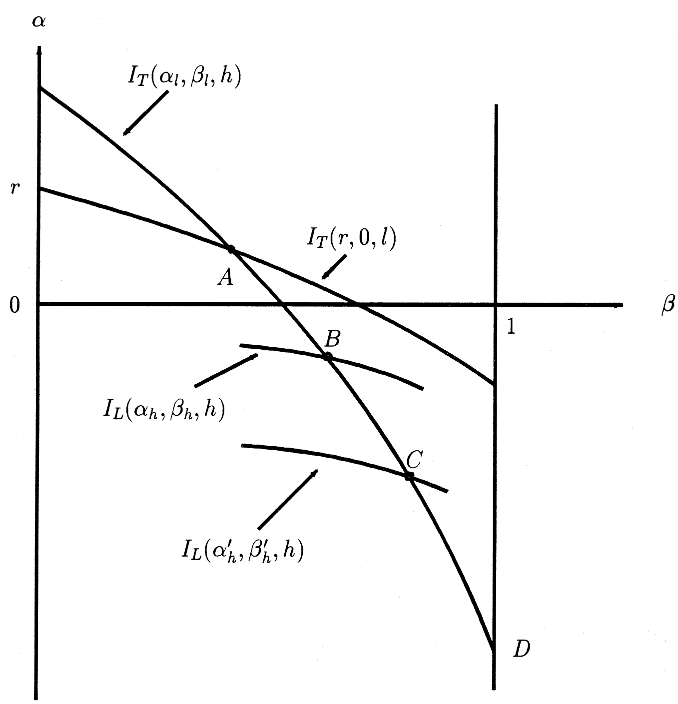

Fig. 1.

the single-crossing property established earlier, it follows that the expected utility to the landlord has increased, which constitutes a contradiction. □

By using the results contained in Lemma 2, Lemma 3 and Proposition 1, the optimisation problem (Eq. (14)) can be considerably simplified as follows. First, for each $\beta_l \in [0,1]$, define $k(\beta_l)$ to be the unique solution to $V_T(k(\beta_l),\beta_l,l) = r$. Hence, the landlord's expected utility (Eq. (13)) can be written as only a function of β_l, to be denoted by $E_L(\beta_l)$.

$$E_L(\beta_l) = \left[\pi z(1,h) + (1-\pi) z(\beta_l,l)\right] - \left[\pi V_T\left(k(\beta_l),\beta_l,h\right) + (1-\pi) r\right]. \quad (15)$$

The value of β_l in the optimal type-contingent menu of contracts maximises E_L over the interval [0,1]. The values of α_l and α_h in the optimal type-contingent menu of contracts are then obtained by using $k(.)$ and Lemma 3, respectively.

Differentiating E_L w.r.t. β_l, and at the same time substituting for the derivatives of k and z (w.r.t. β_l), and finally using Eq. (3), we obtain:

$$\frac{dE_L(\beta_l)}{d\beta_l} = (1-\pi)\left[(1-\beta_l) f_e\left(E^*(\beta_l,l),l\right) E^*_\beta(\beta_l,l)\right] - \pi\left[f\left(E^*(\beta_l,h),h\right) - f\left(E^*(\beta_l,l),l\right)\right]. \quad (16)$$

It is straightforward to verify that the second derivative of E_L w.r.t. β_l is strictly negative everywhere, and hence E_L is strictly concave in β_l. Moreover, it can also be verified that

$$\frac{dE_L(1)}{d\beta_l} < 0. \quad (17)$$

This implies that at the optimum $\beta_l < 1$. Hence, a rent contract designed for the low-type will never (for any values of π, l and h) form part of the optimal type-contingent menu of contracts. This result, combined with Proposition 1, seems to support the hypothesis that the nature of the tenurial contract will be sensitive to the farmer's privately known skill level.

It is straightforward to show (after substituting for $E^*_\beta(0,l)$) that

$$\frac{dE_L(0)}{d\beta_l} = \frac{(1-\pi)\left[f_e(0,1)\right]^2}{c_{ee}(0)} - \pi\left[f(0,h) - f(0,l)\right]. \quad (18)$$

Indeed, in the optimal type-contingent menu $\beta_l = 0$ if and only if Eq. (18) is less than or equal to zero. The next result follows trivially.

Lemma 4. *For any $0 \le l < h \le 1$, there exists a $\overline{\pi}$, namely*

$$\overline{\pi} = \frac{[f_e(0,l)]^2}{[f_e(0,l)]^2 + c_{ee}(0)[f(0,h) - f(0,l)]}$$

such that in the optimal, full commitment, type-contingent menu of contracts: (i) if $\pi \in [\overline{\pi},1)$ then $\beta_l = 0$, and (ii) if $\pi \in (0,\overline{\pi})$ then $0 < \beta_l < 1$.

Notice that $\overline{\pi} < 1$ if and only if $f(0,h) > f(0,l)$. If a zero effort level is interpreted as the minimal effort level, then the latter inequality seems reasonable. On the other hand, if zero effort is given a literal interpretation, then it seems sensible to actually assume that $f(0,s) = 0$ (for all s). This question of interpretation is important as it bears upon the issue of whether wage contracts will ever form part of an optimal menu of contracts. The above result states that if $f(0,h) > f(0,l)$ and if the probability that the tenant has high skill is sufficiently large, then the low-skill tenant will be offered a wage contract.

We now come to our second main result, which essentially re-states the result contained in Lemma 4 in a much more revealing manner. Fix $\pi \in (0,1)$ and $h \in (0,1]$. It is easy to show that in the optimal type-contingent menu of contracts $\beta_l = 0$ if and only if l (where $0 \le l < h$) is such that $f(0,h) \ge \phi(l)$, where

$$\phi(l) = f(0,l) + \left[\frac{1-\pi}{\pi c_{ee}(0)}\right][f_e(0,l)]^2. \tag{19}$$

Given our assumptions, it follows that $\phi(h) > f(0,h)$ and that $\phi_l(l) > 0$. Furthermore, since

$$\frac{\partial^2 E_{\mathrm{L}}(\beta_l)}{\partial \beta_l \partial l} > 0$$

at an interior maximum, the optimal β_l is strictly increasing in l. Furthermore, note that β_l is continuous in l on the whole interval $[0,h)$. Hence, we have the following result.

Proposition 2. *Fix $\pi \in (0,1)$ and $h \in (0,1]$. (i) If $\phi(0) < f(0,h)$, then there exists an $l^* \in (0,h)$ such that in the optimal full commitment menu of contracts $\beta_l = 0$ if $l \in [0,l^*]$, and $0 < \beta_l < 1$ if $l \in (l^*,h)$; (ii) If $\phi(0) > f(0,h)$, then in the optimal full commitment menu of contracts $0 < \beta_l < 1$ for all $l \in [0,h)$;* and *(iii) If $\phi(0) = f(0,h)$, then in the optimal full commitment menu of contracts $0 < \beta_l < 1$ for all $l \in (0,h)$, and $\beta_l = 0$ if $l = 0$. At an interior maximum, β_l is strictly increasing in l. Furthermore, β_l is continuous in l on the whole interval $[0,h)$.*

Thus, unless $\phi(0) \le f(0,h)$, wage contracts designed for the low-type will never form part of an optimal full commitment menu of contracts, no matter how small is the low-type's skill level. Indeed, even if we assume that $f(0,h) > f(0,l)$, it need not be true that $\phi(0) \leq f(0,h)$. The latter inequality will hold, however, if

$$\pi[f(0,h) - f(0,0)] \geq (1-\pi)\left[\frac{[f_e(0,0)]^2}{c_{ee}(0)}\right]. \quad (20)$$

The interpretation behind Eq. (20), which also provides some intuition for Proposition 2, is as follows. Suppose that the low-type's skill level is zero, and consider the situation in which the contract designed for her is a wage contract. Now, suppose that the landlord considers offering the low-type a contract that is slightly different from this wage contract; that is, the landlord considers offering a share contract with the value of the share β_l arbitrarily close to zero, but not equal to zero. The cost and the benefit, respectively, to the landlord of such a marginal change in the low-type contract is captured by the left-hand and right-hand sides of Eq. (20). The left-hand-side of Eq. (20) denotes the expected decrease in the 'rent' extracted by the landlord, while the right-hand-side denotes the expected increase in the surplus. Hence, if the cost is greater than or equal to the benefit, then the proposed change in the contract is not profitable for the landlord. Proposition 2 then follows trivially by a 'continuity' argument.

If Eq. (20) holds, then the low-type will be offered a wage contract if her skill level is sufficiently small (that is, less than or equal to l^*), and a share contract otherwise. The critical number l^* is the unique solution to $\phi(l) = f(0,h)$. Given our assumptions, it follows that l^* is increasing in both h and π.

In summary, then, the results contained in Propositions 1 and 2 do provide some (theoretical) support for the hypothesis that the nature of the tenurial contract will be sensitive to the farmer's privately known skill level. In particular, 'low' skill farmers work for wage contracts, those with the highest skill level work for rent contracts, and farmers with 'moderate' skill levels work for share contracts.

4. Optimal renegotiation-proof contracts

This section presents an analysis of the game described by Stages 1, 2, 2.5 and 3. That is, we extend the analysis of Section 3 by allowing the two parties to engage in contract renegotiation after the tenant accepts (at Stage 2) a contract from the menu offered at Stage 1, but before the game moves to Stage 3 (where some binding contract is implemented).

A contract accepted at Stage 2 is defined to be *renegotiation-proof* if and only if in any perfect Bayesian equilibrium of the contract renegotiation game at Stage 2.5 the landlord chooses to cease the renegotiations immediately in 'period' 0. We shall first characterise the set of all renegotiation-proof contracts. And then, we shall characterise the optimal renegotiation-proof contracts. Note that from the renegotiation-proofness principle it follows that the optimal renegotiation-proof contracts will be optimal. [19]

Any rent contract is renegotiation-proof, since productive efficiency is achieved. Another straightforward observation is that any wage or share contract is renegotiation-proof only if it is accepted by both types with strictly positive probability. Indeed, unlike the optimal full commitment contracts, which perfectly screen/separate the two types, optimal renegotiation-proof contracts must involve some positive degree of pooling in equilibrium. This is the first simple, yet important, consequence of renegotiation-proofness: renegotiation-proof tenurial contracts cannot perfectly screen a tenant–farmer's type. Another useful observation is that, since α has no influence on productive efficiency, [20] whether a contract is or is not renegotiation-proof does not depend on the value of α.

A menu (or, pair) of contracts (α_l, β_l) and (α_h, β_h) is admissible if it satisfies the two individual rationality constraints (Eqs. (9) and (10)), the two incentive-compatibility constraints (11) and (12), and if each contract in this menu is renegotiation-proof. Notice that the landlord's expected utility from such a menu is not necessarily given by Eq. (13), since the renegotiation-proof constraint may require that some type randomise between the two contracts on offer.

Without loss of generality, we assume that the s-type tenant (where $s = l, h$) accepts the contract (α_s, β_s) with some strictly positive probability. Of course, the tenant will choose between the two contracts on offer randomly only if she is indifferent between them. [21] It is straightforward to verify that Lemmas 1–3 and

[19] That is, in any perfect Bayesian equilibrium of the game defined by Stages 1, 2, 2.5 and 3, the equilibrium payoff to the landlord is less than or equal to his payoff from the optimal renegotiation-proof contracts. This is a rather straightforward observation, which follows from the fact that the landlord can always anticipate, at Stage 1, the final implemented contract associated with any (initial) non-renegotiation-proof contract, and offer that contract at Stage 1 itself.

[20] Note that α influences the distribution of the surplus between the two parties.

[21] As we will shortly see, the existence of an optimal renegotiation-proof menu of contracts requires that the high-type tenant randomize over the two contracts on offer. Hence, mixed strategies are introduced in order to ensure the existence of an equilibrium in our model without commitment. Indeed, in most game-theoretic models, mixed strategies are introduced for precisely that reason—to ensure the existence of an equilibrium. However, this raises issues of interpretation, for it is seldom the case that a player will choose her strategy in a random manner. Furthermore, since she is indifferent between the two pure strategies, there is the issue of interpreting the use of a particular mixed strategy. The simplest and, perhaps, the most compelling interpretation is as follows. The equilibrium mixed strategy of a player is interpreted as her opponent's equilibrium beliefs about the pure strategy that she will choose. Thus, although the player will choose a pure strategy, her opponent has only probabilistic beliefs about that. With this interpretation, a mixed strategy equilibrium seems far more plausible than a pure strategy equilibrium, since in the latter kind of equilibrium a player would have a 'point expectation' about her opponent's pure strategy choice—i.e., she would know the exact equilibrium pure strategy chosen by her opponent. For further discussion on the interpretation of mixed strategies, see Rubinstein (1991).

Proposition 1 continue to be valid. [22] These results have two key implications. First, in any optimal renegotiation-proof menu of contracts, the low-type will choose the contract (α_l,β_l) with probability one. A second implication is that the contract $(\alpha_h,1)$ is renegotiation-proof. Since the high-type is indifferent between the two contracts on offer, let us assume that she chooses contract (α_l,β_l) with some probability λ, where renegotiation-proofness requires that $\lambda > 0$.

In what follows we shall simplify the analysis by assuming that λ is independent of the values of α_l and β_l. [23] Hence, the landlord's expected utility $E_{\mathrm{L}}^{\mathrm{rp}}$ from a renegotiation-proof menu of contracts, which (as before) can be written as only a function of β_l, is as follows.

$$E_{\mathrm{L}}^{\mathrm{rp}}(\beta_l) = \left[\pi(1-\lambda)z(1,h) + \pi\lambda z(\beta_l,h) + (1-\pi)z(\beta_l,l)\right] - \left[\pi V_{\mathrm{T}}\left(k(\beta_l),\beta_l,h\right) + (1-\pi)r\right]. \tag{21}$$

We now turn to a derivation of the constraint that is a necessary and sufficient condition for a contract (α_l,β_l) to be renegotiation-proof.

4.1. The renegotiation-proofness constraint

Suppose the tenant at Stage 2 accepts the contract (α_l,β_l). Then, at the beginning of the contract renegotiation game at Stage 2.5 the landlord's *posterior* belief μ that the tenant has high skill is (using Bayes' rule) as follows:

$$\mu = \frac{\lambda\pi}{\lambda\pi + (1-\pi)}. \tag{22}$$

This updated belief is, by assumption, independent of the values of α_l and β_l.

In Fig. 2, point A depicts the contract (α_l,β_l). Consider the following path of play in the contract renegotiation game. In period 0, the landlord offers a new contract (α,β) which lies on the low-type indifference curve $I_{\mathrm{T}}(\alpha_l,\beta_l,l)$ and is such that $\beta > \beta_l$. Such a contract is depicted by point C in Fig. 2. Both types accept this new contract, and in period 1 the landlord ceases the renegotiations. [24] By construction, the high-type prefers this new contract to the initial contract

[22] Of course, in the statements of these results, one must replace 'optimal type-contingent menu of contracts...' with 'optimal renegotiation-proof contracts...'.

[23] This assumption may be motivated by 'bounded rationality' considerations. However, we note that the main qualitative effects of renegotiation-proofness on the characteristics of the optimal contracts (derived under this simplifying assumption) are robust to a generalization in which this probability λ is allowed to depend on both α_l and β_l.

[24] And thus, play proceeds to Stage 3, where the new contract is implemented.

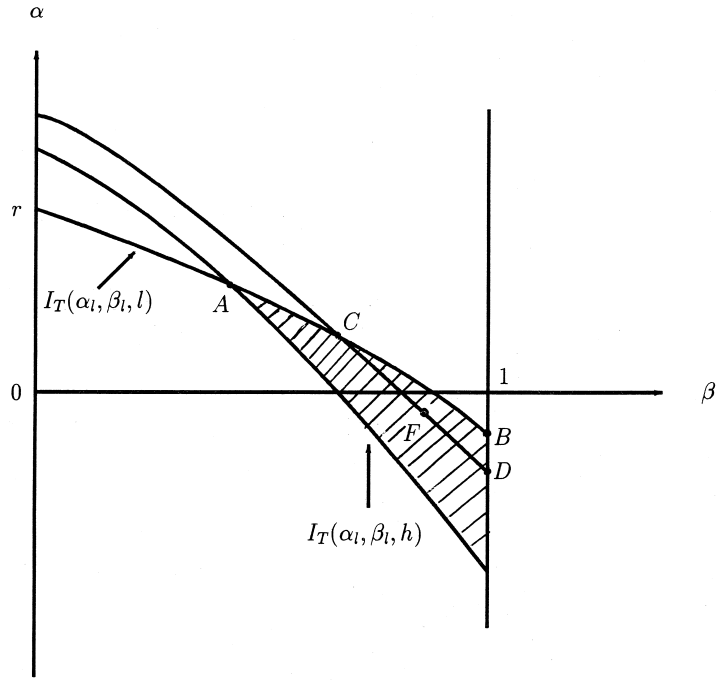

Fig. 2.

(α_l,β_l), while the low-type is indifferent between them. The landlord's expected utility, computed at the beginning of the contract renegotiation game, is: [25]

$$\hat{E}_{\mathrm{L}}(\beta) = [\mu z(\beta,h) + (1-\mu)z(\beta,l)] - [\mu V_{\mathrm{T}}(k(\beta),\beta,h) + (1-\mu)r]. \tag{23}$$

If the derivative of $\hat{E}_L$ (with respect to β) evaluated at $\beta=\beta_l$ is strictly positive, then the contract (α_l,β_l) cannot be renegotiation-proof. Hence, since $\hat{E}_L$ is strictly concave in β, it follows that a necessary condition for a contract (α_l,β_l) to be renegotiation-proof is that the derivative of $\hat{E}_L$ (with respect to β), evaluated at $\beta=\beta_l$, is less than or equal to zero. That is, β_l must necessarily satisfy:

$$\big[\mu(1-\beta_l)f_e(E^*(\beta_l,h),h)E^*_\beta(\beta_l,h) + (1-\mu)(1-\beta_l) \times f_e(E^*(\beta_l,l),l)E^*_\beta(\beta_l,l) - \mu\big[f(E^*(\beta_l,h),h) - f(E^*(\beta_l,l),l)\big]\big] \leq 0. \tag{24}$$

It turns out that this is also a sufficient condition for renegotiation-proofness. Hence, we can now state the desired result.

[25] Notice that, since both types accept this new contract, no (further) separation of the two types takes place along this path of play.

Lemmma 5. *A contract* (α_l,β_l) *is renegotiation-proof if and only if* β_l *satisfies Eq. (24).*

Proof. The necessity of Eq. (24) has been established above. The sufficiency is proven in Appendix A. □

4.2. The main results

The value of β_l in the optimal renegotiation-proof menu of contracts maximises Eq. (21) over the interval [0,1] subject to satisfying Eq. (24). As in Section 3, the values of α_l and α_h in the optimal renegotiation-proof menu of contracts are then obtained by using $k(.)$ and Lemma 3, respectively. Differentiating E_L^{rp} with respect to β_l, and at the same time substituting for the derivatives of k and z (w.r.t β_l), and finally using Eq. (3), we obtain:

$$\frac{\mathrm{d}E_L^{rp}(\beta_l)}{\mathrm{d}\beta_l}\left[\pi\lambda(1-\beta_l)f_e(E^*(\beta_l,h),h)E_\beta^*(\beta_l,h)+(1-\pi)(1-\beta_l)\right.$$
$$\left.\times f_e(E^*(\beta_l,l),l)E_\beta^*(\beta_l,l)-\pi\left[f(E^*(\beta_l,h),h)-f(E^*(\beta_l,l),l)\right]\right]. \tag{25}$$

After substituting for μ using Eq. (22), and then using Eq. (25), it is trivial to verify that the renegotiation-proofness constraint (Eq. (24)) becomes:

$$\left[\frac{\mathrm{d}E_L^{rp}(\beta_l)}{\mathrm{d}\beta_l}+\pi(1-\lambda)\left[f(E^*(\beta_l,h),h)-f(E^*(\beta_l,l),l)\right]\right]\leq 0. \tag{26}$$

The second derivative of E_L^{rp} w.r.t. β_l is strictly negative everywhere, and hence E_L^{rp} is strictly concave in β_l. Moreover, it can be verified that there exists a $\hat{\beta}<1$ such that any $\beta_l\in[\hat{\beta},1]$ satisfies the renegotiation proofness condition (Eq. (26)). Hence, since

$$\frac{\mathrm{d}E_L^{rp}(1)}{\mathrm{d}\beta_l}<0 \tag{27}$$

it follows that at the optimum $\beta_l<1$. Thus, as in the optimal full commitment menu of contracts, a rent contract designed for the low-type will never (for any values of π, l and h) form part of the optimal renegotiation-proof menu of contracts.

It is straightforward to show (after substituting for $E^*_\beta(0,h)$ and $E^*_\beta(0,l)$) that

$$\frac{\mathrm{d}E^{\mathrm{rp}}_{\mathrm{L}}(0)}{\mathrm{d}\beta_l}=\frac{\pi\lambda[f_e(0,h)]^2}{c_{ee}(0)}+\frac{(1-\pi)[f_e(0,l)]^2}{c_{ee}(0)}-\pi[f(0,h)-f(0,l)]. \tag{28}$$

Using Eq. (26), it follows that in the optimal renegotiation-proof menu $\beta_l=0$ if and only if Eq. (28) is less than or equal to

$$-\pi(1-\lambda)[f(0,h)-f(0,l)]. \tag{29}$$

The following result, which is the analogue to Lemma 4, follows trivially.

Lemma 6. *For any* $0\le l<h\le 1$, *there exists a* $\hat{\pi}$, *namely*

$$\hat{\pi}=\frac{[f_e(0,l)]^2}{[f_e(0,l)]^2+\lambda c_{ee}(0)[f(0,h)-f(0,l)]-\lambda[f_e(0,h)]^2}$$

such that in the optimal, renegotiation-proof, menu of contracts: (i) if $\hat{\pi}>0$ *and* $\pi\in[\hat{\pi},1]$ *then* $\beta_l=0$, *(ii) if* $\hat{\pi}>0$ *and* $\pi\in[0,\hat{\pi})$ *then* $0<\beta_l<1$, *and (iii) if* $\hat{\pi}\le 0$ *then, for all* $\pi\in(0,1)$, $0<\beta_l<1$.

Notice that whether $\hat{\pi}$ is ≤ 0 or >0 depends in part on the value of λ. For example, if λ is sufficiently small, then $\hat{\pi}>0$. Comparing Lemma 6 with Lemma 4, it is straightforward to verify that if $\hat{\pi}>0$ then $\hat{\pi}>\overline{\pi}$. The basic insight, therefore, that emerges by comparing these two lemmas is as follows. If contracts are required to be renegotiation-proof, then it is 'more likely' that the low-type will work for a share contract, as against a wage contract. More precisely, for example, if $\pi\in(\overline{\pi},\hat{\pi})$ then in the optimal renegotiation-proof menu $0<\beta_l<1$, while in the optimal full commitment menu $\beta_l=0$.

We now come to our second main result, which essentially re-states the result contained in Lemma 6 in much more revealing manner. Fix $\pi\in(0,1)$ and $h\in(0,1]$. It is easy to show that in the optimal renegotiation-proof menu of contracts $\beta_l=0$ if and only if l (where $0\le l<h$) is such that $f(0,h)\ge\hat{\phi}(l)$, where

$$\hat{\phi}(l)=f(0,l)+\left[\frac{1-\pi}{\pi\lambda c_{ee}(0)}\right][f_e(0,l)]^2+\frac{[f_e(0,h)]^2}{c_{ee}(0)}. \tag{30}$$

Given our assumptions, it follows that $\hat{\phi}(h)>f(0,h)$ and that $\hat{\phi}_l(l)>0$. If Eq. (28) is strictly greater than Eq. (29), then, in the optimal renegotiation-proof menu, β_l is the unique value which ensures that the left-hand side of Eq. (26) is equal to zero. That is, $0<\beta_l<1$ is the unique solution to:

$$\xi(\beta_l)=0$$

where $\xi(\beta_l)$ denotes the left-hand-side of Eq. (26). It is easy to verify that, at any interior maximum, β_l is strictly increasing in l. Furthermore, note that β_l is continuous in l on the whole interval $[0,h)$. Hence, we have the following result.

Proposition 3. *Fix $\pi \in (0,1)$ and $h \in (0,1]$. (i) If $\hat{\phi}(0) < f(0,h)$, then there exists an $\hat{l} \in (0,h)$ such that in the optimal renegotiation-proof menu of contracts $\beta_l = 0$ if $l \in [0,\hat{l}]$, and $0 < \beta_l < 1$ if $l \in (\hat{l},h)$; (ii) If $\hat{\phi}(0) > f(0,h)$, then in the optimal renegotiation-proof menu of contracts $0 < \beta_l < 1$ for all $l \in [0,h)$;* and *(iii) If $\hat{\phi}(0) = f(0,h)$, then in the optimal renegotiation-proof menu of contracts $0 < \beta_l < 1$ for all $l \in (0,h)$, and $\beta_l = 0$ if $l = 0$. At an interior maximum, β_l is strictly increasing in l. Furthermore, β_l is continuous in l on the whole interval $[0,h)$.*

The interpretation and intuition behind this result is similar to that for Proposition 2. Comparing Propositions 2(i) and 3(i), it is easy to verify that $\hat{l} < l^*$. Indeed, as we saw by comparing Lemmas 4 and 6, it emerges that if contracts are required to be renegotiation-proof, then the low-type tenant, if her skill level $l \in (\hat{l},l^*]$, will work for a share contract, as against a wage contract (which is what she would work for if the two parties could fully commit themselves to the contract accepted at Stage 2).

In summary, then, in the optimal renegotiation-proof menu of contracts $\{(\alpha_l,\beta_l),(\alpha_h,\beta_h)\}$, $\beta_h = 1$ and the value of β_l (which will be strictly less than one) is characterised in Proposition 3. The low-type tenant accepts the contract (α_l,β_l) with probability one. The high-type tenant accepts the contract (α_l,β_l) with probability $\lambda > 0$ and the contract (α_h,β_h) with probability $(1-\lambda) > 0$.

4.3. A comparison with the commitment case

The optimal, full commitment, menu perfectly screens/separates the two types. In contrast, if contracts are required to be renegotiation-proof, then the high-type tenant must choose the low-type contract (α_l,β_l) with some strictly positive probability. This implies that, with some strictly positive probability, even the high-type tenant will work for a wage contract (if the optimal $\beta_l = 0$) or a share contract (if the optimal $\beta_l \in (0,1)$). Indeed, with some strictly positive probability, tenants of both types will work for the *same* contract. This ‘pooling’ property (which is a necessary consequence of renegotiation-proofness) does not support the hypothesis that tenants with differing skill levels will work for different kinds of contracts.

With some strictly positive probability, on the other hand, the hypothesis can be vindicated in the no commitment case as well. However, in this case there is an interesting effect, by dropping the commitment assumption, on the nature of the tenurial contracts. This is illustrated in Fig. 3, which depicts two continuous functions, $\beta^{FC}(.)$ and $\beta^{RP}(.)$.

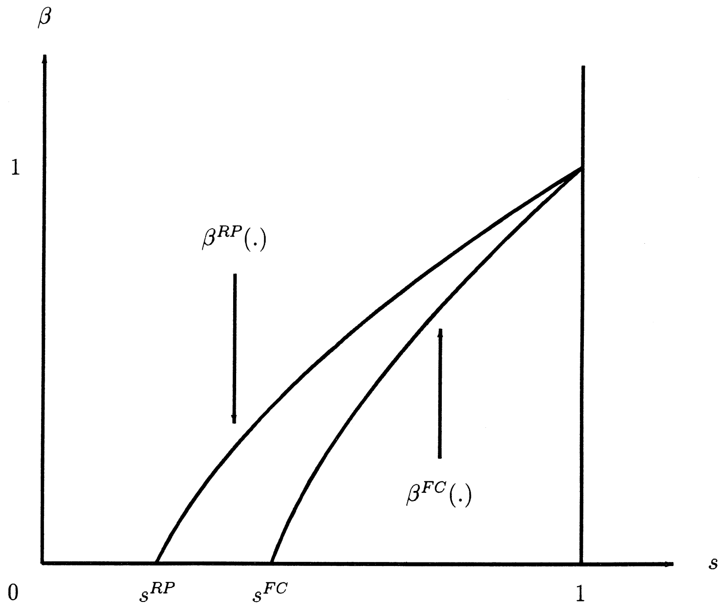

Fig. 3.

These two functions characterise the optimal value of β as a function of the skill level s, with and without the commitment assumption. In the commitment case, with probability one a tenant with skill level s works for a contract with $\beta=\beta^{\mathrm{FC}}(s)$. However, in the no commitment case, with some strictly positive (but strictly less than one) probability a tenant with skill level s works for a contract with $\beta=\beta^{\mathrm{RP}}(s)$. Notice that in both cases there exists a critical skill level such that tenants with skill levels below this critical value work for wage contracts, while those with skill levels above this value, with the exception of the highest skill tenants (i.e., $s=1$), work for share contracts. This critical value is higher when the parties can fully commit themselves to the initially (binding) accepted contract. Hence, as is illustrated in Fig. 3, tenants with ‘very low’ skill levels work for wage contracts in both the commitment and no commitment cases, and tenants with ‘low’ skill levels who would work for a wage contract in the commitment case, would work for share contracts in the no commitment case. With the exception of the highest skill level tenants (who work for rent contracts whether or not commitments can made), tenants with the other (higher) skill levels continue to work for share contracts, but when the commitment assumption is dropped the shares increase. Notice therefore that the renegotiation-proofness requirement enhances expected productive efficiency.

To summarise, then, even when the parties can engage in mutually beneficial contract renegotiation, the hypothesis that has motivated this paper is justifiable, although not with probability one. Our theory, therefore, can explain both (i) the co-existence of wage, share and rent contracts, and (ii) the existence of just one form of tenurial arrangement (which can be either sharecropping or wage contracts, but not rent contracts).

5. Concluding Remarks

5.1. Type-contingent reservation utilities

We now briefly discuss the effects on the results obtained above if, instead, it is assumed that the tenant's reservation utility is strictly increasing in her skill level. To do so, we introduce a new parameter θ (where $\theta \geq 0$), and let r and $r+\theta$ denote the reservation utilities of the low and high types, respectively. The case $\theta = 0$ has been studied above. We now consider the case $\theta > 0$. The following observation, which is trivial to verify, will prove useful below. With reference to the first best contracts, Eqs. (7) and (8), note that the rent $-\alpha_h^*(\theta)$ in the first best contract designed for the high-type is strictly decreasing in θ. Furthermore, there will exist a $\bar{\theta} > 0$ such that $-\alpha_h^*(\bar{\theta}) = -\alpha_l^*$.

It is rather intuitive that if θ is sufficiently high (so that there need not be any gains from trade between the landlord and the high-type), then it may no longer be optimal for the landlord to employ both types. In this case, the optimal full commitment menu may involve offering only the first best low-type contract. Notice that this optimal menu is renegotiation-proof. Let us now focus attention on values of θ such that $\theta < \bar{\theta}$, because only for such values of θ is $-\alpha_h^*(\theta) > -\alpha_l^*$. That is, for such values of θ the first best contracts are not implementable because the high-type will pretend to be a low-type in order to pay the lower (low-type) rent.[26] As we argue below, for such values of θ, the analysis conducted above is applicable, and moreover, the results are similar to those obtained above.

The optimisation problem that determines the optimal full commitment menu of contracts continues to be defined by Eq. (14), but with the right-hand-side of Eq. (9) being replaced by the term $r+\theta$. The results stated in Lemmas 1–3 and Proposition 1 are valid here, although the arguments are slightly more involved (but the arguments are still pretty standard). Hence, it is still the case that the high-type tenant works for a rent contract. There is one important effect of $\theta > 0$ on the subsequent analysis and on the optimal value of β_l, to which we now turn. First, let us define a new critical value of β. For each $\theta \in [0, \bar{\theta}]$, let $\beta^*(\theta)$ denote the unique value of β where the indifference curves $I_T(r,0,l)$ and $I_T(r+\theta,0,h)$

[26] If $\theta > \bar{\theta}$, then $-\alpha_h^*(\theta) < -\alpha_l^*$; hence, it is the low-type who has an incentive to pretend to be a high-type. Notice that if $\theta = \bar{\theta}$, then the first best contracts are implementable, since the first best rents are identical.

intersect.[27] It is trivial to verify that $\beta^*(\theta)$ is continuous and strictly increasing in θ over the interval $[0,\bar{\theta}]$, and that $\beta^*(0)=0$ and $\beta^*(\bar{\theta})=1$. These indifference curves do not intersect for values of $\theta > \bar{\theta}$.

It is straightforward to show that Lemmas 2 and 3 imply that, for any $\theta \in [0,\bar{\theta}]$, the value of β_l in the optimal menu of contracts must be greater than or equal to $\beta^*(\theta)$. Hence, since, for $\theta > 0$, $\beta^*(\theta) > 0$, it follows that the low-type tenant will not work for a wage contract. Although Eq. (15) is still applicable, the value of β_l in the optimal full commitment menu of contracts now maximises E_L over the closed interval $[\beta^*(\theta),1]$. Since Eq. (17) continues to hold, it follows that the low-type will not work for a rent contract. Indeed, therefore, the low-type will work for a share contract in the optimal full commitment menu.

It is easy to verify that the analysis in Section 4 is still applicable, subject to the changes discussed above—in particular, that in the optimal renegotiation-proof menu $\beta_l \geq \beta^*(\theta)$. Indeed, the results and insights obtained in Section 4 continue to be valid subject to the change that wage contracts no longer form part of the optimal menu. The main effect, therefore, of $\theta > 0$ (but keeping $\theta \leq \bar{\theta}$) is to shift upwards the two curves $\beta^{RP}(.)$ and $\beta^{FC}(.)$ shown in Fig. 3. Hence, in both the optimal full commitment and the optimal renegotiation-proof menus, expected productive efficiency is strictly increasing in θ over the interval $[0,\bar{\theta}]$.[28]

5.2. On the relationship between effort and skill

The results obtained in Sections 3 and 4 are based on the assumption that the tenant's marginal productivity of effort is strictly increasing in her skill level (i.e., $f_{es} > 0$). This assumption seems plausible, and moreover, it is a standard assumption. Let us, however, briefly discuss the extent to which our results are affected if, instead, $f_{es} < 0$.[29] A crucial issue is whether or not the single-crossing property will continue to hold.[30] It is straightforward to show that, at any point (α,β), where $\alpha \in \mathscr{R}$ and $0 \leq \beta \leq 1$, the slope of the low-type indifference curve is strictly greater (resp., strictly smaller) than the slope of the high-type indifference curve if and only if

$$\Delta = f_s c_{ee} + \beta(f_e f_{es} - f_s f_{ee}) > 0(\text{resp.}, < 0),$$

where the various derivatives are evaluated at the utility maximising effort level $E^*(\beta,s)$. Notice that Δ does not depend on α. Given our assumptions $f_s > 0$ and

[27] Note that the former (resp., latter) is the low-type's (resp., high-type's) indifference curve that defines the set of all contracts (α,β) which give her a payoff equal to r (resp., $r+\theta$).

[28] The first best is implementable when $\theta = \bar{\theta}$.

[29] It is trivial to verify that our main results continue to be valid if, instead, $f_{es} = 0$.

[30] If the single-crossing property fails to hold, then the optimization problems become pretty intractable.

$c_{ee} > 0$, if $\beta = 0$ then $\Delta > 0$. Hence, the single-crossing property holds if and only if $\Delta > 0$ for all $\beta \in [0,1]$.

Given our assumptions $f_e > 0$, $f_s > 0$, $f_{ee} < 0$ and $c_{ee} > 0$, it follows that at any point $0 < \beta \leq 1$, $\Delta > 0$ if and only if

$$f_{es} > \frac{f_s(\beta f_{ee} - c_{ee})}{\beta f_e}.$$

Since the right-hand-side of this inequality is strictly negative, it follows that the single-crossing property holds not only if $f_{es} \geq 0$ but also if f_{es} takes some strictly negative values. It is therefore straightforward to verify that if $f_{es} < 0$ and f_{es} satisfies the above inequality, then the analysis in Section 3 and 4 continues to be applicable, and our main results (namely, Lemmas 1–6 and Propositions 1–3) continue to be valid.

5.3. Repeated interaction

We have studied the problem of determining the tenurial contract between a risk-neutral owner–landlord and a risk-neutral tenant–farmer in a ‘one-shot’, or ‘static’, context. That is, the parties are assumed to ignore the potential effects of the contract agreed for this season on the contracts that they may agree in future seasons, or indeed, on the contracts that the tenant–farmer might work for with other landlords in the future. In particular, we have therefore ignored the potential affect that such future may have on the nature of this season’s contract. It is clearly interesting and important to extend our model to incorporate such ‘dynamic’ considerations. A simple first way to conduct such a study is to consider a model in which the parties engage in contract determination in two successive seasons. [31]

Suppose that the parties will write long-term contracts that describe the contract for the current season and for the next season. If we assume that the parties can commit themselves to any long-term contract accepted at Stage 2 in the first season, thus ruling out any renegotiations of the long-term contract at any point in the two seasons, then it can be shown that the optimal long-term menu of contracts constitutes the optimal ‘static’ full commitment menu of contracts (described in Section 3) in both seasons. [32]

This commitment assumption can be relaxed in several ways. For example, the parties can be assumed to be committed to the contract for the first season, but could renegotiate the terms of the second season contract at the beginning of the second season.

[31] That is, one could study a repeated game in which our ‘static’ game is repeated at least once.
[32] This result is quite general. See, for example, Baron and Besanko (1984).

In whatever manner the commitment assumption is relaxed, it will be case that the optimal full commitment long-term menu of contracts will no longer be viable. The same issues that arose in Section 4, when we relaxed the commitment assumption in the 'static' model, arise in this repeated contracting model. Of course, it may be that no long-term contracts can be written. In which case, the analysis would center on the sequence of short-term contracts that emerge in a perfect Bayesian equilibrium. [33]

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Appendix A. Proof to Lemma 5

We have already established the necessity of Eq. (24) in the main text. Here, we establish that if a contract (α_l, β_l) accepted at Stage 2 satisfies Eq. (24), then it is renegotiation-proof. Fix an arbitrary perfect Bayesian equilibrium of the contract renegotiation game. We shall establish that if the initially accepted contract (α_l, β_l) satisfies Eq. (24), then in equilibrium the landlord will choose to cease the renegotiations immediately, in 'period' 0.

In equilibrium, the utility received by the s-type tenant (where $s = l,h$) must be greater than or equal to the utility $V_T(\alpha_l, \beta_l, s)$ that she obtains from the initially accepted contract, for she can always choose to enforce that contract. [34] Moreover, the landlord's equilibrium expected utility must be greater than or equal to his expected utility $\hat{E}_L(\beta_l)$ (defined in Eq. (23)) from the initially accepted contract, for he can always choose to cease the renegotiations in 'period' 0.

Recalling, from Eq. (23) for example, that the landlord's expected utility is equal to the difference between the expected surplus and the tenant's expected utility, the observations stated above imply that if an alternative contract is proposed and accepted, then it must be because the expected surplus does not decrease. Hence, the landlord will never offer a contract such that $\beta < \beta_l$.

In Fig. 2, point A depicts the initially accepted contract. The landlord will never offer a contract that lies strictly above the low-type's indifference curve

[33] Laffont and Tirole (1994) (Chaps. 9 and 10) study a repeated contracting model. Their techniques and methods should prove useful in the analysis of our repeated contracting model.

[34] In the contract renegotiation game, she can achieve this outcome by a pure strategy that rejects all offers made by the landlord.

$I_T(\alpha_l,\beta_l,l)$, since both types would accept an alternative contract that has the same value of β but a slightly smaller value of α, and since this alternative contract would increase the landlord's expected utility. Furthermore, since both types would reject any contract that lies strictly below the high-type's indifference curve $I_T(\alpha_l,\beta_l,h)$, the landlord will never offer such a contract. Hence, in equilibrium, contract offers may only lie either in the shaded region or on the boundaries of this shaded region.

Of course, the low-type will only accept contract offers that lie on his indifference curve $I_T(\alpha_l,\beta_l,l)$, between points A and B. Suppose that the final contract accepted by the low-type is as depicted by point C. If this contract C is not equal to the contract depicted by point B (i.e., is not a rent contract), then any contract that the high-type finally accepts with positive probability must lie on the high-type indifference curve that goes through point C, between points C and D, such as at point F. Any contract that lies off this indifference curve will never be accepted by the high-type. For example, if the high-type accepts a contract that lies above this indifference curve, then she should accept it with probability one. But then, following a rejection of that offer, the landlord will infer that the tenant has low skill and thus offer the contract depicted by point B, a contradiction to our hypothesis. Note that, by construction, Eq. (24) rules out the possibility that the landlord offers the contract depicted by point B.

Notice that a contract depicted by point C, which is the final contract accepted by the low-type with probability one, must be accepted by the high-type with strictly positive probability. For otherwise, the acceptance of the offer would reveal that the tenant has low skill, and thus the landlord would then offer the contract depicted by point B, contradicting the hypothesis that C depicts the final accepted offer by the low-type. Let γ denote the probability with which the high-type accepts the contract (α,β) depicted by point C. Therefore, the equilibrium expected utility to the landlord must be bounded above by

$$\bar{E}_L(\beta) = [(1-\gamma)\mu z(1,h) + \gamma\mu z(\beta,h) + (1-\mu)z(\beta,l)] - [\mu V_T(k(\beta),\beta,h) + (1-\mu)r]$$

Notice the similarity of this expression to Eq. (23). Indeed, it is trivial to verify that (since the first term in Eq. (24) is strictly positive) if the initially accepted contract (α_l,β_l) satisfies Eq. (24), then the derivative of $\bar{E}_L$ (with respect to β), evaluated at $\beta=\beta_l$, is less than zero. Hence, since $\bar{E}_L$ is strictly concave in β, it follow that in the perfect Bayesian equilibrium the landlord will choose to cease the renegotiations immediately, in 'period' 0.

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